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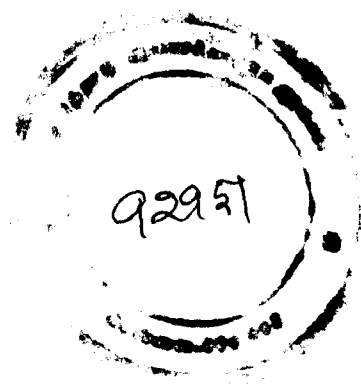
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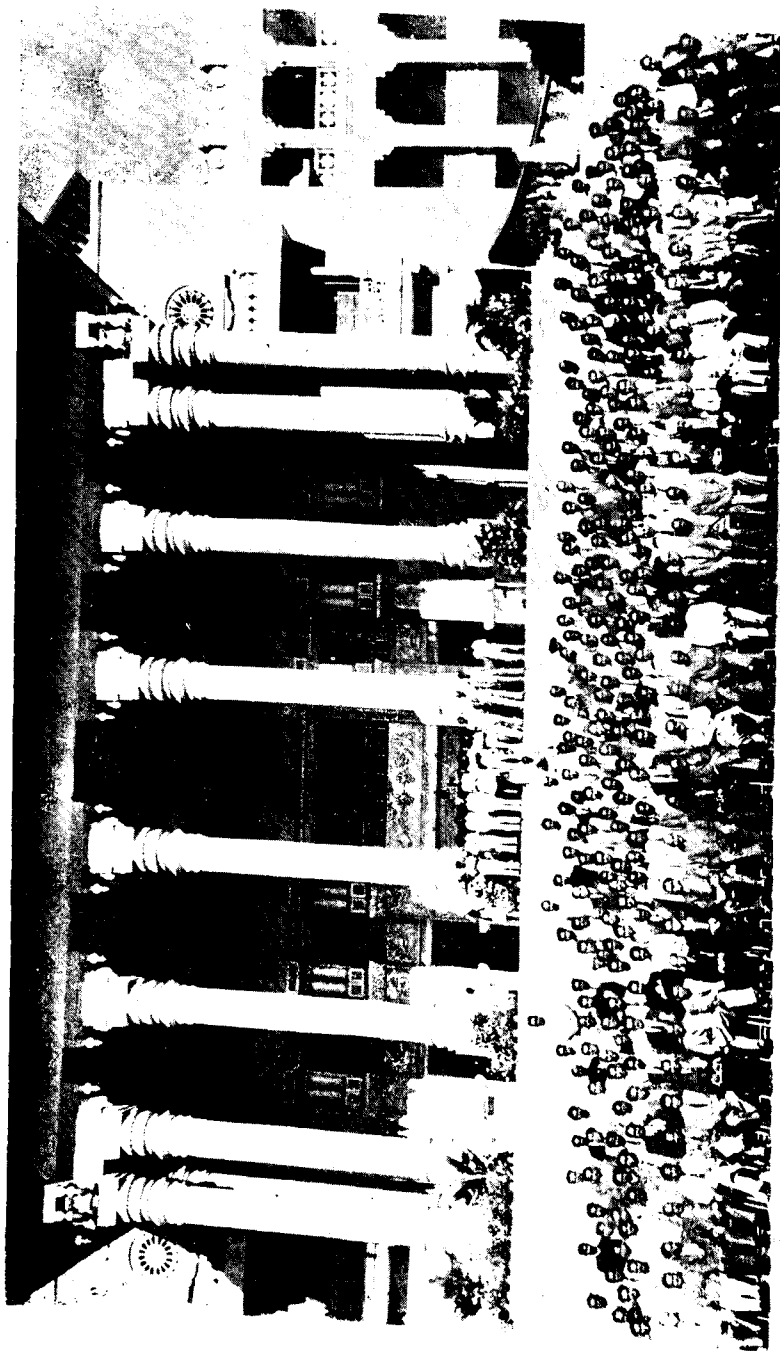
LIST OF MEMBERS OF THE COUNCIL FOR 1959-60

- | | |
|------------------------------------|-----------------------|
| 1. R. E. Aserappa,
Maj. General | 15. Kishorilal Mathur |
| 2. F. P. Antia, Dr. | 16. J. Mukand |
| 3. M. P. Apte | 17. S. R. Mehra |
| 4. K. Barua | 18. M. Meeran |
| 5. M. S. Bisht | 19. W. X. Mascarenhas |
| 6. T. S. Chathunny | 20. S. C. Nayak |
| 7. Y. K. Chougule | 21. K. K. Nambiar |
| 8. P. V. Divatia | 22. Jagdish Prasad |
| 9. N. G. Dewan | 23. R. C. Roy |
| 10. C. J. Fielder | 24. H. R. Sayoji Rao |
| 11. G. S. Ganapathy | 25. S. N. Sinha |
| 12. S. K. Ghosh | 26. P. D. Shivdasani |
| 13. K. K. Kartha | 27. H. L. Uppal, Dr. |
| 14. G. C. Khanna | 28. L. C. Verman, Dr. |
| | 29. P. L. Varma |
| | 30. P. N. Wanchoo |

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22-11-1951
11-11-1951

The Indian Roads Congress as a body does not hold itself responsible for statements made, or for opinions expressed, in the Papers, Research and Information Sections or discussions in its Proceedings, etc.





INDIAN ROADS CONGRESS, TWENTY-FOURTH SESSION, BANGALORE, JANUARY-FEBRUARY 1960.



SHRI UPENDRA J. BHATT, B. E., S. M. (Civil Eng., M. I. T.),
M. ASCE., M. I. E. (India), **President, I. R. C., 1959-60.**

Shri Bhatt was born in February 1909 and obtained his B.E. (Civil) degree from Bombay University in 1931, and S. M. (Civil Engineering) with Honours from the Massachusetts Institute of Technology, U. S. A. in 1933.

Having served as Assistant Borough Engineer for six months, in 1933, at New Fort, England, Shri Bhatt joined the Bhavnagar State P. W. D. as special Sanitary Engineer and was responsible for designing complete sewage purification and water treatment plant—first of its kind in Western India. Later he served as Chief State Engineer of Bhavnagar State from 1935 to 1948.

On the merger of Princely States, in April 1948, he was selected as Chief Engineer and Secretary to P. W. D. (Roads, Buildings, Irrigation and Public Health) to the Government of Saurashtra and worked there till November 1956. During this period he was responsible for completing the First 5-Year Plan targets for roads and irrigation for the State of Saurashtra.

On the reorganization of States in November 1956, Shri Bhatt came to Bombay where he is now working as Chief Engineer (Roads, Buildings, Ports and Harbours) and Joint Secretary to the Government of Bombay.

Shri Bhatt is one of the most widely travelled Presidents of the Society. After visiting England and U. S. A. in 1939, where he inspected various Irrigation and other projects like TVA and Boulder Dam, he toured Honolulu, Japan, Philippines, Malaya and Ceylon. In April 1954, he was the Leader of the Indian delegation to the Second International Congress of Irrigation and Drainage in Algiers. After this Congress, he visited important Engineering works in Sweden, Holland, West Germany and Italy. He also participated in the Symposium on Wind Power and Solar Energy organized by UNESCO.

Shri Bhatt is one of the oldest members of the Indian Roads Congress and has been serving on its Council and various Committees for a number of years. He is also a member of the Executive Council of the C.R.R.I. and the C.B.R.I. of the C.S. & I.R. besides being a member of the Institution of Engineers (India) and the American Society of Civil Engineers.

INDIAN ROADS CONGRESS
NOTICES AND ANNOUNCEMENTS
CONTRIBUTION OF PAPERS FOR THE
TWENTY-FIFTH SESSION OF THE
INDIAN ROADS CONGRESS

The next General Session of the Indian Roads Congress will be held at Bhopal from the 3rd to the 10th January, 1961. Members are requested to contribute Papers on any subject connected with Highway Engineering for discussion at the Session.

2. Procedure: Members willing to contribute Papers for discussion at the next Session are requested to intimate the fact to the Secretary, Indian Roads Congress, and to send a short synopsis of their proposed contributions as early as possible.

On receipt of acceptance of the subject matter of the Paper, the member concerned should send his contribution to the Secretary, Indian Roads Congress, complete in all respects and with original drawings, photographs, etc. as and when ready. At least **three** copies of the typescript matter should be sent, typed 'double space' on one side of good stout paper of foolscap size.

3. The complete Paper, if intended to be read at the next Session, should preferably be submitted as early as possible.

From past experience it is observed that most of the members send in their contributions at the last moment, when the Congress Office is busy on work connected with the Session. As it takes a long time to get Papers printed in the Journal and as it is desirable that members should have sufficient time to study the Papers well in advance of the date of the Session, members are particularly requested to **make an effort to send their contributions as early as possible.**

Members may please note that Papers received late in the year are likely to be carried over to the next year.

4. The younger engineers are particularly requested to contribute Papers which, if required, will be suitably edited before publication.

Serial No.	Roll No.	Name.	Address.
15	2641	R. R. Paul	Assistant Engineer, E. C. C. Sub Division I, Dhalukbari, P.O. Dhalukbari, Gauhati (Assam).
16	2642	B. K. Verma	Engineer Assistant, C/o. Shri R. K. Verma, Advocate, Anugari Narayan Path, Kadam Kuan, Patna-3 (Bihar).
17	2643	Balram Thakar	Sub Divisional Officer, P.W.D. (R & B), Project Sub Division, Gaya (Bihar).
18	2644	K. Srinivasulu	Assistant Engineer, (H), Investigation, Vijayawada-2 (A.P.)
19	2645	Md. Hasibuddin	Sub Divisional Officer, P.W. D., Rajgir , (Patna).
20	2646	S. S. Thakur	Assistant Engineer, P. W. D., (B & R), Khandwa Sub Division, Khandwa , (M.P.).
21	2647	S. Radhakrishnan	Assistant Engineer, Highways, Research (Soils), Highways Research Station, Madras-25 .
22	2648	K. K. Madan	Assistant Engineer, Basoli Sub Division, P. O. Basoli, Dist. Kathua , (J. & K. State).
23	2649	B. M. Das	Executive Engineer, Office of the Chief Engineer, (R & B), P.O. New Capital, Bhubaneswar , (Orissa).
24	2650	V. D. Kirpekar	Executive Engineer, Poona East Division, P.W.D., Poona .
25	2651	J. P. Agarwal	Assistant Engineer, C. P. W. D., Jairampur (N. E. F. A.).
26	2652	B. N. Tewary	Sub Divisional Officer, P. W. D., Koilwar, At & P. O. Koilwar, Dist. Shahabad (Bihar).
27	2653	J. P. Goel	Assistant Engineer, P. W. D., Uttarakashi (Tehri - Garhwal), (Uttar Pradesh).
28	2654	S. J. Phadke	Executive Engineer, P. W. D., B. & R., Panna (M. P.)
29	2655	M. S. Venkatesan	Senior Scientific Officer (Concrete), Central Road Research Institute, P. O. CRRI, Okhla, New Delhi-20 .
30	2656	S. Jayaram	Deputy Engineer, Visnagar Sub Division, Visnagar (North Gujarat).
31	2657	L. N. Maheshwari	Assistant Engineer, B. & R., P. W. D., Dist. Sub Division East, Jaipur (Rajasthan).

Serial No.	Roll No.	Name.	Address.
32	2658	C. Rama Das	Assistant Engineer (H), Cheyyar Bridge Works, Tiruvethipuram Post, N.A. District , (Madras State.)
33	2659	J. E. Pondurangam	Supervisor, 6569, Shivaji Nagar, Secunderabad , (A.P.)
34	2660	George John	Bitumen Engineer, Burmah-Shell, P.B. No. 50, Bangalore .
35	2661	Zafer Mohiuddin	Executive Engineer, P. W. D., Rangapur Bridge Division, P.O. Rangapur Bridge, Dist. Mahboobnagar , (A.P.)
36	2662	K. K. Hemanna-setty	Junior Engineer, Special W. C. S. Brahmavar, South Kanara (Mysore State).
37	2663	Y. K. Sharma	Bitumen Department, Burmah-Shell, Bombay .
38	2664	C. T. Nariani	Deputy Engineer, Plot No. 11, Sindhi Immigrants Co-operative Housing Society Ltd., Chembur, Bombay-71 .
39	2665	D. P. Pavri	Traffic Engineer Specialist, 77-A, Park Street, Calcutta-16 .
40	2666	K. N. Bheema Rao	Junior Engineer, Highways, 326, Vepamanu Street, Chittoor P. O. & District (A.P.).
41	2667	N. V. Joglekar	Deshpande Nagar, Hubli (S. Rly.)
42	2668	N. H. Shah	Deputy Engineer, Dakor Sub Division, Dakor, Dist. Kaira , (Bombay State).
43	2669	J. V. Badami	Senior Municipal Engineer, Municipal Board, Allahabad (U.P.)
44	2670	N. P. Shah	Executive Engineer, R. & B., P. W. D., Baroda Division, Baroda .
45	2671	D. Mohan	Assistant Engineer, Highways, No. 46, Alandur Road, Saidapet, Madras-15 .
46	2672	P. K. Thomas	Assistant Engineer (Consultant), Ministry of Transport & Communications, Deptt. of Transport, Roads Wing, New Delhi-2 .
47	2673	Ninan Koshi	Assistant Engineer (Consultant), Ministry of Transport & Communications, Deptt. of Transport, Roads Wing, New Delhi-2 .

Serial No.	Roll No.	Name.	Address.
48	2674	D. P. Gupta	Assistant Engineer (Consultant), Ministry of Transport & Communications, Deptt. of Transport, Roads Wing, New Delhi-2 .
49	2675	Ram Bhai Khushal Bhai Patel	Engineer & Contractor, Kharivav Road, Baroda .
50	2676	Md. Hasnain	Executive Engineer, P.W.D., P.O. Hazaribagh (Bihar).
51	2677	Onkar Prasad	Executive Engineer & Personal Assistant (Technical) to Chief Engineer, U.P., P.W.D., 40-Cantt. Road, Lucknow (U.P.).
52	2678	R. K. Pandita	Divisional Engineer, P.W.D., Poonch, Poonch R & B Division, P.O. Poonch (J. & K. State).
53	2679	K. S. Srinivasan	Executive Engineer, P.W.D., Raipur Division, B & R., Raipur (M.P.)
54	2680	N. M. Shah	Deputy Engineer, P.W.D., Narsingh's Pole, Kapasia Khadki, Baroda .
55	2681	S. Venkatraman	Roads Engineer, Standard Vacuum Oil Co., P.O. Box No. 181, Bombay-1 .
56	2682	U. C. Sanghvi	Assistant Engineer, Madhya Pradesh P.W.D., (B & R Branch), 14, Sanyogita Ganj, Indore (M.P.)
57	2683	S. S. Panda	Executive Engineer, Sambalpur Division, P.W.D., P.O./At Sambalpur , (Orissa).
58	2684	M. Prakasa Rao	Special Assistant Engineer, Highways, 12/229, Gandhi Road, Madanapalle, Chittoor District (A.P.)
59	2685	Onkar Singh	Joseph Allen Strin & Associates, A-15/3, Asaf Ali Road, New Delhi .
60	2686	V. L. Tank	Deputy Engineer, District Local Board, Surat .
61	2687	B.B. Kumar	Assistant Engineer, P.W.D., 189, Jhaparnagar, Meerut (U.P.)
62	2688	K. Rudraiah	Assistant Engineer, District Development Council (D.L.B), Hubli (Mysore State).
63	2689	T. S. Narayana Rao	Consulting Architect & Engineer, No. 9, Mahatma Gandhi Road, Bangalore-1 (Mysore State)

Serial No.	Roll No.	Name.	Address.
64	2690	G. K. Rajan	Executive Engineer, P.W.D., Chikmagalur (Mysore State)
65	2691	Rajendra Prakash	Assistant Engineer, Temporary Division, Lucknow (U.P.)
66	2692	Jaladhar Behera	Assistant Engineer, Bridges Sub-Division, P.W.D., P.O. Pamposh, Dist. Sundergarh , (Orissa).
67	2693	V. K. Chitale	Executive Engineer, Municipal Corporation, 14, Moghebhwan, Gokhale Road N., Dadar, Bombay-28 .
68	2694	N. V. Srinivasiah	Executive Engineer, P.W.D., (B & R), Hoshangabad (M.P.)
69	2695	Nuruddin S. D. Khambati	Executive Engineer, Designs Division, No. 3, Old Secretariat Building, Fort, Bombay-1 .
70	2696	S. A. Sharma	Superintending Engineer, Rewa Circle, Rewa (M.P.)
71	2697	M. A. Abraham	Executive Engineer, Madras Central Division (South), Central P.W.D., Madras-10 .
72	2698	K. Sripathy	Assistant Engineer, Corporation of Madras, 5/1, Kellys Road, Kilpauk, Madras-10 .
73	2699	K. Sarkar	Assistant Engineer (W & B), Govt. of West Bengal, 5/29, Dum Dum Road, Calcutta-30 .
74	2700	Phalgunni Banerji	Assistant Engineer (W & B Deptt.), Govt. of West Bengal, 58, Maharaj Tagore Road, Calcutta-31 .
75	2701	D. K. Gupta	Executive Engineer, P.W.D., B & R., Planning Division, Jaipur (Rajasthan).
76	2702	H. C. Sanghvi	Assistant Engineer, P.W.D., Office of the Superintending Engineer, Betul , (M.P.)
77	2703	S. B. Chakrabarty	Assistant Engineer, Suri Construction Sub-Division, Suri, Birbhum (W. Bengal).
78	2704	M. K. Chatterjee	Executive Engineer, P-5, C.I.T. Road, (6th Floor), Calcutta-14 .
79	2705	Hari Har Chatterjee	Assistant Engineer (Roads), P.O. Arambagh, Dist. Hooghly , (W. Bengal).

Serial No.	Roll No.	Name.	Address.
80	2706	M. L. Jain	Assistant Engineer, Punjab, P.W.D., Patiala .
81	2707	O. S. Srivastava	Assistant Engineer, P.W.D., U.P., Nainital .
82	2708	M. D. Kulkarni	Deputy Engineer, Express Highways Sub Division, Chambur, Bombay-7 .
83	2709	J. D. Kale	Deputy Engineer, P.W.D., Sachivalaya, Bombay .
84	2710	A. S. Bhatnagar	Assistant Engineer, U.P., P.W.D., Allahabad .
85	2711	N. K. Rath	Executive Engineer, Ganjam, R & B Division, Berhampur , (Orissa).
86	2712	B. S. Kalsy	Assistant Engineer, Roads Sub Division, Chandigarh , (Punjab).
87	2713	Khairu Ram	Executive Engineer, Delhi State, Division No. 1, 6/7, Radha Kishan Bhawan, 6, Ansari Road, Darya Gunj, Delhi .
88	2714	R. L. Sreshta	Executive Engineer, P.W.D., Marcara , (Mysore State).
89	2715	K. A. Desai	Junior Engineer, C/o Executive Engineer, Dharwar Division, Dharwar , (Mysore State).
90	2716	T. N. Subba Rao	Engineer, M/s. Gammon India Private Ltd., Bombay .
91	2717	S. K. Basu	Assistant Engineer, Road (Dev.) Department, P.O. Plassey, Dist. Nadia , (West Bengal).
92	2718	R. L. Subburaya Setty	Assistant Engineer, Challakere, Chitaldurg District , (Mysore State).
93	2719	B. V. Patankar	Consulting Engineer, 407-6th Main Road, Malleswaram, Bangalore-3 .
94	2720	N. J. B. Kotagama	Executive Engineer, P.W.D., Howelwela Walanwa, Bivile (Ceylon).
95	2721	A. A. D. O. P. Saparamado	Research Institute, P.W.D., Ratmalana (Ceylon).
96	2722	M. A. Moqeen	Superintending Engineer, Investigation Circle, Hydro Electric Projects Bangalore (Mysore State).
97	2723	N. Y. Patil	Executive Engineer, P.W.D., Kolhapur Division, Kolhapur , (Bombay State).

Serial No.	Roll No.	Name.	Address.
98	2724	Mahmood Alam	Sub Divisional Officer, P.W.D., Milki Mohalla, Arrah (Shahabad), (Bihar).
99	2725	A. Krishnaswamy	Executive Engineer, Special West Coast Division, Mangalore (Mysore State).
100	2726	P. Raghunatha Rao	Personal Assistant to the Executive Engineer, Tumkur Division, Tumkur , (Mysore State).
101	2727	B. N. Das	Executive Engineer, P.W.D., P.O. Phulbani , (Orissa).
102	2728	N. V. V. Kamat	P. A. to Superintending Engineer, Rural Engineering Cell, Development Commissioner's Office, Secretariat, Patna , (Bihar).
103	2729	T. N. Suryakantha Raj	Assistant Engineer, 383, 9th Cross, Malleswaram, Bangalore .
104	2730	S. Rangaiah	Junior Engineer, C/o. T. Siddappa, Editor, Tainad, Daily, Bangalore Tata Institute Post, Bangalore-12 .
105	2731	S. V. Rama Raju	Assistant Engineer, No. 4, Sub Division P.W.D., Chennagiri, Shimoga District , (Mysore State).
106	2732	Padmalochan Dandapat	Assistant Engineer, Mahanadi Bridge, Cuttack , (Orissa).
107	2733	B. Narayana Rao	Junior Engineer, No. 2, Sub Division, Kadur (Mysore State).
108	2734	K. Hema Singh	Junior Engineer, No. 4, Sub Division, Yelandur , (Mysore State).
109	2735	Mushtaq Ahmed	Junior Engineer, P.W.D., Special Bridge Sub Division, Kampi P.O., Bellary District , (Mysore State).
110	2736	J. Durai Raj	Superintending Engineer, NEFA, Shillong .
111	2737	Karam Chand	Sub Divisional Officer, P.W.D., (B & R), Spiti at Kulu , (Punjab).
112	2738	M. R. Sethumadhava Rao	Assistant Engineer, No. 5, K. R. Pet Sub Division, K. R. Pet (Mysore State).
113	2739	Sheik Mohamood	Junior Engineer, Mysore Engineering Research Station, Krishnaraj Sagar , (Mysore).
114	2740	P. C. Chouhan	Assistant Engineer, P.W.D., Burham-pur (M.P.)

Serial No.	Roll No.	Name.	Address.
115	2741	H. G. Abdul Hameed	Executive Engineer, Mandya Division, Mandya, (Mysore State).
116	2742	S. L. Khandapnavar	Executive Engineer, Bidar, (Mysore State).
117	2743	R. P. Sinha	P.A. (Technical) to Chief Engineer, P.W.D., (B & R), Bihar, Patna.
118	2744	C. Gopala Rao	Assistant Engineer, Buildings Division, Bangalore, (Mysore State).
119	2745	H. K. Pandita Radhya	Executive Engineer, Buildings Division, Bangalore, (Mysore State).
120	2746	K. Ramachandriah	Executive Engineer, Special Building Division, Bangalore, (Mysore State).
121	2747	N. C. Jayaraman	Executive Engineer, C.P.W.D., II-0143, Lajpatnagar, New Delhi-14.
122	2748	I. M. Magdum	Superintending Engineer, Raichur Circle, Raichur, (Mysore State).
123	2749	Kongovi Srinath	Assistant Engineer, Sindanur, Raichur District, (Mysore State).
124	2750	S. V. Narayana Raju	Junior Engineer, P.W.D., No. 152, 4th Main Road, Chamaraupet, Bangalore-18.
125	2751	Bhaskor T. Patel	C/o. Patel & Shah, Engineers, Opp: Bharati-Society, Ahmedabad-6 (W. Rly.)
126	2752	Kulbir Singh	Superintending Engineer, P.W.D., B & R Punjab, Jullundur Captt.
127	2753	B. P. Surendra	Executive Engineer, 32, Purnaiah's Chattrane Road, Bangalore City, (Mysore State),
128	2754	B. B. Sinha	Assistant Engineer, P.W.D., Soil Research Sub Division, Patna-Gaya Road, Patna (Bihar).
129	2755	B. V. Rama Sastry	Assistant Engineer, No. 2, Sub Division, Bangalore Division, Bangalore, (Mysore State).
130	2756	P. S. Kothavale	Municipal Engineer, Sholapur Municipality, Sholapur, (Bombay State).
131	2757	T. V. K. Chari	Engineer & Contractor, 39, Police Station Road, Basavangudi, Bangalore-4.
132	2758	Gopala Krishnan	Technical Assistant to the Chief Engineer, P.W.D. (B & R), Trivandrum.

Serial No.	Roll No.	Name.	Address.
133	2759	S. S. Ghose	District Engineer, P.O. Suri, District Birbhum, (W. Bengal).
134	2760	I. Gokulechandra Singh	Executive Engineer, Highways North Division, P.W.D., Manipur, Imphal.
135	2761	R. Venkataraman	Lecturer, Engineering College, 2/233, Glenview, Kuravarkonam, Trivandrum-1.
136	2762	M. S. Murthy	Assistant Engineer, District Development Board, Gadag, Dharwar District (Mysore State).
137	2763	J. Subramaniam	Assistant Engineer, (Highways), Sivaganga, Ramnad District, (Madras State).
138	2764	J. Ramalingam	Assistant Engineer, Highways, Tiruchirapalli (Madras State).
139	2765	M. M. Wani	Assistant Engineer, Bandipur Sub Division, Bandipur (Kashmir).
140	2766	S. D. Bokil	Deptt. of Civil Engineering (Highways), University of Roorkee, Roorkee.
141	2767	Y. V. Tokekar	Executive Engineer, Nira Right Bank Canal Division, Phalton, Dist. N. Satara.
142	2768	J. L. Kaul	Assistant Engineer, P. W. D., Karan Nagar, Srinagar (Kashmir).
143	2769	Baldev Singh Dhimani	Assistant Engineer, P. W. D., Office of the Chief Engineer, Capital Project, Chandigarh-1.
144	2770	S. R. Tamrakar	Assistant Engineer, P. W. D., Raipur Circle, Raipur (M. P.).
145	2771	R. Thillainayagam	Junior Engineer (Highways), Research Station, Guindy, Madras-25.
146	2772	G. R. Joshi	Assistant Engineer, Road Map Sub Division No. 2, P. W. D., B & R., Jaipur (Rajasthan).
147	2773	S. M. Basu	Executive Engineer, P.W.D., Kohima, N. H. T. A.
148	2774	S. Balakrishnan	Assistant Engineer (Highways), Housing Scheme, Ramnad at Madurai-2.
149	2775	H. S. Thyaranna	Assistant Engineer, D.D.C. Haveri, Dist. Dharwar, (Mysore State).

Serial No.	Roll No.	Name.	Address.
150	2776	A. P. Ranga Rao	Junior Engineer, Technical Section, Office of the Chief Engineer (Highways), Hyderabad-16 (A.P.).
151	2777	N. Nagappa	Assistant Engineer, No. 35 "Swamy Nilaya", Cumara Park East Extension, Bangalore-1 .
152	2778	M. Korah	Assistant Engineer, (R & B), P. W. D., Bolangir P.O., Dist. Bolangir (Orissa).
153	2779	H. C. Bhargava	Assistant Engineer, P. W. D., (B & R), Karauli (Rajasthan).
154	2780	C. Chidambaram	Assistant Engineer (H), Special West Coast Sub Division No. 1, Mangalore S.K. (Mysore State).
155	2781	K. G. Sivaswamy	Assistant Engineer, P. W. D., Chikballapur (Mysore State).
156	2782	K. V. Kirpekar	Deputy Engineer, 1806 - Kirpekar Sadan, Deshmukhwadi, Sada Shiv Peth, Poona-2 .
157	2783	P. D. Dutta	Executive Engineer, P. W. D., (R & B), North Lakhimpur Division, P. O. North Lakhimpur (Assam).
158	2784	J. K. Tiwary	Assistant Engineer, P. W. D., B & R, Nowgong Circle, Nowgong (M. P.).
159	2785	Ram Mohan	Assistant Engineer, Road Maps, Rajasthan, P.W.D. (B & R), Jaipur .
160	2786	B. L. Narayan	Junior Engineer, P. W. D., 869, Skip's Compound, 17th Cross Road, Malleswaram, Bangalore-3 .
161	2787	B. Sarangi	Assistant Engineer, University Sub Division, Capital Construction Division, P. O. New Capital, Bhubaneswar, District Puri (Orissa).
162	2788	S. K. Kumbhar	Junior Engineer, C/o. Executive Engineer, Bijapur Division, Bijapur , (Mysore State).
163	2789	A. K. Majumdar	Sub Divisional Officer, (W & B), Dhananagar Sub Division, P. O. Dharmanagar (Tripura State).
164	2790	B. M. Schoo	Assistant Engineer, (Investigation), Revenue Divisional Commissioner's Office, Northern Division, Orissa, Sambalpur .

Serial No.	Roll No.	Name.	Address.
165	2791	Narain Prakash	Assistant Engineer, P. W. D., B & R, Sub Division, Dungarpur (Rajasthan).
166	2792	S. P. Sharma	Sub Divisional Officer, Chandigarh Provincial Sub Division, Chandigarh .
167	2793	P. V. Parmar	Assistant Engineer, P.W.D., B & R, Branch, 421, New Palasia, Indore (M.P.).
168	2794	K. C. Mehrotra	Sub Divisional Officer, P. W. D., Bistupur, Jamshedpur .
169	2795	K. Venkata Raman	Assistant Engineer, Highways, Special Sub Division, Theni, Madurai District (Madras State).
170	2796	U. S. Aswal	District Engineer, P. W. D., Narendra Nagar , (Tehri-Garhwal).
171	2797	T. K. Kalo	Deputy Engineer, Construction Sub Division, Poona-1 .
172	2798	H. K. Nagpaul	Assistant Engineer, Punjab P. W. D., B & R, Branch, Dharubara, Dist. Gurgaon .

ASSOCIATE MEMBERS

1	82	C. K. Sethi	Manager, Construction Equipment Department, M/s. William Jacks & Co. Ltd., Hamilton House, Ballard Estate, Bombay-1 .
2	83	M/s. Millars' Timber & Trading Co. Ltd.	Victoria House, Victoria Road, Bombay-27 .
3	84	M/s. Norinceo (Private) Limited.	14, Netaji Subhas Road, Post Box 2211, Calcutta-1 .
4	85	Dwarika Choudhory	District Engineer, Santhal Parganas, District Board, Dumka (Bihar).
5	86	C. J. Tylee	C/o. United Provinces Commercial Corporation, 6-Ganesh Chandra Avenue, Calcutta-13 .
6	87	M/s. Martin Burn Ltd.	12, Mission Row, Post Box No. 23, Calcutta-1 .

III. DEATHS

The Council have received with regret intimations of the death of the following members.

Serial No.	Roll No.	Name.	Address.
1	516	P. N. Sharma	District Engineer, Chaibasa, District Singhbhum, (Bihar).
2	1780	J. S. Pimple	Engineer, District Local Board, Sholapur.
3	1783	R. N. Saxena	Consulting Engineer, P. O. Mahendru, Patna, (Bihar).
4	1560	K. V. Siddabasaiah	Executive Engineer, Shimoga Division, P. W. D., Shimoga, (Mysore State).
5	488	D. B. Nagarkar	Regional Engineer, The Concrete Association of India, Mutual Building, P.O. Box 56, Calcutta-1.
6	1146	M. D. Menon	Deputy Bridges Officer, Ministry of Transport and Communications, Department of Transport (Roads Wing), Jamnagar House, New Delhi.
7	1059	(L.M.) P. S. Sharangpani	Chief Engineer (Retired), M. P., 30, Koregaon Park, Poona-1.
8	258	(L.M.) H. F. Bamji	Chaman Chambers, 3rd Floor, Room No. 2, 1st Marine Street, Near Metro Cinema, Dhobi Talao, Bombay-1.

IV. ADDRESSES WANTED

Communications addressed to the following Members have been returned unclaimed by the Post Office. Members able to give information regarding the present address of any of them are requested to forward particulars to Secretary, Indian Roads Congress.

Serial No.	Roll No.	Name.	Address.
1	2113	Adhiraj, T.	Assistant Instructor, Engineering College, Guindy, Madras-25.
2	1260	Banerjee, S. C.	Assistant Engineer, Jaipur Sub Division, Devi Bhavan, Jacob Road, Jaipur.
3	323	Chambers, J. (Lt.-Col.)	'Artistry House', 15, Park Street, Calcutta-16.
4	2252	Das, S. S.	Junior Engineer, Assam P.W.D., C/o. Shri S. K. Das, Professor, Para Malki, Shillong. (Assam).
5	1477	Dalal, M. N.	Principal & President, Indian Roads & Transport Development Association, 3-Cuffe Parade, Bombay.
6	1625	Gonsalves, G. F. D.	1650, East First South, Salt Lake City, Utah, (U.S.A.).
7	652	Guruswamy, S.	No. 8, Appaswami Koil Street, P.O. Mylapore, Madras.
8	148	Mahabir Prasad	Chief Engineer, P.W.D. (Retired), 10, C. Y. Chintamani Road, George Town, Allahabad. (U.P.)
9	673	Mohd. Shareali	Divisional Engineer (Highways), Retired, 25, Motilal Street, Tiruvellore, Chingleput District.
10	417	Parang, Hari Ram	Retired Executive Engineer, Lal Chowk, Qila Gujar Singh, Lahore, (Pakistan).
11	589	Rao, B. M.	Resident Engineer, Messrs. Thadani & Co. Ltd., 6A/DBZ (South) Gandhidham. (Kutch).
12	194	Sankaran, G. B.	Door No. 8-12-6, Police Club Road, Gandhinagar, Kakinada, East Godvari District. (A.P.).
13	2126	Sikander Lal Malik	Executive Engineer, (Retired), Sector 18, Qr. No. C 2/9B, Rourkela-3. (Orissa).
14	12	Sowani, D. G.	Bhide Wade Shevde Bol, 851 A, Sadashiv, Poona-2.
15	1795	Subbayya, K. B.	2108, College Apartment, Utah State Agricultural College, Logan, Utah. (U.S.A.)

V. REMOVALS FROM ROLLS OF THE SOCIETY

List of Members of the Indian Roads Congress whose names have been struck off from the rolls in default of payment of arrears of subscription.

<i>Serial No.</i>	<i>Roll No.</i>	<i>Name of Member.</i>
1	1161	Shri P. De Sousa
2	1497	„ D. V. Deshpande

PROCEEDINGS OF THE TWENTY-FOURTH SESSION OF THE INDIAN ROADS CONGRESS

Vol. XXIV-Part 5 BANGALORE

January-February 1960

PRESIDENTIAL ADDRESS

The Twenty-Fourth Session of the Indian Roads Congress was held at Bangalore from the 28th January to the 4th February, 1960 and was formally opened by Shri Raj Bahadur, Minister of State for Transport and Communications, Government of India, on Friday the 29th January 1960 in the Town Hall, Bangalore. The proceedings opened with an Address by Shri U. J. Bhatt, the President, the full text of which is given below :

SHRI RAJ BAHADUR, LADIES AND GENTLEMEN,

As President of the Indian Roads Congress, it is my pleasant privilege to extend a very warm and cordial welcome to you all this morning on the momentous occasion of the Silver Jubilee Session of our Organization. We are deeply grateful to you, Sir, for the honour you have done us by agreeing to inaugurate this Session, and to you, ladies and gentlemen, for gracing the occasion by your presence.

We are deeply indebted to the State of Mysore for inviting us to hold this Session in this progressive city of Bangalore which is also a beautiful health resort with a bracing climate. Mysore has been one of the most progressive States of India with a tradition of benevolent rulers served by able and liberal administrators. It has also the distinction of achieving a balance between industry and agriculture, science and art, education and culture. To us engineers, it is a place of pilgrimage where the first River Valley Scheme was conceived and implemented—I refer to the Krishnaraja Sagar and basin-wise development of the storage and canal system of River Cauveri—visualised and fulfilled by that pre-eminent Indian Engineer-Industrialist-Statesman, Sir M. Visvesvarayya.

This is not the first time we are meeting in this beautiful city. The Indian Roads Congress in the formative period of its life held

its 2nd Session in Bangalore, in 1936, and it is in the fitness of things that we are holding our Silver Jubilee Session in this very city.

I am voicing the sentiments of all gathered here when I express my sincere thanks to the Chief Engineer, Mysore, and his loyal and efficient staff for making such excellent arrangements for our stay and deliberations here.

INDIAN ROADS CONGRESS

As an organization we have just crossed a landmark now having completed 25 years of life. It would not be out of place if I review how the Congress was founded and with what objects and the useful work it has done in the fulfilment of these objects. In 1927, the Government of India appointed the Jayakar Committee to report on the question of road development in the country. The Committee also looked into the urgent and insistent demand for creating a forum for bringing together road engineers in the country, so that they could discuss the science and practice of road construction and maintenance. It was in pursuance of the recommendation of this Committee, that the Indian Roads Congress came into existence in 1934, under the inspiration of Sir Kenneth Mitchell, when the Central Road Fund was placed on a permanent footing. Prior to this, it was not possible for road engineers in India to get together and discuss questions relating to the administration, planning, design, construction, operation, use and maintenance of roads. Very little of experimental or research work was undertaken, and that little was seldom correlated in an effective way; the Central and the State Governments had no organized means of obtaining the collective opinion of road engineers in the country; and no standards for road and bridge designs existed for uniform application throughout the country. The Indian Roads Congress was set up to make good these shortcomings.

Starting with a modest membership of 73, the Congress has today on its roll no less than 2,000 members representing highway engineers of all ranks from Central and State Governments, Military Engineering Services and business concerns associated with road building. During the twenty-five years of our life, we have had 23 General Sessions during which we have discussed 212 technical Papers of a high order of merit. We have held 54 Council meetings and numerous meetings of subcommittees, which are striving to evolve standard specifications for bridge and road building, among which the "Standard Specifications and Code of Practice for Road Bridges" deserves special mention as a valuable addition to Engineering Handbooks.

The Indian Roads Congress has also devoted attention to matters pertaining to the training of engineers in road construction and techniques. On the advice of the Congress, the Government of India sent delegations of serving Road Engineers to the U.K. in 1946 and the U.S.A. in 1947 and 1949. At the suggestion of the Indian Roads Congress, the Government of India had invited to India, in 1946, two famous American Engineers, Major-General P. B. Fleming, Head of the Public Works Administration in the U.S.A., and the late Thomas H. MacDonald, Commissioner, U.S. Bureau of Public Roads to advise on road problems. Needless to say, we have benefited greatly by the training of our highway engineers in other more advanced countries.

It was also as a result of a recommendation of the Indian Roads Congress that a Central Road Research Institute was set up in 1952. The Institute has now grown into a full fledged National Laboratory with excellent facilities for research work on all problems connected with road design and construction.

We have built up a very efficient and up-to-date lending library service. The Journal of the Indian Roads Congress reaches the far corners of the world and, besides being highly esteemed among highway engineers, has proved an excellent guide to young engineers in the course of their professional work. It was gratifying to note that many eminent engineers at the XIth International Road Congress in Rio de Janeiro in September, 1959, whom I met, expressed their appreciation and paid compliments to our Journal.

During the past several years, it has been our practice to hold a technical exhibition on a modest scale at each General Session. This has contributed in no small measure to the dissemination of knowledge of the latest practices and methods of road building not only among engineers but also the general public who as tax-payers have to be educated in the developmental activities in the country.

ROAD DEVELOPMENT

A rapid glance at our history will show how roads have developed both in the past and in recent years. The importance of highways was recognized in India as early as 4th century B. C., when Emperor Asoka built up a good network of roads to give strength, unity, and prosperity to his realm. Thereafter, over the centuries that rolled past, road development was slow, depending chiefly on the spurts of energy of some rulers, who, in between their preoccupation with wars, realised that roads were essential for promoting agriculture, stimulating trade, facilitating pilgrimage, warding off famines, increasing prosperity and retaining control over the country.

The invention of the steam engine marked the beginning of an industrial era and the advent of Railways. Vested interests gave impetus to the construction of the railways sometimes at the expense of road transport to such an extent that transport became synonymous with Rail Transport! This outlook persisted for almost a century during which roads were neglected with consequent poverty and stagnation of the country-side. In 1928, the Jayakar Committee made far reaching recommendations for road development. Though these were accepted by Government, the predominant voice of the railway administration persisted, and continues to persist to-day, and this retarded the development of a good road communication system for a long time. It is gratifying to note that the Government have now come to realise that one system of communication should not be developed at the cost of the other and there is greater need to devote attention to road communication whose development is vitally linked with the progress of the interior of the country. Without transport facilities, how can the large agricultural and industrial expansion envisaged in our plans be possible? How will the social service facilities for health and education, reach the remote parts of the country? These are the many problems which face us to-day. I would, therefore, earnestly appeal that the problem of communications in India over its entire field should be tackled from the stand point of planned economic development of our country. If that is done, I am sure, road and road transport development will receive foremost consideration and be accorded its rightful place as a powerful and effective means of improving the standard of living of the common man. To implement this at Government level, may I once again emphasize and reiterate the suggestion put forth by many of my predecessors for the formation of a Road Board at the Centre. Only a high power body like that can efficiently implement and co-ordinate the activities of road and road transport development in its various phases and diverse functions.

I shall now briefly review the progress of road development since the formulation of the Nagpur Plan in 1943. This plan delineated a policy for the development of roads in India in the post-war period and provided for increasing the length of hard surface roads from 83,000 miles to approximately 1,23,000 miles and of earthen roads from 1,32,000 miles to 2,08,000 miles in the Indian Union. However, the activity which was seen during the war period slackened off immediately the war was over and not much progress was made before Independence until we embarked on the First Five-Year Plan.

At the commencement of the First Five-Year Plan, the country had 97,000 miles of hard surfaced roads and 1,47,000 miles of unsurfaced roads. At the end of the First Plan period, the total

milage of roads stood at 1,21,617 miles of pucca (surfaced) and 1,95,051 miles of kutchra (unsurfaced) roads. In the First Five-Year Plan, the provision for road development amounted to Rs 155 crores. The Second Five-Year Plan provides Rs 224 crores and the targets include 61,200 miles of new roads, of which about 18,000 miles are to be hard surfaced. This will result in increasing the total road milage to 3.79 lakhs in 1960-61. Out of the category of bridges, each costing more than Rs 5 lakhs, 30 have been completed in the 1st Five-Year Plan, 24 in the 2nd Five-Year Plan and work on 46 is in hand. In addition, a very considerable number of bridges costing less than Rs 5 lakhs each have been completed and are under construction.

Thus, though road development has had a chequered career in its implementation during the last eight years, and though the programme may not be as large as it should have been in view of the prevailing needs in the matter of adequate road communication in this vast country, we have cause to be satisfied that our efforts are beginning to bear fruit in as much as rapid strides have been taken in this direction with the commencement of the Five-Year Plans, though a long way yet remains to be covered.

It is a matter for gratification that side by side with our coming of age, we have taken a big step forward by formulating the Second 20-Year (1961-81) Road Plan for India. This Plan, as worked out by the Chief Engineers and endorsed by the Council of the Indian Roads Congress, is before the Government for consideration and adoption. It should be our endeavour to create better atmosphere in its favour both among the engineers and administrators and also among the people and their representatives in the Parliament.

I am convinced that this is a modest plan compared to our needs visualised over the next 20 years. It is also modest in expenditure considering the development planned in other sectors. But it is vital and even imperative to implement this plan to carry the burden of transport of both goods and passengers which will come to the roads in the next 20 years. I would, therefore, commend its adoption with your unanimous support and the support of the people and request the Government for early announcement of its acceptance. The new plan has been with you during the last year and, I am sure, you must have studied it being vitally interested in the development of road transport system of the country. While resisting the temptation of enumerating the features of this plan at length, I cannot help focussing attention on some vital aspects.

With the attainment of Independence, the country has embarked upon a programme of industrialization and increase in

production on an unprecedented scale. An increase in production will naturally mean increased transport because the various raw materials have to be carried from their sources to the places of manufacture and the finished goods have to be taken to the consumer. It has been estimated that between 1950 and 1980 agricultural produce will jump up from 68 million tons to 150 million tons, whereas the produce of industry will increase from 7.2 million tons to 236 million tons. In order to feed the industries, the production of minerals like coal, iron ore, etc., is expected to go up from 43 million tons to 519 million tons. All in all, long distance traffic taken at 70 to 80 per cent of the total production is expected to increase from 93 million tons in 1950 to 800 million tons in 1980.

It is quite obvious that a very large proportion of this increased long distance traffic will have to be handled by road transport. By their very nature, Railways cannot be developed and expanded to keep pace with all aspects of the development in traffic in the country. Road transport will, therefore, have to take its due share and it is necessary for us to foresee the requirements and to make adequate arrangements in time. For this purpose, development must proceed both in regard to roads as well as road transport vehicles.

The road system will have to comprise minor roads from villages and sources of raw materials merging together to form District Roads and State Roads. These will ultimately go to make National Highways and Expressways forming the arterial routes. In the network of roads all types of roads are important and have their own part to play. The programme of road development, therefore, must be well balanced and the Plan takes good care of this aspect. This is evident from the importance given to the various types of roads in the Plan.

National Highways will increase from 13,800 miles to 32,000 miles at a cost of Rs 980 crores;

State Highways from 35,000 to 70,000 miles at a cost of Rs 1,580 crores;

Major District Roads from 95,200 to 1,50,000 miles at a cost of Rs 1,360 crores;

Other District Roads from 78,300 to 1,80,000 miles at a cost of Rs 650 crores; and

Village Roads from 1,56,700 to 2,25,000 miles at a cost of Rs 630 crores.

The total cost of the improvement and new construction of all types of roads in the twenty year period is estimated to be Rs 5,200

crores and the total increase in mileage will be from 3,79,000 miles to 6,57,000 miles.

The target proposed in the Plan is not too ambitious. Even when it is fully implemented, many villages of the country will still be 4 miles from a metalled road and $1\frac{1}{2}$ miles from any road and it will take a considerably bigger effort to bring all villages in the country on to a road.

As regards the ways and means position, I wish to emphasize that in the present-day economy, roads are self-supporting. Before the advent of the motor vehicle, the road user paid nothing directly towards the cost of making or maintaining roads. But the position now is that the vehicles in India are the most heavily taxed in the world. The total revenue from road transport in 1956-57, both in the Centre and State sectors, was Rs 71 crores, while the total expenditure on roads was Rs 75 crores. In 1960-61, the corresponding figures are expected to be Rs 120 crores for income and Rs 90 crores for expenditure. Even with the increased tempo of construction and maintenance recommended in the report of the Chief Engineers, the total expenditure over a period of 20 years is expected to be Rs 6,550 crores for construction and maintenance, while the estimated revenue from road transport is expected to be Rs 6,150 crores. The comparatively small gap of Rs 400 crores can very easily be bridged by levying some minor taxes, like betterment tax on roadside property, road cess on land revenue, etc.

As mentioned by me a short while ago, the production of vehicles must keep step with the development of traffic arising out of the development of industrial production. It must have been noticed by you that the production of motor vehicles received a very unfortunate setback during the current plan, with the result that the number of vehicles produced will be hardly 50 per cent of the target set for the plan. Steps must, therefore, be taken immediately to accelerate the manufacture of motor vehicles for carrying both passengers and goods.

It should be realised that the provision of a wide network of roads reaching all corners of the country is inescapable for the social, cultural, and economic development of the country. The roads can be self-paying only if they are adequately used by vehicles. The transport needs of the country cannot be fulfilled unless road transport is utilised to the maximum possible extent. All these facts clearly indicate the desirability of simultaneous expansion both of roads and road transport vehicles.

The objectives of the Twenty-Year Plan recommended by the Chief Engineers can be achieved only if a beginning is made in right earnest immediately and adequate funds are made available in the

Third and subsequent Five-Year Plans. In the interest of orderly planning and the most economical use of manpower and materials, the funds must be assured in advance. Without such an assurance, continuity in the development work cannot be ensured and the highway engineers would not be able to deliver the goods. I may also add here that so far as the dividends from investment are concerned they are realised more quickly from road transport than from any other mode of transport. Further, we should also bear in mind that the benefits of expenditure on roads are spread over large areas of the country, and extend to a large number of people. Such works afford the best opportunity for the utilization of voluntary contribution. These are weighty considerations in the context of the socialistic pattern of society which is our cherished goal.

IMPLEMENTATION OF THE PLAN

One word to my colleagues in the Centre and the States. We should take it as a religious duty to implement our share of the Plan without any delay. There was a time when there were not enough funds for road development and we were clamouring for more funds. To cope with the increased tempo of work as a result of greater allocation of funds, we must not hesitate now to streamline our organization and completely cut delays at all levels. Efficiency is judged by quality of construction as well as speed. We must be ready for suitable alterations in our procedure of working, if necessary, to cope up with increase in speed and volume of work. There should be a time limit for sanctioning all projects, and I would urge upon the Chief Engineers of the States that they introduce a system of time programme at every stage and keep it up by reviewing it periodically to remove obstacles and hurdles.

Another effective way to cut out delays is to vest the highway authority with requisite powers to take direct action as regards procedure for tackling encroachment cases through courts. It is also necessary that a special land acquisition officer should be on the staff of the Chief Engineer to cut out inordinate delays in the land acquisition proceedings on the lines proposed in the Model Highway Bill. The Bombay Govt. has already passed a Highway Act. I hope the other States will follow suit. I may also point out that the Highway authorities in the U.S.A., U.K., and some of the European countries are vested with these powers and the system is functioning effectively and efficiently.*

* During the XIth International Congress in Brazil, we had opportunity to check the system of working under DNER where the Central Highway Departments maintain a large establishment for land acquisition and the lawyers help enforce the Highways Act and prevent encroachment. The highway departments have even the special Police force under them.

While we are on the threshold of launching the Second 20-Year Plan, it would also be worth-while to consider the pre-requisites for successful and timely implementation of the plan. The highway system to be functionally and operationally successful must (1) have adequate capacity to carry the volume of traffic and the heavy physical loads imposed thereby; (2) be constructed at minimum costs commensurate with the requirements of the above factors; and (3) be maintained economically.

In a vast country like ours, there are various kinds of local materials which have not yet been fully utilized for road construction. It would therefore, be advantageous to carry out research, assess their values and process them with a view to minimising construction costs. Proper selection of subgrade materials will further lead to a durable surface requiring a minimum of maintenance.

Road research can help in finding economical solutions in this respect. The best utilization of available materials and adequate pavement design are entirely dependent on the results of laboratory tests and, as such, highway research is a pre-requisite to all new design and construction. From this platform, time and again the need for establishing research laboratories in the States has been emphasised and I can only add my own conviction* that unless this is done it will neither be possible for us to have proper designs for lasting structures nor shall we be able to effect economy in construction. Among the national laboratories we are fortunate in having a laboratory for road research also, viz., the Central Road Research Institute which is in a position to co-ordinate the work of the State laboratories all over the country.

In the New Plan, while thousands of miles of new roads will have to be constructed, it will be nonetheless necessary to upgrade the surface of thousands of miles of existing roads which are crumbling under speed, weight and intensity of traffic which was never anticipated before the war. Road research can be an effective guide in this direction also.

The next question is that of transport capacity of the highway. For raising the road haulage, an increase in the speed of vehicles is an important factor. Each stage in the development of our modern civilization has been accompanied by a specific advancement in the facility of transportation. The automotive generation of today takes for granted speeds of 40 to 50 miles per hour with safety and comfort. The time has now come when slow moving vehicles will have to be

* If the laboratory tests carried out by the Central Road Research Institute were not done at the instance of the Bombay Government, the Express Highway now under construction could not have proceeded on right lines.

segregated or will have to be kept off at least from some of the main highways. Truck-trailer combinations will be on the increase. To cope with this increase, all the streams will have to be bridged. I would also say that whenever a new link of a national highway is taken up for construction or an existing road upgraded to the standard of a national highway, construction and strengthening of minor cross drainage works and bridges should go side by side, if not precede, the construction of the improved surface.

I would like to invite attention next to the maintenance of district roads (which cover the great mileage of roads, not falling in the class of trunk and inter-state routes) on which the State Governments have spent largely from Plan funds to serve rural population. Maintenance of these roads rests with the District Local Boards. It is a general complaint that maintenance of these roads is neglected and the surface is fast deteriorating. Are we going to shut our eyes to this for the time being and then start afresh building these roads in another ten year's time? The only alternative is to entrust these roads to the State Highway Departments, even though this may sound a retrogressive step in the context of autonomy of the Local Self Government.

I would now come to the need of having a separate Highway Department in every State and for specialisation within that Department. Irrigation work in India is unparallel in the world both in regard to efficient execution and proper maintenance. We have a network of railways, well developed and adequately maintained. Both the above services have been possible because of organised services of engineers specialised in these departments. Such a specialised organisation under separate Highway Departments, I am convinced, is now overdue for rapid development and proper upkeep of our roads. I would go a step further and say that in the Highway Department there must be specialisation in all sections to ensure modern standards and up-to-date service. Specialisation could only be achieved if our young engineers are afforded opportunities for training and to see and learn the best modern practices in highway engineering.

Another important aspect of speedy construction and proper maintenance is employment and maintenance of mechanical equipment. We must not hesitate to use more and more such machinery as boring plants, drills, compressors, crushers, rollers, trucks, vibrators, batching plants, bulldozers, motor graders, pile drivers, bitumen boilers and sprayers, mixers and pavers both for bitumen and cement concrete, all of which are necessary not only for speedy execution of work but also for securing proper quality and finish.

The Chief Engineers have planned carefully as regards road building machinery and have estimated their total requirement with

a break-up of items that are available in the country and those which will have to be imported. I would urge that early steps be taken to step up the production of road building machinery in India such as rollers, pumps, stone crushers, tar boilers, concrete mixers, etc., and also launch on the manufacture of motor graders, mixers both for bitumen and concrete and bitumen pressure distributors as they will be required in large numbers. The increase in production of machinery will rise from three to six times during the next 20-year period. To quote only a few items, while we would need 2,400 rollers in 1961, their requirement would rise to 6,400 in 1981, and that of motor graders from 400 in 1961 to 1,200 in 1981. Early steps should, therefore, be taken for importing the machinery which cannot be planned to be manufactured in the country during that period. Planning in advance has been recommended by the Chief Engineers for implementation of the Plan. It would, therefore, be proper for the Government of India to release foreign exchange of about Rs 80 crores for such road-making machinery as cannot be manufactured in India for the Road Plan. I would urge that this recommendation be given due consideration.

Road building has been looked upon from time immemorial as a labour-intensive device and there is a widespread belief that machinery employed on road work will oust the labour and increase unemployment. In this connection I should like to allay all fears by quoting the 20-year Plan figures of labour engaged for maintenance in 1961 which is estimated at 8 lakhs and which will rise to 42 lakhs in 1981.

Further, there is the possibility of achieving a balance by which many operations could be entrusted to machinery and ancillary occupations to labour, thereby ensuring speed and quality.

In conclusion, I should like to emphasize the role of the Indian Roads Congress in the scheme of things to come. This body has been co-ordinating the activities of the Roads Wing of the Ministry of Transport, the Highway Departments of the States, the Central and State Road Research Institutes and others interested in highway construction and development in India and has strived to evolve standards and codes of practices for uniform adoption. In the implementation of the Second 20-Year Plan, a greater responsibility will fall on this Organization and it can well play its role as the central agency to zealously promote the interests of road and road transport development in the country, and exert its influence for timely implementation and effective control. Our work will increase in magnitude with the expanding road programmes, and the Government will require the highest technical advice on important problems.

This function can be fulfilled by technical bodies like the Indian Roads Congress and the Institution of Engineers. I would, therefore, urge in the national interest to look upon the Indian Roads Congress as the co-ordinating agency that would form a pool of the best technical talent available in the country in the matter of highway design and construction and serve the Centre and the States as the most competent consulting agency.

While engaged in a work of basic importance for economic uplift of masses of our country, the Indian Roads Congress is keenly aware that though the problems which it has solved in the past are substantial, many more still remain to be solved.

I pray that the launching of the New 20-Year Road Plan may coincide with a new era of technical development and prosperity in our country and that the development of roads and transport system may dovetail itself with the development in all other sectors.

We, as members of this Congress, pledge ourselves once again on this day of its Silver Jubilee Session to the highest ideals of service to our countrymen through our noble profession.

At this juncture we look upon you, Sir, well-known for your keen interest in roads and road transport, to take up our cause and lend all support from Government in the promotion of road and road transport development in this great country. I have very great pleasure at this auspicious moment to request you, Sir, to inaugurate this Silver Jubilee Session of the Indian Roads Congress.

INAUGURAL ADDRESS

By

SHRI RAJ BAHADUR

Minister of State for Transport and Communications

MR. PRESIDENT, LADIES AND GENTLEMEN,

MAY I, at the outset, express my thanks to the Indian Roads Congress for inviting me to inaugurate this historic session when the Society is celebrating its silver jubilee. I consider this a great privilege and I am glad to have an opportunity to meet this premier body of highway engineers, who have taken upon themselves the task of devising ways and means for the development of road communications in the country on scientific lines.

I have heard, Mr. President, with great interest your address in which you have reviewed the activities of your Society. It is gratifying to note how the Society has grown from strength to strength during the last 24 years and today has on its roll nearly 2,000 members as against the modest number of 73 with which it started. This is an eloquent testimony of the great progress it has made and of the prestige and popularity it enjoys among the highway engineers of the country. It was quite appropriate for you, Mr. President, to speak on this occasion about the valuable contribution of the Indian Roads Congress to the cause of highway engineering in the field of planning, design, construction, research and training and about the many facets of its activities. The Congress has every reason to be proud of its achievements in these fields and let us all join in offering our tribute of thanks and high appreciation to all those who have given their best to make the Congress what it is today.

I need hardly stress the importance of roads to this gathering of road experts who are devoting all their energies to the cause of road development; nor need I dwell upon the progress made in road development so far which has been dealt with elaborately in the Presidential address which we have just now heard. Suffice it to say that the provision of an adequate road system should occupy a pivotal place in any scheme or process of economic planning.

Development in the various sectors of national economy whether it is agriculture, industry or trade vitally depends on the existence of an efficient transport system. The criteria of efficiency, as observed by you, Mr. President, are "speed" and "quality". It is now generally recognised that in both these attributes Auto-

mobile Road Transport exceeds other forms of land transport. In the ultimate analysis, therefore, in order to accelerate the pace of our economic development and to carry the fruits of our successive Five-Year Plans fully and quickly to the remotest nooks and corners of our country, we must appreciate and recognise the need for connecting all our villages and rural areas by an adequate and well-maintained net-work of roads. On this occasion, therefore, I would like to draw your special attention to this great need. Roads are literally the highways to prosperity and in order to put our nation's economy as well as security on sound foundations we must provide the country as quickly as possible with a road-system that could meet all its needs at all times and in all circumstances.

It is indeed true that ever since the achievement of independence and more particularly after the commencement of our Five-Year Plans, the development of rural roads has all along been kept in view by our planners and some good progress has also been made, but we have still a long way to go and cover a lot of ground to reach all our villages. The Nagpur Plan and the recent report of the Chief Engineers on the long-term 20-year road development referred to in the Presidential address have, no doubt, laid a good deal of emphasis on providing easy access to our villages and I am happy to note that the Chief Engineers' Report provides a large mileage of nearly 4 lakhs for serving our rural areas so as to ensure that on the completion of the plan, no village in a developed agricultural area will be more than 1.5 miles from a road. May I, however, point out, in all humility, that with the advent of independence and the ushering in of this new era of development and expansion of our economy, the flood gates of the pentup demands and ambitions of our people, more particularly of those in the rural areas, have been opened and it would be difficult to resist the torrent for a long time. At present there is a demand from each one of our five hundred and fifty thousand villages for being connected by a road without much delay. I wonder whether we can keep our people in the villages waiting for a road for a long period of 20 years. It sounds rather paradoxical that people who could wait for centuries so far should have suddenly become so impatient now, but never before in our history have the people been such complete masters of their own destiny, as they are at present. I would, therefore, urge upon this representative gathering of distinguished engineers of the country kindly to take due note of the aspirations of our people with the urgency that they deserve. Some ways and means shall have to be found to meet the challenge of the situation.

It is against this background that one has to appreciate your observation, Mr. President, about the 20-year road plan to the effect that "this is a modest plan compared with our needs". It is indeed modest keeping in view the time factor for its completion.

So far as the acceptance of this plan by the Government is concerned you will be glad to know that although the Report is still under the consideration of Government, the State Governments have been advised to follow the broad order of priorities indicated in the Report for purposes of formulating road schemes to be included in the Third Five-Year Plan.

Planned development and adoption of suitable standards in respect of alignments and land widths require immediate attention in regard to rural roads, especially as a large mileage of these roads is being constructed under the various self-help schemes. As you are well aware, a number of agencies are responsible for the construction and maintenance of these roads. It is, therefore, essential that construction of these new roads should conform to an integrated plan of road development for each State and for the Country as a whole. This object can be achieved by drawing up comprehensive road maps for each district based on a long-term road development scheme prepared in consultation with the local authorities after taking into account the economic, social and administrative needs of the people. I am glad to say that a scheme for preparing such maps is already being implemented by all the State Governments with the assistance of the Central Government. We should, however, ensure that attempts at co-ordination do not prejudice the chances of voluntary public contribution to these programmes or lead to regimentation in the work of various agencies and thus create delays and bottlenecks in the execution of programmes, as these roads provide one of the most fruitful scopes for utilising local effort in men, material and money.

Another problem of equal importance is the provision of low cost roads in the country. As stated earlier, our requirements in the matter of roads are great but the resources are small. As such, no rural road programme which does not ensure the most economical use of the locally available materials can be practical for the country. I am happy to know that you have a Sub-committee of the Congress which is constantly studying this problem. I have no doubt that their labours will continue to provide the necessary guidance.

I also attach great importance to road research which is fundamental to all road-making activities. The opportunities for research are greater today than ever before and each one of you has a chance to add something to the general store of knowledge already in existence. Let us not forget that we shall be judged by our posterity, not only by the engineering works produced in our generation, but also by our contribution to that store of knowledge which will enable them to excel our achievement.

I agree with you, Mr. President, regarding your suggestion for the establishment of separate Highways Departments in States

for dealing with road development and maintenance. Highway Engineering has already developed as a specialised branch of Civil Engineering and the tempo of road development in the country is increasing day by day. It is essential that a Department should be exclusively in charge of roads so as to give undivided attention to all matters pertaining to road development. I am told that the States of Madras and Andhra Pradesh have already got separate Highway Departments. Let us hope that other States will follow suit in the not too distant future.

I appreciate the suggestion for vesting the Highway Authorities with powers for dealing with encroachments, ribbon development and acquisition of land for road works. In this connection, I would commend the example of the Bombay Government who have enacted a comprehensive legislation covering all these aspects.

In your Address, Mr. President, you have rightly expressed your concern at the set-back in the production of motor vehicles resulting in only a partial fulfilment of the Second Plan targets for automobile production. This is attributed to our foreign exchange difficulties. I am not aware of any other industry of comparable importance, production in which has fallen as low as 50 per cent of the Plan targets as has been the case with the automobile industry. This has naturally affected the development of motor transport and consequently the transport capacity of the country extremely adversely. This underlines the inescapable need for according a relatively much higher priority to the needs of road transport in the Third Plan in order to ensure an adequate and balanced development of the various forms of transport, keeping in view the latest world trends which reflect almost entirely in favour of road transport.

Time has also come when we must give serious thought to the problem of safe travel on our highways. It is opportune for you, therefore, to discuss the engineering aspect of safety on roads. In the ultimate analysis of things, it should be clear that in all forms of transport, safety will be one of the determining factors in the struggle for supremacy besides speed and convenience to the user.

Gentlemen, I do not want to take more of your time, but before I conclude I must express that it has given me the greatest satisfaction to note that due emphasis has been laid by the President in his address on efficiency and the need for a sense of urgency and religious zeal in the execution of the various plan projects and the implementation of the plan by our engineers. This is of utmost importance, because the faith and hope of our people for the realisation of their dreams and the fulfilment of their

aspirations, are today pinned on the patriotism and efficiency of our engineers. I need hardly say anything about the importance of the role of engineers in the country. It is patent that on the engineers of the country devolves the responsibility of harnessing her natural resources for raising the standard of living of common man and her advance towards real economic independence. The country needs maximum effort in this direction and the prime need today is a spirit of selfless service, steadfast devotion to duty and a continuously progressive outlook.

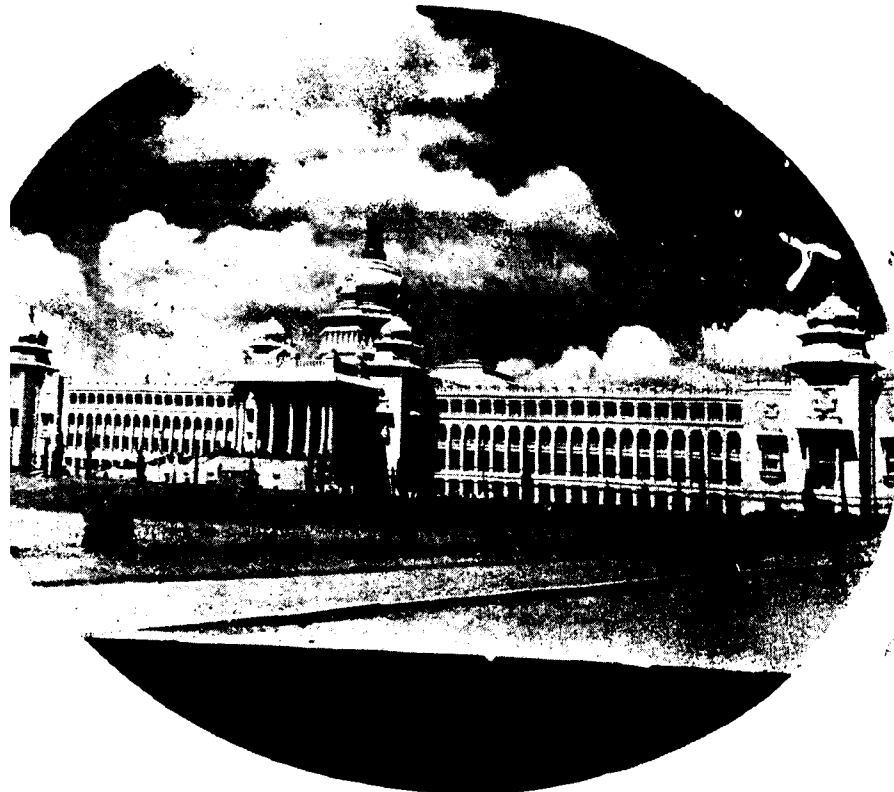
I hope and trust that our engineers are fully conscious of this sacred duty of theirs towards the present and the future unborn generations of our countrymen and that they would never fail to come up to the best expectations of our people. While I say so I am not unmindful of the great and numerous difficulties, handicaps and hurdles against which our engineers have to contend in the daily discharge of their duties. To my mind the only way in which these difficulties or handicaps can be surmounted is to face them boldly. To do this a free and frank discussion and examination of these difficulties is necessary. May I suggest to you in all sincerity, to discuss and analyse the problems that face you untrammelled by any doubts or fears and state your views and offer your suggestions to Government fearlessly and frankly. I have no doubt that the Central and State Governments would give the fullest and the best consideration to your views and suggestions and would do all that is possible to help you in solving your problems and overcoming your difficulties.

Before I close, I have once more to thank the Indian Roads Congress for asking me to inaugurate this memorable session. I have great pleasure in doing so and wish you success in your deliberations and hope your efforts will meet with ever greater success in the years to come.

JAI HIND

INDIAN ROADS CONGRESS SILVER JUBILEE SESSION -BANGALORE, JANUARY-FEBRUARY 1960

Bangalore with all its attractions has become a popular centre for various Conferences. It was appropriately chosen for holding the SILVER JUBILEE Session of the Indian Roads Congress. Bangalore literally means "the town of boiled beans". It is, however, a city of gardens, tanks, architectural buildings, educational institutions and now is more known for big modern industries like the Indian Telephone Industries, the Hindustan Machine Tools and the Hindustan Aircraft.



Vidhana Soudha where all meetings were held

Delegates from various parts of India including three representatives from Ceylon and some representatives of institutions in India and abroad attended the Session. All meetings were held in Vidhana Soudha, a majestic building known for its beauty.

This is the second time the Indian Roads Congress held their Session at Bangalore in Mysore State. The first Session was held there in 1936. Since then both the Indian Roads Congress and the host State have crossed many a milestone.

INAUGURAL SESSION

Shri Raj Bahadur, Minister of State for Transport and Communications, Govt. of India inaugurated the Session on Friday the 29th January 1960 in the Town Hall, Bangalore.

Shri U. J. Bhatt, President of the Indian Roads Congress in his address dealt with the implementation of the road development plans. In this connection he emphasised the need for accelerating the production of motor vehicles for the transport of both passengers and goods.



Shri Raj Bahadur, Minister of State for Transport & Communications, Govt. of India arrives to inaugurate the Session

Roads can be self-paying only when adequately used by vehicles. He also stated that the objectives of the Twenty-Year Plan recommended by the Chief Engineers can be achieved only if a



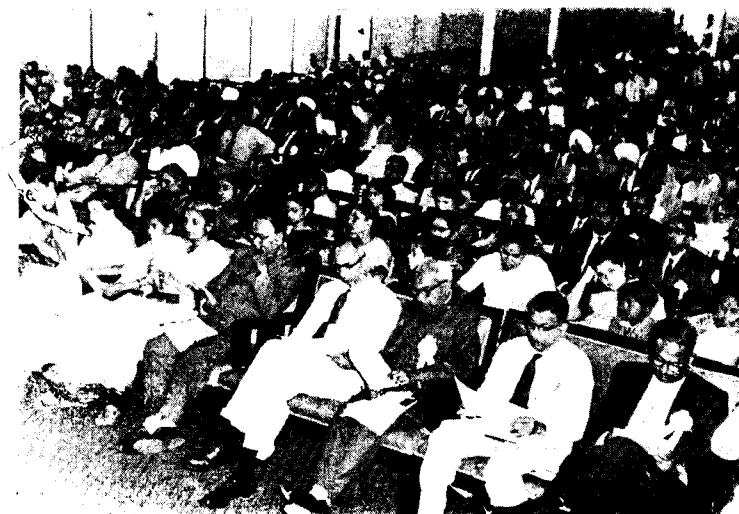
Shri Raj Bahadur, Minister of State for Transport & Communications, Govt. of India, inaugurating the Silver Jubilee Session of the I.R.C. at Bangalore on 29th January, 1960



Shri U. J. Bhatt, President, I.R.C., delivering the Presidential Address

beginning is made in right earnest immediately and adequate funds are made available in the third and subsequent Five-Year plans. He further stated that so far as the dividends from investment are concerned, they are realised more quickly from road transport than from any other mode of transport. Moreover, the benefits of expenditure on roads are spread over large areas of the country and extend to a large number of people. Such works also afford the best opportunity for the utilization of voluntary contribution.

Shri Bhatt also suggested that the highway authority should be vested with requisite powers to take direct action as regards procedure for tackling encroachment cases through courts, a special land acquisition officer should be on the staff of the Chief Engineer to cut out inordinate delays in the land acquisition proceedings on the lines proposed in the Model Highway Bill. Other important recommendations made by Shri Bhatt were about the formation of a Road Board, transfer of District Board roads to P.W.Ds and the need for setting up a separate Highway Department in every State.



Audience listening to speeches with rapt attention

Shri Raj Bahadur, Minister of State for Transport and Communications, Govt. of India while inaugurating the Session stated that although the Twenty-Year Road Plan was still under the consideration of the Govt. of India, the State Govts. have been advised to follow the broad order of priorities indicated in the plan for the purposes of formulating road schemes to be included in the

third Five-Year Plan. The Minister also assured the Congress that the Govt. of India will give due consideration to their recommendation for the formation of a Road Board and suggested that the Indian Roads Congress might work out the details regarding the formation of the proposed Road Board.

Messages of goodwill from the President of India, the Vice-President, the Prime Minister, the Chief Minister of Mysore and Sir M. Visvesvarayya were read out. The Messages were very inspiring and instructive. Messages were also received from the Ministers for P.W.Ds of many States, Past Presidents of the Indian Roads Congress, the President, International Association of Road Congresses, the Chief of the Transport Division of the ECAFE, and from many technical institutions in India and abroad. These messages are published in the Silver Jubilee Souvenir publication issued by the Indian Roads Congress.



Shri K. F. Antia speaking on one of the Papers

Papers

After the inauguration, the delegates assembled to discuss technical Papers, one of the most important features of the Session. In all, ten Papers covering a wide field, viz., soil mechanics, road pavements, bridge design and construction, road planning, road operation, road traffic, etc., were discussed during



Members listening to comments on Papers with keen interest

the session. The discussions on Papers are published in this Volume.

Committees

Various Committees met during the Session and discussed a number of problems on various aspects of highway engineering and highway transport. The Traffic Engineering Committee considered the specifications for road markings, traffic signals and the subject of street and highway lighting. The Research Organisation Committee, among other subjects, discussed the ways and means of greater co-ordination among the road research stations in the country. The Specifications and Standards Committee finalised type designs for kilometer stones and recommended practice for location and layout of roadside fuel-filling-cum-service stations. The Provincialization of Local Bodies Engineering Services Committee expressed the view that in order to increase efficiency and economy in administration and construction of engineering works, such as roads, bridges, buildings, etc., these services should be brought under the charge of Chief Engineers in charge of road works.



A meeting of Research Organisation Committee

The Road Transport Operation Cost Committee which was appointed at the instance of the Govt. of India to study (i) the cost of operation of motor vehicles on different classes of roads, and (ii) the economy resulting from road improvements, at its meeting, reviewed the results of further experiments carried out by Bombay, Uttar Pradesh, and Himachal Pradesh Transport Undertakings. A detailed analysis of the data relating to Bombay and Uttar Pradesh generally confirms the findings of the previous report presented by the Committee at its meeting held in January 1959, namely, that there is substantial reduction in the cost of operation of motor vehicles with the improvement of road surfaces. A detailed Paper on the subject by Shri N. D. Daftary and Dr. M. K. Ganguli also came up for open discussion before the Congress.

The Test Track Committee discussed the arrangement for building a new Govt. Road Test Track at Calcutta for studying various road problems. The Committee also reviewed the performance of some stretches of roads in West Bengal.

A sub-committee of the Specifications and Standards Committee discussed the specifications of water-bound macadam roads.

The Soil Research Committee discussed the subject of classification and identification of soils for general engineering purposes,

use of soil-cement blocks for emergency protection work in rivers, stabilization of black cotton and other shrinkable soils for road construction, etc



Road Transport Operation Cost Committee meeting

The Road Transport Development Committee desired that steps should be taken immediately to increase the production of automobiles and provision should be made in the Third Five-Year Plan not only for increasing the production of automobiles to meet the increasing demands of traffic but also for making up the present back-log.

The Committee felt that the use of vehicles with higher carrying capacities should be permitted on all the trunk routes so that goods can be carried by road transport economically and, at the same time, the road capacity is fully utilized. After long discussion it was stressed that all the National Highways and 50 per cent of State Highways, excepting hill roads, should be strong enough to carry vehicles of 27,000 lb laden weight by 1965-66. As a result of this, truck-trailer combinations and other modernised heavy vehicles would be able to ply on these roads without any difficulty.

The Committee also considered the question of limitation imposed on the present laden weight of vehicles in different

States. It was felt that uniformity on the upper limit of laden weight of motor vehicles was essential so that there was no impediment on the smooth flow of traffic on inter-state routes. Varying restrictions imposed on laden weight of vehicles in different States were on many occasions leading to malpractices by the operators which were more or less well known. It was suggested that, if required, roads should be improved so that vehicles of 19,000 lb laden weight can ply uniformly on all major district roads of the various States and vehicles of 27,000 lb can ply on State Highways and National Highways of the country. At present, the restriction imposed on the laden weight of vehicles in many States appears to be extremely conservative and the subject requires a careful study.

The Committee also noted that experience during the past years had shown that the broad iron-tyred wheel has become popular in the Delhi territory. It was possible that similar results might be obtained in other States too and, therefore, they should be requested to introduce the Indian Roads Congress standard iron tyres without delay. This would minimise the damage to the road surfaces as well as keep the bullock-cart on the road map of India as an important feature of the 20-Year Road Development Plan.

The Chief Engineers of Centre and States held two meetings. Among other subjects, they discussed the formulation of road deve-



The Chief Engineers discussing important problems

lopment programmes for inclusion in the Third Five-Year Plan of Central and State Governments, reconnaissance surveys of bridges and culverts on National Highways with a view to strengthening (or reconstructing) the weak ones so as to make them fit for heavy modern loads, difficulties in the way of speedy execution of road works, setting up of highway research stations in the States, sending serving engineers abroad for training, etc.

The Bridges Committee finalised Section III of the Indian Roads Congress Standard Specifications and Code of Practice dealing with Plain and Reinforced Cement Concrete. The subcommittees of the Bridges Committee discussed Section IV of the Bridge Code dealing with Masonry Structures and Section V dealing with Steel. Other subjects discussed by the subcommittees were design standards and construction requirements of prefabricated and composite construction units for culverts and bridges of medium span and the criteria for prestressed concrete.

The manufacture of Road Making Machinery and Mechanization Committee discussed the possibilities of manufacturing more and more items of road making machinery in India.

*On the morning of 1st February 1960, the Annual General meeting (Business meeting) was held where the report of the Council was approved. The new Council was also elected. Resolutions thanking the host Govt. for the excellent arrangements made were



55th Council Meeting on 28-1-60

passed. After this meeting, the delegates continued the discussion of the General Report on road research in India. This discussion apart from enlightening the engineers about the work being done in the various road research laboratories in India serves the purpose of co-ordinating the work of the different laboratories. A panel discussion on "The Use of Soft Aggregates in Road Construction" was also arranged.

The Indian National Group of the International Association for Bridge and Structural Engineering also held its meeting. The report of the work done by the Group was reviewed at this meeting and a new Managing Committee was elected. The Managing Committee later on met and elected Shri S. L. Bazaz, Additional Consulting Engineer to the Govt. of India (Bridges) as Chairman of the Group, Shri H. P. Sinha, Consulting Engineer to the Govt. of India (Road Development) as Hon. Treasurer and Shri A. J. D'Costa as Hon. Secretary. Other members of the Executive Committee elected were M/s D. S. Desai, E. A. Nadirshah, K. K. Nambiar and K. F. Antia.



Another view of the 55th Council Meeting held on 28-1-60

The Council of the Indian Roads Congress at their 55th meeting reviewed the work of the committees and approved the budget of the Congress.

The Council accepted the recommendation of the Traffic Engineering Committee regarding dimensions for road signs as given in

the Motor Vehicles Act and as amplified by the Indian Stores Department. It was also decided to publish the same in the Information Section of the Journal of the Indian Roads Congress.

The Council felt that the Government of India should be approached again to advise State Governments to take early action regarding prevention of ribbon development along roads to avoid difficulties at later stages. The Council also felt that as the mileage of roads being constructed or likely to be constructed under the Community Project and National Extension Service Schemes would be



Discussing a knotty problem

considerable, it was imperative to provide a satisfactory arrangement for maintaining these roads. The matter would be discussed in detail by a Committee of the Congress and necessary recommendations made.

Another important recommendation made by the Council was about inviting eminent road engineers from abroad to attend the Sessions of the Indian Roads Congress as is done by the Indian Science Congress. Such visits would enable the engineers of this country to have personal contacts and opportunity for exchange of ideas with experts of other countries.

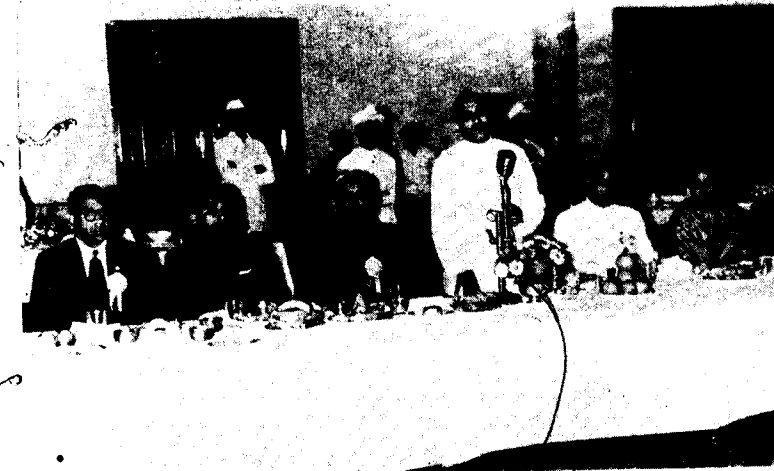
The Council at their 56th meeting held on 2nd February 1960 elected the office bearers for the current year. Shri H. P. Sinha, Consulting Engineer (Road Development) and Joint Secretary to the Govt. of India was elected President for this year. Dr. F. P. Antia, Shri S. C. Nayak, and Shri K. M. Joshi, were elected as Vice-Presidents. Shri A. J. D'Costa would continue to be the Hon. Secretary.



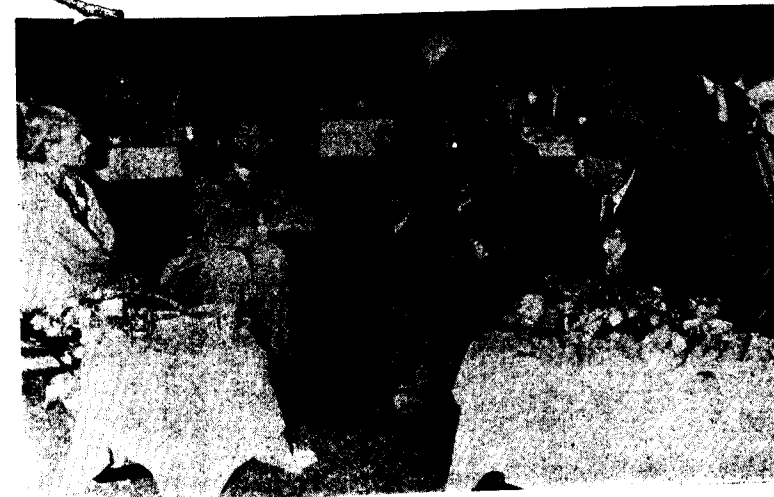
Shri U. J. Bhatt (President, I. R. C.) speaking at the Annual Dinner

Other important functions during the Session were an "AT HOME" by the Mysore Engineers' Association, the State Dinner at Mysore, entertainments to Cultural Shows, and the Indian Roads

Congress Dinner at which the P. W. D. Minister, Mysore State was the Chief Guest. Various engineering firms were also "AT HOME" to the delegates.



Shri Channabasappa, Minister for Public Works, Mysore, speaking at the Annual Dinner



At Home by M/s Burmah-Shell

An engineering exhibition arranged in the grounds adjacent to the Town Hall was again an outstanding attraction. The exhibition showed techniques used in road and bridge construction. Statistical charts showed at a glance the complete picture of the present road system in the country, its future expansion programmes, the number of motor vehicles manufactured and the future programmes, expenditure and income from roads, etc. The State P.W.Ds., the Central Road Research Institute, etc. took part in the exhibition and arranged impressive displays of the work done by them. The exhibition was formally opened by Shri H. M. Channabasappa, Minister for Public Works, Mysore State on the 29th January 1960.

On the 1st and 2nd February 1960, visits were arranged to the Hindustan Aircraft and the Hindustan Machine Tools factories and on the 4th, the delegates visited the Indian Telephone Industries. On the 3rd February, a visit to Mysore city and the famous Brindavan Gardens was arranged. With these visits, the Session came to an end.

VOTE OF THANKS

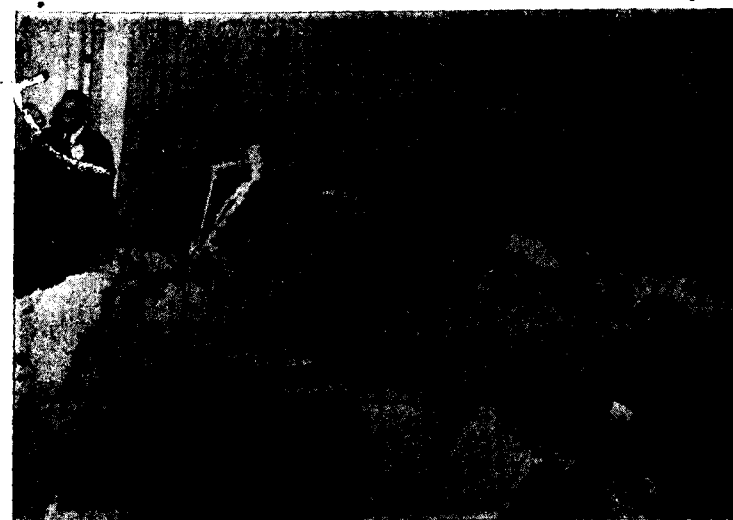
By

SHRI L.R. PATEL,

Vice-President, Indian Roads Congress

Shri Raj Bahadur, Ladies and Gentlemen,

This Silver Jubilee Session of the Indian Roads Congress is indeed our proudest hour crowded as it is with a series of attainments by the Congress in the field of road development in India during its career of 25 years. That you, Sir, have spared your valuable time to come down to Bangalore and grace this occasion is a signal honour which the members of this Congress will ever fondly remember. It also gives me great pleasure to welcome amongst us Shri H. M. Channabasappa, Minister for Public Works, Mysore and thank him for honouring us with his presence.



Vote of thanks by Shri L. R. Patel, Vice-President, I.R.C.

The Mysore State has always taken keen interest in the activities of the Congress. Way back in 1936, it played host to the Second Session of the Congress and the warm hospitality extended

to the delegates attending the Session is still fresh in our memories. We are fortunate to receive that same hospitality of the Government of Mysore and its engineers once more on this occasion.

Known as a premier centre of art and literature, the Mysore State is one of the most progressive States of our country. Its engineering works, beautiful spots and added to these, its bracing climate attract visitors from far and wide. It was, therefore, only appropriate that Bangalore was chosen as the venue for this historic Session. If the second session held in this State in 1936 gave the impetus for achieving what the Congress has to its credit today, I am sure that the present session will give even greater impetus to the activities of the Congress in the years ahead and enable it to discharge heavier responsibilities which the 20-Year Road Development Plan will devolve on the shoulders of the Highway Engineers of the country. And on this occasion, your presence, Sir, gives us great encouragement to march ahead in the accomplishment of our tasks.

On behalf of the President and members of the Indian Roads Congress, I now wish to thank you Sir, and all the ladies and gentlemen, who are with us today for having graced the occasion by your presence. I can assure you that the celebration of the Silver Jubilee will remain a cherished memory in our minds for many years to come.

INDIAN ROADS CONGRESS

TECHNICAL EXHIBITION — JANUARY-FEBRUARY 1960

On the occasion of the Silver Jubilee Session held in January-February 1960, the Indian Roads Congress organised an Engineering Exhibition. The Exhibition was opened on the 29th January 1960, at 4 p.m. by Shri H. M. Channabasappa, Minister for Public Works & Electricity, Government of Mysore. Mr. Channabasappa called on the members of the Roads Congress to apply their mind to the imperative need to bring down the cost of construction of roads and their maintenance without sacrificing the quality. He also urged the need for connecting villages lying in the interior by roads.

The Exhibition which was tastefully laid out depicted the various techniques used in road construction and included maps and charts pertaining to roads and bridges, models of bridges and machinery used in road construction.



The Minister for Public Works, Mysore, opening the I. R. C. exhibition

Various Government Departments and firms dealing with road building materials and machinery, scientific instruments, etc., participated in the exhibition.



The P. W. D. Minister visiting a stall at the exhibition



Another stall at the exhibition

STATE AND OTHER GOVERNMENT DEPARTMENTS

1. Government of India, Ministry of Transport & Communications, Department of Transport, Roads Wing.
2. Public Works Department, Government of Bihar.
3. Public Works Department, Government of Mysore.
4. Road Development Department, Government of West Bengal.
5. Central Road Research Institute.

FIRMS

1. Associated Instrument Manufacturers (India) Ltd.
2. Bengal Chemical & Pharmaceutical Works Ltd.
3. Burmah-Shell Oil Co. Ltd.
4. Caltex (India) Ltd.
5. Gammon India Private Ltd.
6. Gannon, Dunkerly & Co. (Madras) Ltd.
7. Larsen & Toubro.
8. Marshall, Sons (Private) Ltd.
9. Millars' Timber & Trading Co. Ltd.
10. Standard Vacuum Oil Co.
11. Shalimar Tar Products (1935) Ltd.
12. Voltas Ltd.
13. William Jacks & Co. Ltd.

OTHERS

Concrete Association of India.

Minutes of the 55th Council Meeting of the
INDIAN ROADS CONGRESS
held at Bangalore on the 28th January, 1960

Present :

Bhatt, U. J. — President

Antia, Dr. F. P.	Meeran, M.
Apte, M. P.	Mehra, S. R.
Barua, K.	Nadirshah, E. A.
Basu, K. N.	Nambiar, K. K.
Behera, S. S.	Nayak, S. C.
Chougule, Y. K.	Patel, L. R.
Durrani, N.	Prasad, B.
Fielder, C. J.	Shivdasani, P. D.
Ghosh, S. K.	Sihota, Brig. G. S.
Jagdish Prasad	Sinha, H. P.
Khanna, G. C.	Tripathi, S. N.
Mathur, B. D.	Uppal, Dr. H. L.
Mscarenhas, W. X.	

D'Costa, A. J. — Secretary.

The following co-opted members attended :

Antia, K. F.	Sujan Singh
Bannerjee, J. K.	Subrahmanyam, J.
Bazaz, S. L.	Vagh, B. V.

The following attended by invitation :

Bhalla, R. S.	Hardyal
Ganguli, Dr. M. K.	Iyengar, Dr. R. K. N.
Gupchup, N. S.	Trehan, J. M.

Visvesvaraya, Dr. H. C.

Approval of the Minutes of the meetings of the Executive Committee.

While approving the minutes of the meetings of the Executive Committee held at New Delhi on the 13th March, 29th August 1959 and the 13th January 1960, the following suggestions were made :

Item I (1) of the minutes of the Executive Committee meeting held on the 13th March 1959 regarding the recommendations of the Indian Roads Congress in regard to the Prevention of Ribbon Development along roads to avoid difficulties at later stage with the Government as delay in taking effective action is likely to create very great difficulties in the future road development of the country.

Item I (2) of the minutes of the Executive Committee meeting held on the 13th March, 1959.

The Council expressed the view that as the mileage of roads already constructed or likely to be constructed under the Community Project and National Extension Service Schemes would be considerable, it was imperative to provide a satisfactory arrangement for maintaining these roads. The Community Projects Road Maintenance Committee was asked to go through the matter in detail and make necessary recommendations.

2. Audit Report for the year 1958—59

The report of the Auditors for the year 1958—59 was recorded.

3. Draft Report of the Council to the General Body of Members for the period 1st January to the 31st December 1959.

The draft report was approved.

4. Budget.

The budget estimates for 1959-60 and the actuals for 1958-59 were approved.

5. Increased contribution from Central and State Governments towards the funds of the Indian Roads Congress.

The Council noted the response of Central and State Governments to the request of the Indian Roads Congress for increased contributions towards the funds of the Society on the basis of $\frac{1}{4}$ th per cent of the share of each State from the Central Road Fund or $1\frac{1}{2}$ times their present contribution, whichever is greater. The Council recorded their great appreciation of the response of the Govt. of India and some of the State Governments who had kindly agreed to contribute towards the funds of the Congress on the basis proposed, and further suggested that the Chief Engineers of other State Governments should be requested to persuade their Governments to sanction increased contributions proposed by the Indian Roads Congress.

6. Road Signs

The Council accepted the recommendation of the Traffic Engineering Committee regarding the dimensions for the road signs as given in the Indian Motor Vehicles Act and as amplified by the Indian Stores Department. It was also decided to publish the same in the Information Section of the Journal.

The Council further decided that the Committee should continue their study of road signs keeping in touch with the International Standards.

7. Inviting eminent road engineers from abroad.

The Council endorsed a suggestion that the Govt. of India should be requested to invite eminent road engineers from abroad to attend the Sessions of the Indian Roads Congress as is done by the Indian Science Congress. Such visits would enable the engineers of this country to have personal contacts and opportunity for exchange of ideas with experts of other countries.

8. Expansion of the work of the Indian Roads Congress and the composition of the Executive Committee

A suggestion was made that the Member-Secretaryship of some Committees of the Indian Roads Congress should be entrusted to the Assistant Directors of the Central Road Research Institute. After some discussion, it was decided that this matter should be examined in detail and necessary proposals put up to the Council at the next meeting.

Another suggestion made was for amending the composition of Executive Committee so as to include Director, Central Road Research Institute as its ex-officio member. It was later decided that this matter should also be examined in detail and the proposals put up to the Council at their next meeting.

Minutes of the Business Meeting of the

INDIAN ROADS CONGRESS

held at Bangalore on the 1st February 1960.

The Twenty-fourth Annual General meeting of Members was held at Bangalore on Monday, the 1st February 1960 at 9 A.M. In all 317 Members and 20 Invitees (names and particulars at pages 768 to 776) attended the Session.

2. Confirmation of the Minutes of the last Business Meeting.

The minutes of the last Business Meeting held at Hyderabad on the 10th January 1959 as printed on pages 645 to 691 of the Journal of the Indian Roads Congress, Vol. XXIII-Part 4, October 1959 were confirmed.

3. Audit Report.

- (i) The audit report for the period 1st October 1958 to the 30th September 1959, pages 777 to 779, was recorded.
- (ii) It was decided to re-appoint Messrs. Walker, Chandiok and Co., Chartered Accountants and Auditors, Delhi to audit the accounts of the Indian Roads Congress for 1959-60.

4. Report of the Council to the General Body of Members.

The report of the Council (pages 781 to 812) was approved.

5. Resolutions of thanks

The following resolutions were passed :

- (i) The Indian Roads Congress thank Dr. Rajendra Prasad, President of Republic of India for his inspiring and instructive message of congratulations for the Silver Jubilee Session of the Congress.
- (ii) The Indian Roads Congress thank Dr. S. Radhakrishnan, Vice-President of India for his instructive message to the Congress.
- (iii) The Indian Roads Congress thank Shri Jawaharlal Nehru, Prime Minister of India for his inspiring and instructive message and good wishes to the Congress.

- (iv) The Indian Roads Congress thank the Govt. of Mysore for their kind invitation to hold the Silver Jubilee Session at Bangalore and for the excellent arrangements made.
- (v) The Indian Roads Congress thank Shri Raj Bahadur, Minister of State for Transport and Communications, Govt. of India for kindly inaugurating the Silver Jubilee Session and for his very illuminating and inspiring Address on that occasion.
- (vi) The Indian Roads Congress thank Shri B. D. Jatti, Chief Minister of Mysore for his instructive and thought provoking message and good wishes for the success of the Congress.
- (vii) The Indian Roads Congress thank Shri H. M. Channabasappa, Minister for Public Works and Electricity, Mysore State for kindly declaring open the Technical Exhibition organized by the Indian Roads Congress.
- (viii) The Indian Roads Congress thank Sir M. Visvesvarayya for his kind message of good wishes to the Congress.
- (ix) The Indian Roads Congress thank Shri Maqbool Ahmad, Minister of P. W. D., and Local Self Government, Bihar, Shri Nathu Ram Mirdha, Minister for P. W. D., Govt. of Rajasthan, Shri Shanker Lal Tiwari, Minister for P. W. D., Govt. of Madhya Pradesh, Shri Suraj Mal, Minister for Public Works, Punjab and Shri Debeswar Sharma, Minister, Govt. of Assam, for their good wishes and messages for the success of the Congress.
- (x) The Indian Roads Congress thank Sir Kenneth Mitchell, Sir Arthur Dean, Shri Brijmohan Lal, Shri A. C. Muekrjee, Shri G. M. McKelvie, Shri T. Mitra, Shri H. P. Mathrani, Shri K. K. Nambiar, Shri P. L. Verma, Shri M. S. Bisht, and Shri W. X. Mascarenhas—all Past Presidents of the Indian Roads Congress for their good wishes for a very successful Session.
- (xi) The Indian Roads Congress thank Shri A. Rumpier, President, International Association of Road Congresses and Shri M. S. Ahmad, Chief, Transport and Communications Division, ECAFE for their messages of good wishes for the success of the Session.
- (xii) The Indian Roads Congress thank the Bureau of Public Roads, U.S.A. and Institutions and well-wishers who sent messages of goodwill and encouragement.

- (xiii) The Indian Roads Congress thank Shri G. S. Ganapathy, former Chief Engineer, Mysore State, Shri K. M. Joshi, Chief Engineer (General), Mysore, Shri N. G. Joshi, Deputy Chief Engineer, (Local Organizing Secretary, Indian Roads Congress) and other officers and staff of the P.W.D., and general administration Department, Mysore for the excellent arrangements made by them for the Session and for the convenience of the delegates.
- (xiv) The Indian Roads Congress thank the Govt. of Mysore for kindly inviting the delegates to cultural shows.
- (xv) The Indian Roads Congress thank the Mysore Engineers' Association, Bangalore for kindly inviting the delegates to an "At Home".
- (xvi) The Indian Roads Congress thank the Ministry of Information and Broadcasting, Govt. of India for kindly covering in their newsreel selected moments of the proceedings of the Session.
- (xvii) The Indian Roads Congress thank the firms and organizations and Government Departments who participated in the Technical Exhibition organized on the occasion of the Session and showed films.
- (xviii) The Indian Roads Congress thank the Director, All-India Radio for kindly recording the proceedings of the Session and for the assistance rendered to the Congress.
- (xix) The Indian Roads Congress thank the State Bank of Bangalore, Railway Authorities, Indian Airlines, Post and Telegraph Authorities for kindly giving necessary facilities to the delegates.
- (xx) The Indian Roads Congress thank the Mysore Govt. Road Transport Authorities for providing transport facilities for the delegates.
- (xxi) The Indian Roads Congress thank the various newspapers and periodicals for giving prominence to the proceedings of the Indian Roads Congress.
- (xxii) The Indian Roads Congress thank the various firms who were "At Home" to the delegates.

6. Scrutineers for the Election of Council Members.

Sarvshri C. J. Fielder, J. Mukand and Hardyal were appointed scrutineers for the election to the Council under Rule 9-j of the Rules and Regulations of the Indian Roads Congress.

7. **Election.** The following were elected as members of the Council :

9-g. (i) Representatives of Associate members other than public servants.

Antia, Dr. F. P.	Mahadevan, M. R.
Apte, M. P.	Nambiar, K. K.
Campbell, H. H.	Fielder, C. J.

9-g. (ii) Representative of Associate members other than non-public servants.

Verman, Dr. Lal C.

9-h. Representative of District Board Engineers.

Narke, S. P.

9-i. Representative of Municipal Improvement Trust and Cantonment Engineers.

Thakur, D. S.

9-j. Representatives elected by the General Body.

Chanda, R. P.	Mathur, K. C.
Iyengar, C. L. N.	Meeran, M.

Under Rule 9-a, b, c, d, and e, the following were nominated by their respective administrations as members of the Council.

Name of participating Administration	Name of representative
9-a. Andhra	Durrani, N.
Assam	Barua, K.
Bihar	Prasad, B.
Bombay	Bhatt, U. J.
Himachal Pradesh	Mukand, J.
Jammu & Kashmir	Gandotra, H. K.
Kerala	Chathunny, T. S.
Madras	Nayak, S. C.

Name of participating Administration	Name of Representative
Madhya Pradesh	Tripathi, S. N.
Mysore	C. E., (General)
Orissa	C. E., P. W. D., B. & R.
Punjab	Khanna, G. C.
Rajasthan	C. E., P. W. D., B. & R.
Uttar Pradesh	Prasad, Jagdish
West Bengal	C. E. (Road Development)
9-b. Engineer-in-Chief, Army Headquarters.	Maj. Gen. R. E. Aserappa
9-c. Central, P. W. D.	Dewan, N. G.
9-d. Consulting Engineer (Road Development), Govt. of India.	Sinha, H. P.
9-e. Director, Central Road Research Institute.	Mehra, S. R.

Past Presidents.

9-f. Bisht, M. S.
Mascarenhas, W. X.

**LIST OF MEMBERS WHO ATTENDED THE TWENTY-FOURTH
SESSION OF THE INDIAN ROADS CONGRESS HELD
AT BANGALORE IN JANUARY, 1960**

S. No.	Name of States, etc.	No. of delegates who attended the I.R.C. Session.
ABSTRACT		
1. Government of India:		
(a)	Ministry of Transport & Communications, Department of Transport (Roads Wing)	23
(b)	Ministry of Works, Housing & Supply (National Buildings Organization)	1
(c)	Ministry of Railways (Railway Board), Research, Designs and Standardization Organization	1
(d)	Central Public Works Department	4
(e)	Hindustan Steel Limited	1
2.	Central Road Research Institute	18
3.	Central Building Research Institute	3
4.	Engineer-in-Chief's Branch	5
5.	Planning Commission	3
6.	Andhra Pradesh	18
7.	Assam	3
8.	Bombay	49
9.	Bihar	18
10.	Kerala	2
11.	Madras	14
12.	Mysore	52
13.	Madhya Pradesh	15
14.	Orissa	6
15.	Punjab	12
16.	Rajasthan	9
17.	Uttar Pradesh	29
18.	West Bengal	32
19.	Himachal Pradesh	2
20.	Delhi	11
21.	Andaman & Nicobar Islands	1
22.	N. E. F. A.	1
23.	Ceylon	3
24.	Pakistan	1
Total		337

**LIST OF DELEGATES WHO ATTENDED THE 24th SESSION
OF THE INDIAN ROADS CONGRESS HELD AT BANGALORE
FROM THE 28th JANUARY TO THE 4th FEBRUARY 1960.**

S. No.	Roll No.	Name
1. GOVERNMENT OF INDIA		
(a) Ministry of Transport & Communications, Deptt. of Transport (Roads Wing).		
1.	322	Bazaz, S. L.
2.	1446	Bhalla, R. S.
3.	783	Bhargava, T. N.
4.	2040	Bhattacharya, M.
5.	758	D' Costa, A. J.
6.	Invitee	Ganguli, M. K.
7.	1078	Gursahani, R. L.
8.	785	Hardyal
9.	Invitee	Harbans Singh
10.	1880	Kathuria, S. L.
11.	2008	Muthuswamy, C.
12.	950	Nagarsheth, M. P.
13.	1878	Navaney, M. K.
14.	890	Patal, B. P.
15.	752	Ramaswami, N. S.
16.	724	Rajagopalan, S. K.
17.	2020	Rao, B. Balwant
18.	191	Sinha, H. P.
19.	1532	Sehra, P. T.
20.	Invitee	Sachdev, D. B. S.
21.	723	Subrahmanyam, J.
22.	918	Trehan, J. M.
23.	2003	Upadayaya, D. R.
(b) Ministry of Works, Housing & Supply (National Buildings Organization).		
24.	620	Malik, C. P.
(c) Ministry of Railways (Railway Board) Research, Designs and Standardization Organization.		
25.	43-Ass.	Gupta, Baij Nath Prasad
(d) Central P. W. D.		
26.	2697	Abraham, M. A.
27.	Invitee	Bhatia, K. M.
28.	948	Dutt, N. N.
29.	2748	Jayaraman, N. C.
(e) Hindustan Steel Limited.		
30.	886	Gupta, Govinda

S. No.	Roll No.	Name
2. CENTRAL ROAD RESEARCH INSTITUTE		
31.	Hon. Member	Aggarwal, H. R.
32.		Chadda, L. R.
33.	2339	Dhir, M. P.
34.	833	Iyengar, R. K. N.
35.	2549	Krishnamachari, R.
36.	1857	Khanna, T. S.
37.	277	Mehra, S. R.
38.	2202	Natarajan, T. K.
39.	Hon. Member	Nair, K. P.
40.	Hon. Member	Palit, R. M.
41.	2349	Puri, M. L.
42.	1913	Rao, N. Mohan
43.	1311	Subbaraju, Bh.
44.	1345	Swaminathan, C. G.
45.	1720	Sankaran, K. S.
46.	Hon. Member	Shukla, R. S.
47.	847	Uppal, H. L.
48.	2655	Venkatesan, M. S.
3. CENTRAL BUILDING RESEARCH INSTITUTE		
49.	Invitee	Deb, A. K.
50.		Ramaswamy, G. S.
51.	74-Ass.	Williams, Lt. General, H.
4. ENGINEER-IN-CHIEF'S BRANCH		
52.	Invitee	Chaudary, Lt.-Col. P. L. N.
53.	Invitee	Rao, Capt. G. V. V. H.
54.	Invitee	Raju, Lt.-Col. K. Rajan
55.	16-Ass.	Sihota, Brig. G. S.
56.	Invitee	Sobti, Maj. H. S.
5. PLANNING COMMISSION		
57.	2526	Sarup Singh
58.	Invitee	Sethi, H. D.
59.	1820	Vedagiri, T. S.
6. ANDHRA PRADESH		
60.	2105	Atchiraju, P.
61.	2507	Ahmed, Syed Bashiruddin
62.	2502	Chandramouli, T.
63.	246	Durrani, N.
64.	2486	Hussain, Mohd. Altaf
65.	249	Katrak, M. M.
66.	2661	Mohiuddin, Z.
67.	1824	Rajanna, B. V.
68.	628	Raj, P. V.
69.	Invitee	Rao, K. V.
70.	771	Raghaviah, M.
71.	1945	Rao, K. V.
72.	1113	Reddy, T. A. Ramanatha
73.	2666	Rao, K. N. Bheema
74.	1647	Subbarao, M.

S. No.	Roll No.	Name
75.	2380	Sarma, C. V. B.
76.	2130	Vijayaraghavan, G. M. A.
77.	1530	Yegnanarayana, K.
7. ASSAM		
78.	889	Barua, K.
79.	2258	Baruah, P. K.
80.	1237	Momin, G. C.
8. BOMBAY		
81.	32-Ass.	Antia, F. P.—Representing M/s. Cement Marketing Co. of India, Bombay.
82.	1522	Apte, M. P.
83.	1241	Antia, K. P.
84.	214	Bhatt, U. J.
85.	2222	Bhakta, R. M.
86.	2634	Bobade, B. G.
87.	1882	Bhosale, B. Y.
88.	704	Chougule, Y. K.
89.	343	Choksi, B. K.
90.	2451	Campbell, H. H.
91.	2693	Chitale, V. K.
92.	1837	Fondekar, P. B.
93.	663	Gupehup, N. S.
94.	2049	Gupte, A. Y.
95.	858	Gandhi, J. H.
96.	2624	Gokani, P. H. - Representing M/s. Hari Das Vithal Das, Contractor & Sons, Dwarka.
97.	1129	Iyengar, C. L. N.
98.	315	Joshi, S. B.
99.	2033	Jayawant, M. B.
100.	2709	Kale, J. D.
101.	Invitee	Kapadia, B. P.
102.	2650	Kirpekar, V. D.
103.	2708	Kulkarni, M. D.
104.	2695	Khambati, N. S. D.
105.	2756	Kothavaly, P. S.
106.	1687	Latnekar, S. K.
107.	1946	Mascarenhas, W. X.
108.	34	Mehta, J. T.
109.	1716	Menon, T. M.
110.	1482	Modi, I. K.
111.	1002	Mehta, M. A.
112.	76-Ass.	Marathe, S. S. - Representing M/s. S. S. Marathe & Co., Bombay.
113.	268	Nambiar, K. K.
114.	23	Nadirshah, E. A.
115.	33-Ass.	Narayan Singh - Representing M/s. Caltex (I) Ltd., Bombay.
116.	1565	Narurkar, M. S.
117.	2723	Patil, N. Y.
118.	2751	Patel, B. T.
119.	1008	Raghavan, P.
120.	2716	Rao, T. N. Subba

S. No.	Roll No.	Name
121.	1148	Shivadasani, P. D.
122.	1432	Sujan Singh
123.	83-Ass.	Sirdeshpande, P. P. - Representing M/s Millars' Timber & Trading Co. Ltd. Bombay.
124.	2663	Sharma, Y. K.
125.	83-Ass.	Sethi, G. K. - Representing M/s. William Jacks & Co., (C. E. Q. Deptt.).
126.	1501	Taylor, N. H.
127.	2351	Thakur, D. S.
128.	84	Vagh, B. V.
129.	2681	Venkataraman, S.
9. BIHAR		
130.	1655	Aga, A. K.
131.	602	Dubey, B. P.
132.	2676	Hasnain, Mohd.
133.	2728	Kamath, N. V. V.
134.	2724	Mohd. Alam
135.	2007	Nath, S.
136.	733	Prasad, B.
137.	1124	Prosad, G. S.
138.	1976	Parmanand
139.	477	Pershad, B.
140.	1706	Rohatgi, N. N.
141.	1992	Sinha, D. K.
142.	2612	Sharan, A. K.
143.	1978	Sinha, B. K.
144.	2743	Sinha, R. P.
145.	2754	Sinha, B. B.
146.	881	Varma, J. N.
147.	2642	Verma, Bijay Kumar
10. KERALA		
148.	2513	Chathunny, T. S.
149.	2758	Krishnan, Gopala
11. MADRAS		
150.	Invitee	Cornelius, J. N. - Representing M/s Goodyear Tyre & Rubber Co. of (I) Private Ltd., Madras.
151.	2022	Kohli, D. R.
152.	2343	Mohideen, S. M.
153.	671	Meeran, M.
154.	660	Nayak, S. C.
155.	1711	Natu, M. R.
156.	1125	Padmanabhan, C. V.
157.	87	Raghavachary, K. S.
158.	347	Reddy, K. Ramaswamy
159.	1775	Selvam, T. T.
160.	2698	Sripathy, K.
161.	1312	Subramaniam, P. S.
162.	630	Thadaney, K. V.
163.	1572	Thillainayagam, R.

S. No.	Roll No.	Name
12. MYSORE		
164.	1927	Antin, M. C.
165.	242	Adke, A. S.
166.	2735	Ahmed, Mustaq
167.	2352	Basavanna, K.
168.	2519	Bhavikatti, A. R.
169.	2757	Chari, T. V. K.
170.	2715	Desai, K. A.
171.	1641	Ganapathy, G. S.
172.	2056	Gopalasetty, S. V.
173.	2734	Hema Singh, K.
174.	2741	Hameed, H. G. Abdul
175.	Invitee	Joshi, N. G.
176.	2404	Jahagirdar, G. B.
177.	2560	John, George
178.	1656	Javali, S. C.
179.	2283	Joshi, K. M.
180.	2725	Krishnaswamy, A.
181.	2748	Magdum, I. M.
182.	869	Maddimsetty, R. S.
183.	636	Macha, T. K.
184.	2722	Moqem, M. A.
185.	1668	Manchigiah, M. H.
186.	2268	Murthy, C. R. Keshava
187.	1479	Narke, S. P.
188.	1420	Naik, K. Sunder
189.	80-Ass.	Nagaraj, C. N.
190.	2719	Patankar, B. V.
191.	2501	Parthasarathy, M. A.
192.	2523	Patil, S. M.
193.	2742	Pnavar, S. L. Khanda
194.	2745	Panditaradhya, H. K.
195.	2750	Raju, S. V. Narayana
196.	2688	Rudraiah, K.
197.	2731	Raju, S. V. Rama
198.	2730	Rangiah, S.
199.	2689	Rao, T. S. Narayana
200.	2638	Rao, V. V. Subba
201.	2726	Rao, P. Raghunatha
202.	2729	Raj, T. N. Suryakantha
203.	2733	Rao, B. Narayana
204.	746	Raju, R. L.
205.	2690	Rajan, G. K.
206.	2738	Rao, M. R. Sethumadhava
207.	2499	Rao, B. N. L.
208.	2744	Rao, C. Gopala
209.	2746	Ramachandriah, K.
210.	2485	Saldanha, W. G.
211.	2718	Setty, R. L. Subbaraya
212.	2714	Sreshtha, R. L.
213.	2749	Srinath, K.
214.	2753	Surendra, B. P.
215.	2755	Sastry, B. V. Rama
13. MADHYA PRADESH		
216.	1873	Aramadhu, P. R.

S. No.	Roll No.	Name
217.	2365	Balu, S. A.
218.	2740	Chouhan, P. C.
219.	2489	Gupta, Shri Ram
220.	1320	Hirmath, S. A.
221.	2583	Kand, C. V.
222.	584	Patil, Y. K.
223.	2682	Sanghvi, U. C.
224.	2739	Sheikh Mohamood
225.	2696	Sharma, S. A.
226.	2702	Sanghvi, H. C.
227.	2694	Srinivasiah, N. V.
228.	1921	Tripathi, S. N.
229.	2608	Varma, G. T.
230.	578	Yadav, H. J.
14. ORISSA		
231.	2692	Bahera, J.
232.	328	Behera, S. S.
233.	2727	Das, B. N.
234.	2732	Dandapat, Padmalochan
235.	2649	Das, B. M.
236.	2711	Rath, Nilkanth
15. PUNJAB		
237.	<i>Invitee</i>	Gupta, H. K.
238.	2706	Jain, M. L.
239.	<i>Invitee</i>	Jain, M. K.
240.	2088	Khosla, Mohinder
241.	446	Khanna, G. C.
242.	2331	Kalia, R. C.
243.	2752	Kulbir Singh
244.	2737	Karam Chand
245.	2712	Kalsey, B. S.
246.	<i>Invitee</i>	Mattoo, H. K.
247.	<i>Invitee</i>	Sodhi, J. S.
248.	1666	Toki, G. S.
16. RAJASTHAN		
249.	2701	Gupta, D. K.
250.	2307	Kachwaha, M. S.
251.	2095	Lauria, P. K.
252.	2467	Maroo, A. L.
253.	2455	Mathur, S. M.
254.	1966	Mathur, A. R.
255.	834	Mathur, B. D.
256.	800	Rao, K. Gopinath
257.	1807	Shevade, S. V.
17. UTTAR PRADESH		
258.	1782	Agrawal, Ram Singh
259.	2405	Agarwal, B. K.
260.	2669	Badami, J. V.
261.	2710	Bhatnagar, A. S.
262.	1525	Chaturvedi, D.C.
263.	1831	Gupta, I. P.

S. No.	Roll No.	Name
264.	1915	Goyal, D. K.
265.	52	Jagdish Prasad
266.	2687	Kumar, B. B.
267.	1199	Laroia, D. K.
268.	2434	Mittal, R. R.
269.	2121	Muthur, R. K.
270.	999	Misra, K. N.
271.	2621	Mital, K. C.
272.	1822	Mathur, K. C.
273.	1157	Prem Mohan
274.	2677	Prasad, Onkar
275.	743	Partap Singh
276.	2470	Qazi, I. G.
277.	2609	Rajendra Prakash
278.	2707	Srivastava, O. S.
279.	2452	Sharma, A. C.
280.	2061	Sharan, Shitala
281.	1889	Satish Prasad
282.	960	Sinha, K.
283.	2309	Sharma, H. K.
284.	2562	Tyagi, S. C.
285.	2373	Tayal, J. C.
286.	1085	Wadhwani, G. B.
18. WEST BENGAL		
287.	15-Ass.	Bhattacharjee, B.B.—Representing M/s. Heatly & Gresham Ltd., Calcutta.
288.	962	Bannerjee, J. K.
289.	1421	Basu, K. N.
290.	2248	Banerjee, A.
291.	2717	Basu, S. K.
292.	2900	Banerjee, P.
293.	2704	Chatterjee, M. K.
294.	2705	Chatterjee, Harihar
295.	2703	Chakravorty, S. B.
296.	1426	Chatterjee, P. C.
297.	1324	Chanda, R. P.
298.	165	Desai, D. S.
299.	41-Ass.	De, K. C.—Representing M/s. Bengal Chemical & Pharmaceutical Works Ltd., Calcutta.
300.	2250	De, Padmalochan
301.	231	Fielder, C. J.
302.	808	Ghosh, S. K.
303.	2002	Gangopadhyaya, S. S.
304.	936	Gupta, S. N.
305.	1550	Ghose, M. B.
306.	2627	Gupta, S. N. Dutta
307.	1942	Ghosh, D. K.
308.	2084	Ganguli, K.
309.	2037	Karnik, A. V.
310.	2631	K. Singh
311.	1566	Laha, S. K.
312.	<i>invitee</i>	Narayanan, V.—Representing M/s. Goodyear Tyre & Rubber Co. of (I) Private Ltd., Calcutta.

INDIAN ROADS CONGRESS, 1959
BALANCE SHEET AS AT 30TH SEPTEMBER, 1959.
 (Excluding Transport-Communications Monthly Review).

LIABILITIES		Rs	nP.	Rs	nP.	ASSETS		Rs	nP.	Rs	nP.
SUNDRY LIABILITIES						EQUIPMENT					
Creditors for Expenses	...	6,579	37			Balance as per last Balance Sheet	...	6,521	42		
Income tax payable on salaries	...	415	00			Additions during the year	...	1,188	90		
Shri McKelvie's Silver Salver Fund	...	120	84				...	7,710	32		
Advances for Publications	...	18	95	7,134	16	Less: Depreciation written off	...	980	42	6,729	90
						LIBRARY BOOKS AND PERIODICALS					
						Balance as per last Balance Sheet	...	2,268	39		
						Additions during the year	...	1,160	74		
							...	3,429	13		
						Less: Depreciation written off	...	342	91	3,086	22
CHEQUES ISSUED BUT NOT ENCASHED				5,392	62	DRAWING MATERIALS					
SUBSCRIPTIONS RECEIVED IN ADVANCE FROM:						Balance as per last Balance Sheet	...	16	87		
Ordinary Members						Less: Depreciation written off	...	1	50	15	37
1959-60	585 38					INVESTMENTS					
1960-61	65 00					Rs 44,000/- 12 years National Savings Certificates	...	44,000	00		
1961-62	10 00	660	38			Rs 74,600/- 10 years Treasury Savings Deposit Certificates	...	74,600	00		
Associate Members						Rs 21,300/- 3% Loan 1963-65	...	20,271	62		
1959-60		20	00	680	38	Rs 11,100/- 3½% National Plan Loan, 1964	...	10,984	12		
						Rs 3,000/- 3½% National Plan Bonds, 1967	...	2,955	00	1,52,810	74
MITCHELL MEDAL FUND (Invested as per contra)						INTEREST ACCRUED ON INVESTMENTS					
As per last Balance Sheet		1,933	27	1,980	77	PROVIDENT FUND					
Add: Interest realised		47	50			12 years National Savings Certificates	...	33,200	00		
						Interest accrued thereon to 30th Sept., 1959	...	4,662	50		
						Balance with State Bank of India	...	2,754	17		
BUILDING, MUSEUM & TECHNICAL FUND						Loans Advanced	...	2,591	00	43,207	67
Balance as per last Balance Sheet	...	1,74,982	74			MITCHELL MEDAL FUND					
Add: Amount of Life Membership	...	861	00			Rs 1,600/- 3% Loan 1963-65	...	1,652	93		
Interest on Investments	...	6,193	50			Interest accrued thereon	...	16	00		
Rent of Exhibition Stalls at New Delhi, transferred from Suspense Account	...	9,162	00	1,91,199	24	Balance with State Bank of India	...	311	84	1,980	77
						STOCK-IN-HAND					
						(Certified as to quantities & values by the Secretary)					
RESERVE FOR BAD & DOUBTFUL DEBTS				10,000	00	Journals	...	63,251	12		
PROVIDENT FUND DEPOSITS				43,102	06	Paper	...	6,814	71	70,065	83
PROVIDENT FUND INTEREST DISTRIBUTABLE						SUNDRY DEBTORS					
Balance as per last Balance Sheet	...	596	64			Subscriptions in arrears from:					
Add: Interest earned	...	1,116	41			(i) Ordinary Members	17,504 19				
		1,713	05			(ii) Associate Members	480 00	17,984	19		
Less: Distributed	...	1,001	44	711	61	Outstandings - Publications	...	1,507	76		
						Subsidies Receivable (including Rs 3,000/- of previous year)	...	57,000	00		
AMOUNT HELD IN SUSPENSE (pending adjustment)				112	85	ADVERTISEMENTS					
INCOME & EXPENDITURE ACCOUNT						Considered good	1,143 00				
Balance as per last Balance Sheet	...	1,41,531	58			Considered doubtful	149 00	1,342	00		
Add: Balance being Excess of Income over Expenditure as per annexed Income and Expenditure Account	...	12,348	48	1,53,880	06	SESSION EXPENSES RECOVERABLE					
						Transport Charges (of which Rs 58-75 nP. considered doubtful)	748 75				
						Delegation Fees	4,305 00	5,063	75	82,897	70
Total	...			4,14,193	75	ADVANCES					
						The Deputy Controller of Stationery & Printing, Calcutta	...	165	23		
						Staff (against Cycles Purchased)	...	1,210	00		
						Recoverable from the Local Organising Secretary, (against Government Grants)	...	3,218	29		
						Advances for Travelling to Staff	...	440	00		
						Due from T.C.M.R.	...	5,253	72		
						Due from the Post Office, New Delhi (cheque returned for Correction)	...	337	48	10,624	72
						CASH & OTHER BALANCES					
						With State Bank of India	...	29,128	51		
						Cheques pending realisation	...	599	31		
						Stamps in hand (including Revenue Stamps)	...	38	17	29,765	99
						Total	...			4,14,193	75

(Sd.) A. J. D'COSTA,
 Secretary.

AUDITORS' REPORT.

We have audited the Balance Sheet of the INDIAN ROADS CONGRESS (excluding Transport-Communications Monthly Review) as at 30th September, 1959, above set forth, and have obtained all the information and explanations we have required.

In our opinion, the above Balance Sheet set forth gives a true and correct view of the state of affairs of the Congress according to the best of our information and explanations given to us and as shown by the books.

41-L, Connaught Circus,
 New Delhi.

(Sd.) J. C. CHANDIOK,
 B.A., A.C.A. (England & Wales), F.C.A.,
 for Walker, Chandiock & Co.,
 Chartered Accountants.

Dated, this 20th day of December 1959.

INDIAN ROADS CONGRESS, NEW DELHI
 EXPENDITURE ACCOUNT FOR THE YEAR ENDED 30TH SEPTEMBER, 1959.
 (Excluding Transport-Communications Monthly Review)

EXPENDITURE		Rs	nP.	Rs	nP.	INCOME		Rs	nP.	Rs	nP.
To Opening Stock of Journals as on 1st October, 1958	...	57,382	36			By Subscriptions					
„ Paper Consumed	...	26,509	72			Ordinary Members (including Rs 110/- of Members restored)	...	30,815	00		
„ Printing Charges and incidentals	...	21,067	07			Associate Members	...	3,760	00		
„ Salaries paid to Representative at Madras	...	900	00			Life Members	...	110	00		
		105,859	15			New Members	...	3,760	00		
Less: Closing Stock of Journals as on 30th September, 1959	...	63,251	12	42,608	03	Associate New Members	...	900	00	39,345	00
„ Establishment	...			41,946	44	„ Entrance Fees :					
„ Local and other Allowances	...			21,395	66	Ordinary Members	...	2,400	00		
„ Honorarium to Secretary	...			1,200	00	Associate Members	...	1,080	00	3,480	00
„ Bank Charges and exchange (Net)	...			283	55	„ Sale of Publications	...	18,704	47		
„ Provident Fund Contribution	...			2,172	00	Less: Sales Returns	...	404	50	18,299	97
„ Audit Fee for 1957-58 and 1958-59	...			1,200	00	„ Advertisements	...			5,510	87
„ Postage & Telegrams	...			8,947	95	„ Subsidies (including arrears)	...			74,500	00
„ Office Printing & Stationery	...			2,517	31	„ Interest on Cycle Advances	...			43	57
„ Uniforms to Class IV Servants	...			266	00	„ Receipts — 23rd Session					
„ Telephone, Revenue Stamps and other Miscellaneous Expenses	...			2,035	40	(i) Delegation Fees	...	8,295	00		
„ Publicity Expenses	...			600	00	(ii) Transport Charges etc.	...	2,185	00	10,480	00
„ 23rd Session Expenses	...			10,106	03	„ Income for Printing of 'Road Research' Papers					
„ Subscription to other Societies	...			350	00	Income	...	10,042	50	2,340	11
„ Travelling and Daily Allowances on the Meeting held outside the Headquarters	...			573	59	Expenses	...	7,702	39		
„ Bad Debts written off	...			4,124	25						
„ Depreciation written off	...			1,324	83						
„ Balance being Excess of Income over Expenditure carried to Balance Sheet	...			12,348	48						
Total				1,53,999	52	Total				1,53,999	52

41-L, Connaught Circus,
New Delhi.
Dated, this 29th day of December 1959.

(Sd.) A. J. D'COSTA,
Secretary.

In terms of our report appended to the Balance Sheet.
(Sd.) J. C. CHANDIOK,
B.A., A.C.A., (England & Wales), F.C.A.,
for Walker, ChandioK & Co., Chartered Accountants.

INDIAN ROADS CONGRESS
Transport-Communications Monthly Review
INCOME & EXPENDITURE ACCOUNT FOR THE YEAR ENDED 30TH SEPTEMBER, 1959.

EXPENDITURE		Rs	nP.	INCOME		Rs	nP.
To Paper Consumed	...	10,400	92	By Sales and Subscriptions of the Journal	...	4,937	26
„ Printing Charges (including Rs 600/- paid as proportionate salary to Representative at Madras and other incidentals)	...	7,354	28	„ Advertisements	...	9,054	16
„ Postage	...	1,535	67	„ Balance being Excess of Expenditure over Income carried to Balance Sheet	...	5,559	09
„ Miscellaneous Expenses	...	63	50				
„ Bad debts written off	...	196	14				
Total	...	19,550	51	Total	...	19,550	51

BALANCE SHEET AS AT 30TH SEPTEMBER, 1959.

LIABILITIES		Rs	nP.	ASSETS		Rs	nP.
SUNDRY CREDITORS				BOOK DEBTS			
Salary proportionate to Representative at Madras for the month of September, 1959		50	00	For Advertisement	...	2,764	75
DUE TO A—GENERAL ACCOUNT	...	5,253	72	For Sale of Journal	...	101	63
SURPLUS ACCOUNT				STOCK IN HAND (Certified as to quantities & values by the Secretary)	...	2,866	38
Balance as per last Balance Sheet	...	5,441	10	STAMPS IN HAND (including Revenue stamps)	...	45	09
Less: Balance being excess of Expenditure over Income as per annexed Income & Expenditure Account	...	5,559	09	PROFIT AND LOSS ACCOUNT			
Balance as per contra	...	117	99	Balance as per contra	...	117	99
Total	...	5,303	72	Total	...	5,303	72

(Sd.) A. J. D'COSTA,
Secretary.

AUDITORS' REPORT

We have audited the Balance Sheet of the INDIAN ROADS CONGRESS (Transport-Communications Monthly Review) as at 30th September, 1959, above set forth, along with the Income & Expenditure Account for the year ended upon that date and have obtained all the information and explanations we have required.

In our opinion, the above Balance Sheet set forth gives a true and correct view of the state of the affairs of the Congress according to the best of our information and explanations given to us and as shown by the books.

41-L, Connaught Circus,
New Delhi.
Dated, this 29th day of December, 1959.

(Sd.) J. C. CHANDIOK,
B.A., A.C.A. (England & Wales), F.C.A.,
For Walker Chandiock & Co., Chartered Accountants.

INDIAN ROADS CONGRESS

REPORT OF THE COUNCIL TO THE GENERAL BODY OF MEMBERS FOR THE PERIOD 1ST JANUARY TO THE 31ST DECEMBER 1959.

[The report covers the period from the 1st January to the 31st December 1959, though a few matters referred to in it are carried beyond the latter date for convenience and completeness of record.]

1. GENERAL

The Twenty-third Session of the Indian Roads Congress was held at Hyderabad in January 1959 when 288 members and 11 invitees attended the Session. The 7 Papers published in the Journal of the Indian Roads Congress, Volume XXIII-parts 1 to 3, were read and discussed. Eighteen Committees were reconstituted to deal with various engineering and administrative problems. The Executive Committee held meetings at New Delhi on the 13th March, the 29th August 1959, and the 13th January 1960.

2. ADMINISTRATION

Shri U. J. Bhatt, Chief Engineer, P.W.D., B. & R., Bombay was elected President at the Hyderabad Session. Shri H. P. Sinha, Consulting Engineer to the Govt. of India (Road Development), continued to function as Honorary Treasurer, and Shri D. G. Bhagat, Deputy Consulting Engineer (Roads) continued to work as Honorary Deputy Treasurer.

Shri A.J. D'Costa continued to work as Honorary Secretary. Shri Hukam Singh was appointed as Tech. Secretary on the 11th April 1959.

3. OFFICE

The office continued to function in New Delhi. It disposed of 14,192 receipts and issued 39,000 letters during the period under report.

The staff worked satisfactorily.

4. MEMBERSHIP

(1) The number of members on the rolls on the 30th September 1959 was 1805 (1 Honorary, 1 Associate Honorary, 1758 ordinary and 45 associates). During the year there were 198 new admissions and 75 removals from the rolls. The removals were the result of: 25 resignations; 14 deaths; 36 non-payment of arrears of subscription.

In view of the Silver Jubilee Session of the Congress, special efforts were made to increase the number of members. As a result of various efforts made, 205 new members have been enrolled from 1-1-59 to 31-12-59. This is a record increase on the rolls of the Congress in any particular year.

(2) **Life membership:** During the Congress year, 1st October 1958 to the 30th September 1959, 11 members were enrolled as life members. The number of life members on the 30th September 1959, was 154. This number is, however, included in the total number of ordinary members. The fees received from them have been transferred to the Building, Museum and Technical Fund after deducting Rs 10 per member for initial expenses.

5. DEATHS

It is with deep regret that the Council records the deaths of the following members:

P. N. Sharma	J. P. Singh
S. K. Subramaniam	J. C. Gauba
B. C. Das	G. N. Senapathy
J. S. Pimple	M. D. Menon
M. Krishnamurti	D. B. Nagarkar
K. V. Siddabasaviah	P. S. Sharangpani
B. D. Nanda	J. K. Roy
H. E. Ormerod	S. Jambunathan
Teja Singh Malik	H. F. Bamji

6. BUDGET

The budget for the year 1959-60 and the "actuals" for 1958-59 were placed before the Executive Committee at their

meeting held on the 13th January 1960. The estimates have been placed before the Council at their 55th meeting. The actuals for 1958-59 show a deficit of Rs 5,413 against an estimated deficit of Rs 35,412. The reduction in the deficit was mainly due to savings under 'Establishment', 'Equipment' and 'Printing'.

The total contribution received from the Central and State Governments during the year ending the 30th September 1959 amounted to Rs 65,000 against an estimated amount of Rs 80,000. The defaulter States are being urged to expedite payment of the outstanding contributions. It is expected that the outstanding contributions will be realized during the current year. Sums totalling Rs 31,500 have been already received after the 30th September 1959.

An appeal for increased contributions towards the funds of the I.R.C. on the basis of $\frac{1}{4}$ per cent of the share of each State from the Central Road Fund or $1\frac{1}{2}$ times the present contribution, whichever is greater, was issued to all State Governments on the 19th March 1959. This appeal was followed by D.O. letters to Chief Engineers of States to persuade their Governments to agree to the request of the Indian Roads Congress for enhanced financial assistance on the basis proposed so that the I.R.C. may be able to tide over the financial difficulties and continue the useful programme of work. In response, the Govt. of India and the following States have kindly increased their annual contribution to the full amount requested for by the I. R. C.

Name of Govt.	Old contribution	Contribution proposed	Contribution sanctioned
	Rs	Rs	Rs
Govt. of India	10,000	20,000	20,000
Madras	2,500	5,500	5,500
Mysore	2,000	5,500	5,500
Punjab	2,500	4,500	4,500

The Indian Roads Congress is in correspondence with other States to increase their contributions to the amounts proposed.

The matter was considered by the Council at their 55th meeting held at Bangalore on the 28th January 1960 and while greatly appreciating the response of the State Governments who had kindly agreed to contribute towards the funds of the Congress on the basis proposed, the Council hoped that other States would also soon agree to contribute towards the funds of the Congress at the scale proposed.

The Council also greatly appreciated the increase in contribution of the Government of India from Rs 10,000 to Rs 20,000 which will go a long way to help the Congress to undertake extra technical activities.

The arrears of subscription at the beginning of the Congress year 1958-59 amounted to Rs 16,868 which were due from 341 members. The names of 40 members, who had failed to pay their subscription, were removed from the rolls. Consequently, a sum of Rs 4,737.50 standing as arrears against these members was written off by the Executive Committee during 1958-59.

A sum of Rs 3,291.25 was realised from 90 members during 1958-59.

After adding the arrears for 1958-59, the total arrears as on the 1st October 1959 stood at Rs 18,009.19 due from 343 members. Efforts are being made to realise the arrears.

7. AUDIT

At the Twenty-third Session at Hyderabad it was decided to appoint M/s. Walker, Chandiook & Co., Chartered Accountants and Auditors, Delhi to audit the accounts of the Congress for 1958-59. The report was examined by the Executive Committee on the 13th January 1960. It was also placed before the Council at their 55th meeting on the 28th January 1960.

8. PUBLICATIONS

There was a very increased demand for the publications of the Indian Roads Congress during the year under report. Publications amounting to Rs 17,656 were sold during the year against a sum of Rs 10,231 realised on this account last year.

During the year, finalised Section II of the Bridge Code dealing with "loads and stresses" and Bound Volume XXII and XXIII were issued. In addition, Paper No. 167 "Design of Small Bridges and Culverts" and "Recommended Practice for the Location and Layout of Roadside Motor-Fuel Filling Stations"

were reprinted. The increase in sales is mainly due to Section II of Bridge Code and Paper No. 167.

Copies of the publications continued to be supplied on reciprocal basis to several technical institutions in India, the United States of America, the United Kingdom, Australia, Switzerland, Germany, Japan, New Zealand, U. S. S. R., etc. Copies were also sent to the offices of the United Nations Organization in the Far East. Recently some more Institutions have agreed for the exchange of their literature with our Journals. A list of the periodicals which are being received in the I. R. C. library is given in the Appendix.

The Transport-Communications Monthly Review : The Indian Roads Congress is popularising modern ideas on Road Development and Road Engineering for the benefit of Engineers who, owing to their whole-time pre-occupations with official duties, are not able to keep abreast of the advances in the science of Road Engineering. Original articles on roads and bridges are also being published in the Review.

The members of Indian Roads Congress, subordinate engineering staff and engineering students can obtain this publication at a concessional rate of Rs 8 per annum against the ordinary rate of Rs 14 per annum. At present there are 350 subscribers for this publication.

Complimentary copies of the Review are being issued as usual to important persons and engineering colleges in India. Complimentary copies of the issue for February 1959 were also given to all members of the Indian Roads Congress.

Members and other readers of the Review are requested to take a hand in making the Review more useful by sending articles, photographs, etc., for publication.

9. INFORMATION

Enquiries from members as well as non-members on various problems relating to Highway Engineering and allied subjects were attended to.

10. LIBRARY

A large number of technical journals of institutions in India and abroad were received in exchange for the Indian Roads Congress publications. Some new books and standards of the British, Swiss, German and the Indian Standards Institution were added to the Library of the Congress. Members can borrow books from

the libraries of the Congress, and the Consulting Engineer (Road Development) by writing to the Secretary, Indian Roads Congress. The rules regarding the loan of books are published in Volume XXIV-part 1 of the Journal of the Congress. Lists of additions to the two libraries are published every month in the "Transport-Communications Monthly Review". Further, lists of selected literature classified according to subjects, are being published for the information of members. Abstracts of more important books and articles are also published. Members are requested to make free use of the library.

132 books were issued on loan during the year under report. This is a very small number considering that the Society has a membership of nearly 1,850. Members have to be urged to make more use of these libraries.

11. MEDALS AND PRIZES

The Papers Committee considered the Papers discussed at the Twenty-second Session for the award of "Mitchell Medal" and the "I. R. C. Medal". The Committee selected the following Paper for the award of "Indian Roads Congress Medal".

Paper No. 205—"The Importance of Subgrade Compaction in the Economic Design of Flexible Pavement" by Shri S. R. Mehra & Dr. H. L. Uppal.

The Committee also highly commended Paper No. 200—"Asphalt Paving Mixtures—Their Design and Composition" by Shri N. H. Taylor.

The award was made by His Excellency the Governor of Andhra Pradesh at the Inaugural Ceremony of the Twenty-third Session at Hyderabad in January 1959.

12. BRIDGING INDIA'S RIVERS

The Indian Roads Congress had been collecting information relating to a number of bridges built on National Highways and some other roads. A Booklet giving an account of about 50 bridges has been issued. It is proposed to issue a few complimentary copies of this publication to Ministers and high officials interested in the subject.

13. MEMBERSHIP OF SOCIETIES

- (1) The Indian Roads Congress is a member of the Indian National Society of Soil Mechanics and Foundation

Engineering. Shri S. R. Mehra is the representative of the Indian Roads Congress.

- (2) The Congress is a sustaining member of the Indian Standards Institution and maintains a close liaison with the activities of the Institution through representatives nominated to serve on their Committees dealing with subjects which have a bearing on roads.

The present representatives of the Congress on the Councils and Committees are:

- (i) **Engineering Division Council:** Goverdhan Lal
- (ii) **Building Division Council:**
Principal representative —Shri K. K. Nambiar
Alternate „ —Shri V. Kandaswamy
- (iii) **Bridges Sectional Committee:**
Principal representative —Shri S. K. Ghosh
Alternate „ —Shri R. K. Kochhar
- (iv) **Cement Sectional Committee:** Dr. Bh. Subbaraju
- (v) **Bitumen & Tar Products Sectional Committee:**
Principal representative —Shri Kartik Prasad
Alternate „ —Shri C. G. Swaminathan
- (vi) **Drawings Sectional Committee:**
„ —Shri H. P. Sinha
- (vii) **Tar & Tar Products Subcommittee:**
Principal representative —Shri G. S. Ganapathy
Alternate „ —Shri Balbir Singh

The other representatives of the Congress on the various Committees of that Institution are:—

- | | |
|---|---|
| EDC: Terminology | } Shri J. M. Trehan (Principal representative) |
| Notations and Drawings Sectional Committee | |
| | } Shri J. Subrahmanyam (Alternate representative) |
| | |
| BDC: 7—Structural Steel Sectional Committee | } Shri D. S. Desai (Principal representative) |
| | |
| | } Shri M. P. Nagarsheth (Alternate representative). |
| | |

(3) Shri K. K. Nambiar continued to represent the Indian Roads Congress on the Prestressed Concrete Group.

(4) Expert Panel to guide the indigenous development of Road Making and Constructional Equipment.

The Government of India, have formed an "Expert Panel" to gather data to guide the indigenous development of Road Making and Constructional Equipments. Shri K. K. Nambiar continues to represent the Indian Roads Congress on this Panel.

(5) Council and Committees for the Central Road Research Institute.

The following represent the Indian Roads Congress:

Executive Council—President, Indian Roads Congress
(Principal representative).

Shri D. G. Bhagat—(Alternate representative)

Scientific Advisory Committee—Shri Goverdhan Lal

Road Research Committee —Shri J. M. Trehan

14. TECHNICAL ACTIVITIES

(1) Specifications and Standards Committee

The last meeting of the Committee was held on the 16th August 1958. The following subjects were discussed:

- (i) Design of kilometre stones;
- (ii) Layout for fuel filling-cum-service stations;
- (iii) Limiting gradients and lengths for cycle tracks;
- (iv) Numbering of bridges and culverts;
- (v) Standards for roads within urban limits;
- (vi) Future programme of the Committee; and
- (vii) Metricization in matters concerning road design, etc.

The standard on the design of kilometre stones finalised by the Committee was considered by the Council at their meeting held on the 6th January 1959 where it was decided that before the question of finalization of the design was considered, the CRRI, should carry out the necessary experiments and submit a complete report to the Specifications and Standards Committee. The report of CRRI has

since been received and it will be considered by the Specifications and Standards Committee at their next meeting.

The Committee discussed the various difficulties in the layout for fuel filling-cum-service stations and decided that this question should be examined in detail. The oil companies were requested to submit their proposals, if any, so that these might be kept in view while working out draft standards. The draft standards will be placed before the Specifications and Standards Committee at the next meeting.

The Central Road Research Institute and the Punjab P.W.D. had been requested to investigate the volume of cycle and other vehicular traffic which would justify the provision of separate cycle tracks and to determine the limiting gradients which should be adopted. A report of investigation received from the Central Road Research Institute was considered by the Committee at its meeting held on the 4th January 1958. It was decided that (i) further study should be conducted to find out the maximum distance for the various gradients and that (ii) pending further investigation the maximum gradient of 1 in 50 could be adopted on approaches to road over-bridges.

The Central Road Research Institute have since intimated that the work was carried out in the field to find volume of cycle traffic justifying separate cycle tracks and it was observed by them that justification of separate cycle tracks also had its relationship with the volume of other type of traffic travelling on that road. A research Paper on the subject has been promised by the Central Road Research Institute.

The Punjab P.W.D. had intimated that the intensity of cycle traffic on most of the roads in the State was insufficient for providing cycle tracks.

The comments of various Municipalities obtained on the Recommended Practice for the Design and Layout of Cycle Tracks have been considered and draft Recommended Practice will be considered by the Committee at its meeting at Bangalore so that a finalised standard may be issued.

The standard entitled "Numbering of Bridges and Culverts" as approved by the Committee and later by the Council has been published in Vol. XXIV-part I of the Journal of the Indian Roads Congress and also separately.

As decided by the Committee, the space standards for urban roads framed by the Town Planning Organization for Greater Delhi have been circulated to the Chief Engineers of States for their

comments. Comments have been received from a few States. As soon as comments from other States are received the Committee will be requested to lay down standards for roads within urban limits.

The Committee decided to allot the drafting of standards on some subjects to the existing concerned Committees of the Indian Roads Congress. For some other subjects on their agenda, they decided to set up subcommittees for drafting standards and codes of practice. Progress about the work of these Committees is awaited.

The Committee agreed to proceed with the work of metricization in matters concerning road design, etc., in consultation with the Indian Standards Institution.

The draft Recommended Practice for Borrow Pits for Highway Embankments is expected to be finalised shortly in the light of the comments of members of the Committee and Council.

A small subcommittee had been entrusted to go into the details of the studies being made to find out the benefits of road communication in under-developed regions. Their report is awaited.

The amendment allowing reasonable relaxation to the Recommended Practice for Location and Layout of Roadside Motor Fuel-Filling Stations was approved by the Council at their meeting held at Hyderabad in January 1959 and it has since been incorporated in the standard.

The question of the publication of the form for recording the test values of stone metal and type designs for village or place name sign as approved by the Committee is still under consideration.

The Council at their 50th meeting held on the 4th January 1958 considered the recommendations of the Committee that the British Standard on the definition of the nominal sizes for road aggregates and tolerances as well as the method of determining the flakiness index (B.S. 63:1951) may be adopted. It was agreed by the Council that the matter may be further reconsidered by the Committee in view of the difficulties that might have to be faced due to the change-over to the metric system.

The standards of Road-Rail Level Crossings revised in the light of comments of the Committee had been forwarded to the Ministry of Transport and Communications (Roads Wing) for finalisation in consultation with the Railway Board.

The Council at their meeting held in August 1958 discussed the draft standard form for recording traffic census on non-urban roads. It was to be finalised by the Convenor of the Committee in the light of comments of the members of the Council. The finalised forms when received will be published.

It is proposed to finalise a Policy on Roadside Advertisement, after taking into consideration the views of various Organizations concerned in the matter. Accordingly, this Policy was circulated for comments to various Municipalities/Organizations. Some comments have already been received. After some more comments are received, those will be passed on to the Specifications and Standards Committee for consideration.

The finalisation of the standard on (1) Road Layout, Land Widths, Building Lines and Control Widths, (2) Road Profile Gradients, (3) Road Design Vehicles and Clearances, (4) Sight Distances and Set Backs, (5) Horizontal, Transition and Superelevation of Curves, (6) Vertical Curves and Shock Free Curves at Highways is also in progress.

The following subjects are under consideration* of the Committee:

- (i) Design of road intersections at grade;
- (ii) Specifications for water-bound macadam;
- (iii) Arboriculture;
- (iv) Standard section and profiles of road on curves;
- (v) Concrete pavements;
- (vi) Bituminous pavements;
- (vii) Earthwork for roads;
- (viii) Base courses; and
- (ix) Specifications for light chipping carpets for $\frac{3}{4}$ in. thick bituminous carpet and $\frac{3}{4}$ in. thick tar carpets.

(2) Bridges Committee

The Committee held meetings on the 8th and 9th January 1959 and on the 11th and 12th August 1959.

Section I of the Bridge Code dealing with "General Features of Design" and Section II dealing with "Loads and Stresses" have already been printed.

Sections of the Bridge Code dealing with the following subjects are under study :

- (i) Prestressed Concrete ;
- (ii) Steel Structures ;
- (iii) Masonry Structures ; and
- (iv) Reinforced Cement Concrete.

(3) Test Track Committee

The Committee held its meeting on the 9th January 1959.

The Committee at its earlier meeting held on 5-12-58 had reviewed the results of the 11th series of tests which related to bituminous carpet over (a) sand-soil aggregate stabilized base course with and without stone metal grafting, (b) stone metal grafted sand-moorum stabilized base, and (c) sand-soil-cement stabilized base course having stone grafted and water-bound macadam surface under adverse moisture conditions.

The observations indicated the necessity of a compacted layer of water-bound macadam in between the bituminous surfacing and the stabilized soil course under the conditions of the test in which water could not be completely prevented from getting into contact with the stabilized soil course.

It is, however, to be seen whether laying of bitumen surfacing directly over the stabilized soil pavement with stone graft may be suitable where surface water can be completely sealed off and the traffic is not very heavy.

All the reports of the work done at the Road Test Track, Calcutta from 1949 to 1958 have been compiled and checked by the Convenor and these will be published shortly.

The land on which the Test Track, Majherhat, was situated was taken on lease from Calcutta Port Commissioners on short term basis. The lease expired in March 1959 and no further extension of it could be arranged as the land was essentially required for remodelling the yard by Eastern Railways. It was, therefore, decided by the Government of India to shift the Government Road Test Track from Majherhat to a permanent site of its own at Pailan on Diamond Harbour Road near Calcutta which is about 8 miles from Alipur, Calcutta, so that research work could be conducted uninterrupted and the highway engineers who are interested in this

type of experimental research work may frequently visit, and acquaint themselves with the research activities. All the electrical and mechanical tools and plant and the structural parts of the traction and lighting equipments of the Test Track, Majherhat have been dismantled, and removed to the new site at Pailan where arrangement is being made to construct the test track on a new plan. The details regarding traction equipments, lighting of the tracks, construction of sub-soil drain, laying of monorails, etc., will be discussed by the Committee at its meeting at Bangalore so that modification to this arrangement, if any considered necessary may be given effect to.

The proposal to build a diversion on Diamond Harbour Road adjacent to the oval test track for testing test track specification was approved at the last Test Track Committee meeting at Hyderabad on 9-1-1959. But it was suggested to convert a section of the Diamond Harbour Road at Pailan into a divided highway so that both carriageways might be used for testing specifications. A layout plan of the diversion as per above proposal has been prepared and will be placed before the Committee for finalization.

Some data have been collected in connection with the behaviour of the sand-soil-stabilized pavement and grafted sand-soil-cement stabilized pavement of some of the roads of West Bengal. These roads were constructed as per specification similar to that of the test track. The detailed reports will be considered by the Committee.

Tests on surface dressing laid on the Delhi-Mathura Road near the Central Road Research Institute, Okhla (Delhi), have been under study for about 4½ years.

(4) Research Organization Committee

The Committee held its meeting on the 6th January 1959.

At its meeting held on the 4th and 5th January 1958, the Committee considered the points arising out of the discussion on the first Road Research Report presented at the Shillong Session of the Congress in May 1957. As a result of this, the following progress was made.

The Central Road Research Institute agreed to carry out investigations to see if some more reliable methods than the flow cone method could be evolved for the measurement of consistency of cement-grout in grouted pavements. The Institute has reported that they are unable to recommend a more reliable method.

On the recommendation of the Research Organization Committee, the Executive Committee, at their meeting on the 14th July 1958, decided that laboratory experiments should be carried out to examine the possibility of using lean concrete mixes in road works, preferably leaner than those so far tried. The Road Research Laboratories were, therefore, requested to carry out the necessary experiments. The reports are awaited.

As suggested by the Committee, the Central Road Research Institute and other Road Research Laboratories were requested to carry out research on the possibilities of partial replacement of sand by soil in cement sand mortars for masonry.

The Central Road Research Institute were requested to draw up a programme for carrying out laboratory and field experiments on evaluation of stripping. It was also suggested that tests should be carried out with various types of stone metal in use at present in different regions. Their report is awaited.

The Government of India had been requested to recommend to State Governments to establish, in the cases of big cities, traffic engineering cells in the engineering set-ups of the concerned Municipalities or Corporations. In the case of other cities, the problems relating to traffic engineering should be referred to the State Chief Engineers for advice. The Offices of Chief Engineers should be staffed with suitable specialists in this line.

The matter was also considered by the Chief Engineers at their meeting held on 9-1-1958 and they promised to send their views to the Roads Wing. The matter is under consideration with them.

At the meetings held on the 11th August 1958 and 6th Jan. 1959, the Committee discussed the points arising out of the discussion on the Second Annual Report on road research in India. As a result the following progress has been made.

Various road research laboratories had been requested to carry out research to establish a co-relation between the compressive strength and abrasive resistance of cement concrete. The reports are awaited.

In order to make a comparative study of the behaviour of flexible overlays, each State P.W.D., had been requested to lay control sections with pavement thickness designed for the subgrade condition near stretches with different thicknesses of over-lays. The Central Road Research Institute could be approached for any advice that might be required.

It was agreed that even though the special type of bitumen used for bituminous pavements for tracked vehicles in U.K., was not available in India, locally available bitumens might be tried by the military authorities who generally used tracked vehicles.

The Central Road Research Institute and the Madras Road Research Station had agreed to conduct research on temperature stresses in rigid pavements. Methods for strengthening concrete pavements and their resistance to abrasion are already under investigation at the Central Road Research Institute.

As recommended by the Committee, the State road research laboratories were requested to conduct experiments, if possible, on the use of air-entrained concrete in road construction on the same basis as experiments on this subject were being conducted by the CRRI. A Paper on this subject has been published in Road Research Bulletin No. 6.

In order to investigate the economic aspect of using silicones as an anti-frothing agent, the Road Research Laboratories were requested to carry out experiments with lime, adhevia-T and silicones to assess their comparative merits as well as comparative economy.

The points arising out of discussions on the last Road Research Report discussed at Hyderabad in January 1959 will be considered by the Committee at Bangalore.

As desired by the Committee, the Chief Engineers of State P.W.Ds. were requested to send annual reports of their road research stations to the Secretary, Indian Roads Congress, as early as possible after the close of the year ending on 31st March 1959. The annual reports were studied and a general report has been published in Volume XXIV-part 4 of the I.R.C. Journal for discussion at the Session of the Congress at Bangalore.

(5) Soil Research Committee

The Committee held a meeting on the 9th January 1959.

It was decided that as soon as specifications for stabilising black cotton soil were ready, the Chief Engineers of States should be requested to lay experimental stretches of sufficient length to those specifications. The draft specifications have been received from the C.R.R.I. and those will be considered by the Committee in their meeting at Bangalore.

The Central Road Research Institute and the Hyderabad Engineering Research Station had been requested to conduct experiments to find out the most suitable particle size to which black cotton soil clods should be reduced for effective stabilization with cement. The Committee, however, felt that as stabilization with lime appeared to hold out better promise, the degree of pulverization for stabilization with lime should be investigated first and for stabilization with cement later on.

The Committee at their meeting held on the 9th January 1959 decided that the degree of pulverization suggested by the Central Road Research Institute (between 60 and 100) should be given a trial by the various road research laboratories for working out the binder content in relation to the required strength. Modifications to the procedure could be suggested on the basis of the experience gained. Accordingly, the road research laboratories were requested to carry out research and to send their reports.

As decided by the Committee, the Chief Engineers of States were requested to try soil-cement blocks wherever possible as a material of construction for protection work on rivers where velocity of flow was not very high. The comments, received will be considered by the Committee at their next meeting.

The Executive Committee at their meeting held on the 14th July 1958 considered the views of the Committee that for a comparative study and for finding out economic possibilities of a particular type of machinery, the use of all types of machinery on a work was necessary and agreed that the Central Road Research Institute should be requested to carry out such tests and prepare a report as early as possible. The Central Road Research Institute were addressed accordingly. Their reply is awaited.

The views of the Committee on the application of the results of research were considered at the Chief Engineers' meeting held on the 9th January 1958. It was agreed at that meeting that the proposal for earmarking 10 per cent of the State's allocation from the Central Road Fund for long experimental stretches should be recommended to State Governments for their consideration. The question is being examined by the Roads Wing in consultation with the State Chief Engineers.

The Committee decided that the classification of black cotton soils suggested in Road Research Note No. 6 should be accepted tentatively and that the various road research laboratories should be requested to test this classification in the field and report practical difficulties and suggest modifications, if necessary. In particular, Bombay, Hyderabad and Madras should take up the investigation

and correlate black cotton soils with the new sub-groups. The Madras Highways Research Station has suggested some modifications which were circulated to other research laboratories for comments. The comments received will be discussed by Committee at the next meeting at Bangalore. The Committee desired that the National Buildings Organization and Central Board of Irrigation and Power should be requested to test the classification from the buildings point of view. The Railway Research Centre at Lucknow should also be requested to test the classification. The question of addressing the various authorities is under consideration.

As desired by the Committee at their meeting held on the 9th January 1959, the State P.W.Ds. have been requested to try the suggested sub-division mentioned in Road Research Note No. 6, check its validity by actual field observations and submit reports. A map showing classification of black cotton soils, received from CRRRI has been forwarded to them.

The Indian Standards Institution sent for the comments of the Indian Roads Congress the draft Indian Standard for Classification and Identification of Soils for General Engineering purposes.

Copies of the draft Indian Standard were circulated to the members of the Soil Research Committee and their comments invited. The subject was also discussed at the meeting of the Committee at Hyderabad on the 9th January 1959.

It is understood that the Indian Standards Institution have finalised their standard on the subject.

As desired by the Committee at their meeting held on 9th January 1959, information on road construction in sandy areas with the technique of stabilization of sand to give a firm base is being collected by the C. R. R. I. and the I. R. C. The State P. W. Ds. have already been addressed in the matter. As soon as this information is collected and processed by the C. R. R. I., it will be placed before the Committee for further action.

The State P. W. Ds. have been addressed to supply information regarding their experiences about the use of soil-cement in road construction. The information when collected will be passed on to the C. R. R. I. for drafting specifications for soil cement pavements for placing before the Soil Research Committee.

The C. R. R. I. have been requested to draft detailed specifications for the compaction of subgrade and sub-base for water-bound

macadam roads and stabilized soil sub-base and base courses for consideration by the Committee.

A copy of the report of the Panel Discussion on construction of roads in waterlogged areas held at Hyderabad in January 1959 has been forwarded to the Soil Research Committee for drafting the necessary specifications for road construction in waterlogged areas having soils richly impregnated with sulphates and other injurious salts.

The Central Road Research Institute have been requested to finalise the specifications for stabilized soil base courses and wearing courses for circulation to members of the Committee. The specifications and practices for stabilised soil base courses and wearing courses received from various State P. W. Ds. had already been passed on to them. The specifications suggested by the Central Road Research Institute will be discussed at the next meeting.

The Executive Committee at their meeting held on the 14th July 1958 did not agree to the setting up of a Research Implementation Committee suggested by the Soil Research Committee. They felt that the Executive Committee could look after this work and that the more important cases could be referred to the Council.

The Committee had also decided that the State Governments should be requested to exploit the local materials (soil and soft aggregates) to the greatest extent possible and that the Central and State Govts. should earmark a certain percentage of their highway budgets for constructing roads using such local materials. The Executive Committee at their meeting held on the 30th Nov. 1957 decided that suitable specifications for the use of cheap materials for road construction should be prepared before recommendations of the Committee are circulated to the authorities. These specifications are awaited from the Committee.

(6) Education Committee

The Committee held its meeting on the 8th January 1959.

Following up the reply from the All-India Council of Technical Education stating that the universities could not switch over to the Indian Roads Congress Education Committee's syllabus for Highway Engineering taking up 60 hours of study in the Bachelors' Degree course, an inquiry was made to find out how many hours of

study were devoted for this subject at present in the different institutions. Their replies indicated that 3 out of the 4 institutions have already more than 60 hours' duration for Highway Engineering in the curriculum of their degree course in Civil Engineering. The substitution of the existing syllabii with the syllabii prepared by the Committee was, therefore, recommended pointing out advantages of a uniform training method in all the colleges. It was also recommended that the universities which did not have this minimum curricular time for Highway Engineering should consider and provide adequate number of hours.

The Ministry of Education intimated that the All-India Board of Technical Studies in Engineering and Metallurgy had noted the views of the Indian Roads Congress and desired that the syllabus Committee for framing the detailed model courses for the National diploma in Civil Engineering on the Five-Year Integrated Pattern (which would be circulated to all the universities) should keep the suggestions of the Congress in view. The Board however expressed the view that the time set apart for the subject in the various universities for subject of Highway Engineering is adequate and no special request need be made to the Universities at this stage, for a uniform provision of 60 hours throughout the course.

As desired by the Board, the views of the Indian Roads Congress regarding the standard syllabus for Highway Engineering will be brought to the notice of its syllabus Committee at its next meeting.

A syllabus in Highway Engineering for inclusion in the diploma courses for overseers and supervisors was being prepared by the Committee. As soon as it is finalised it will be forwarded to the All-India Council for Technical Education.

The syllabii for post-graduate courses in Highway Engineering of Indian Universities is under examination along with the syllabii of Post-Graduate Courses in Highway Engineering in foreign countries.

The views of the Education Committee on the institution of refresher courses at Universities and Colleges were accepted by the Executive Committee. The Education Committee was requested to finalise its own syllabus for refresher courses for Highway Engineering. The Executive Committee also decided that in order to cover various regions in the country, in addition to Guindy, Chandigarh, Kharagpur and Roorkee Engineering Colleges, the V. J. Technical Institute, Bombay, the College of Engineering, Poona and the Engineering College at Anantapur (Andhra) should also be

approached to conduct Refresher Courses for the Highway Engineers.

These three institutions were requested to supply details of the syllabus for Refresher Courses in case they had conducted or intended to conduct such courses. The syllabii received so far from these institutions as well as from a number of foreign technical institutions have been passed on to the Committee for further action.

(7) Provincialization of Local Bodies Engineering Services Committee

The Committee held a meeting on the 9th January 1959.

There has not been any further progress in the work of this Committee except what has already been recorded in the report of the Council published at pages 673-674 in Volume XXII-part 4 of the Indian Roads Congress Journal.

(8) Manufacture of Road Making Machinery and Mechanization Committee

The Committee held meeting on the 9th January 1959.

The Committee agreed that the manufacture of motor graders, bituminous mixers and bitumen distributors should be taken up in India. The Committee further decided the size and type of the machines considered suitable for manufacture in this country. It was also agreed that the forecast of the requirements of the items should be collected from the States in order to ensure early manufacture of these items of machinery.

At the instance of the Technical Subcommittee of the Road Making and Constructional Equipment Machinery Panel set up under the auspices of the Ministry of Commerce and Industry (Development Wing), the following information has been called for from State P.W.Ds. in order to consider the question of the manufacture in India of various items of road making machinery:

- (a) To what extent mechanization is desirable keeping in view the employment angle?
- (b) Likely total requirements of the various items of machinery during the 3rd and 4th Plan periods;

- (c) Sizes of various items of machinery along with numbers which have been in use in the country so far; and
- (d) Whether the sizes which have been in use in the country so far would be suitable for use during the 3rd and 4th Plan periods.

The information called for pertains only to road making machinery and is to be based on the likely requirements of State P. W. Ds. during the 3rd and 4th Plan periods. Earthmoving machinery such as dozers, scrapers, excavators, etc., compressors, pumps and pneumatic tools is being dealt with separately by the Ministry of Commerce and Industry. The information has been received from a few States. As soon as complete information is received, it will be passed on to the Ministry of Commerce and Industry.

The Committee had been entrusted with the compilation of a list of all big and small machinery manufacturers, suppliers and dealers in different parts of India along with their addresses and the types of machinery sold by them. As soon as the compilation is complete, it will be published in the Journal of the Indian Roads Congress for the information of the members.

Other subjects under consideration with the Committee are: (i) the investigation of the suitable equipment to handle supplies of bitumen in bulk, and (ii) using mechanised methods in road construction.

(9) Road Transport Operation Cost Committee

The Road Transport Operation Cost Committee which was appointed at the instance of the Government of India to study (i) the cost of operation of motor vehicles on different classes of roads, and (ii) the economy resulting from road improvements, at its meeting held on the 5th January 1959, considered the revised interim analysis of the cost of operation data of the experiments being carried out by Bombay and Uttar Pradesh State Transport Undertakings according to design and specifications supplied by this Committee. The experiments are being conducted both on katcha and pucca roads. It was observed that the consumption patterns of fuel oil and lubricant oil in the selected routes had almost stabilised and the conclusion will hardly require any revision if the duration of the experiment is extended.

So far as the lubricant oil consumption was concerned, it was once again confirmed that the influence of extraneous factors like crankcase capacity or crankcase dilution by fuel oil, etc., are extre-

mely important as compared to deterioration of lubricating oil on account of types and conditions of surfaces over which vehicles in question travel. As regards the variation in the frequency of oil change by the vehicles in U.P. and Bombay, it was observed that it depended entirely on the maintenance policy of the two Organizations. It was also partly due to the variation of the crankcase capacity of the types of vehicles used in the two States. As desired by the Committee, the information regarding the capacity of crankcase fitted to the experimental vehicles were obtained from the two undertakings and this information will be placed before the Committee at its next meeting.

In order to compare correctly the consumption of fuel-oil, spare parts and tyre life on good concrete road and good black-topped road, the State Transport Undertakings have been requested to furnish to the Committee the details of the load factor, traffic intensity, specifications of surfaces etc. It was also recorded that factors like handling of vehicles, affect the consumption of spare parts and this point should be taken into account while analysing the consumption of spare parts.

The Committee noted that the life of tyre on good concrete road and on good black-topped road had substantially deviated from the previous averages so far as Bombay experiment was concerned. The Bombay State Transport Undertaking has promised to look into the matter.

The Committee has so far received data relating to experimental route in Bombay from March 1956 to February 1959 and in U. P. from December 1955 to January 1959. The Himachal Pradesh Government Undertaking also forwarded data for 2 months only and this being only for a very small period, its analysis has not been attempted so far.

A detailed analysis of the data relating to Bombay and U. P. generally confirms the findings of the previous report presented to the Committee at its meeting held in January 1959. These will be discussed in detail by the Committee at its meeting at Bangalore.

A detailed Paper on the subject has also been published in Vol. XXIV-part 3 of the Journal of the Indian Roads Congress. The results indicate in detail that there is substantial reduction in the cost of operation of motor vehicles with the improvement of road surfaces. Experience of other countries is also reviewed in this Paper.

(10) Cement Concrete Road Surfacing Committee

The Committee held its meeting on the 9th January 1959.

As desired by the Committee a note on a proposed basis for the selection of thickness of concrete roads for Indian conditions was circulated by the Convenor to the members of the Committee and the Chief Engineers of all States. They were also requested to indicate whether they desired to make any special suggestions or modifications to existing practice where laying of concrete for road construction in one layer for thicknesses greater than 6 in. was involved. The matter will be considered by the Committee at its next meeting.

A subcommittee had been formed to draft a standard form of condition survey of concrete roads. But since then the Executive Committee had taken a decision that as many of the concrete road surfaces were sub-standard and the reasons for their failure were so obvious, there would be no benefit in undertaking such a survey. The proposal was, therefore, dropped.

(11) Road Transport Development Committee •

The Committee held its meeting on the 10th January 1959.

The Committee's estimate regarding vehicle requirements were forwarded to the Planning Commission for their examination and action. After examining the proposal, the Planning Commission have informed that the production of commercial vehicles in the country is likely to be handicapped during the next few years by the limitation of foreign exchange and have further stressed that the Tariff Commission in their report of Automobile Industry (1956) had estimated that the annual demand for commercial vehicles would increase to 40,000 by the end of 1960-61. Every effort is being made by them to reach this target and to the extent possible foreign exchange is being released to the indigenous manufacturers to step up their capacity for internal production and to augment indigenous content of the vehicles.

Other recommendations of the Committee were also forwarded to the Governments concerned. As regards recommendations relating primarily to the issue of permits of vehicles with laden weight of 27,000 pounds and more and issue of permits for truck-trailers combinations where adequate standard and geometric design of roads permits such operation, replies received indicate encouraging response.

Other recommendations made by the Committee were the survey of weak bridges and culverts and the question of raising the permis-

sible laden weights of vehicles and upgrading of bridges and culverts, as also road surfaces, wherever necessary to carry additional loads. One more important recommendation made by the Committee was a suggestion that on account of the pressing need to strengthen bridges, culverts and road surfaces to carry the growing traffic, a very high priority has to be accorded to strengthen the existing traffic bearing roads. The response of the State Governments cannot be fully judged at present as only a few replies have been received so far.

The question of surveying and strengthening the weak bridges and culverts was also discussed at the Chief Engineers' meeting held in August 1958 at Bombay. It was decided that the Chief Engineers should survey at least two National Highway roads in their respective States and submit detailed reports to the Consulting Engineer (Road Development). Further, the State Governments were requested by the Roads Wing to carry out similar surveys in respect of State Highways and to take necessary action to strengthen or replace the weak bridges. The replies received will be considered by the Committee.

As regards the recommendation of the Committee to put goods transport by road on an organized basis, the Government of India have informed that a provision has already been included in the Motor Vehicles Act, 1939, empowering the State Governments to frame rules for licensing of agencies engaged in the business of collecting, forwarding and distribution of goods carried by public carriers. Insurance of goods, etc., is the concern of the operator only.

The Committee's recommendation about the maintenance of kutcha roads by proper authorities was also sent to State Governments. The replies received from Kerala and Bombay Governments show that necessary arrangements are being made by them in this direction. The replies from other State Governments are awaited.

In addition to the above recommendations, the Committee in its last meeting at Hyderabad proposed that 33½ per cent of fuel tax may be credited to the Central Road Fund. The recommendations of the Committee were put before the Executive Committee who suggested that the Road Transport Development Committee may reconsider their proposals as the question was intimately linked with the much larger issue of getting adequate funds from General Revenues for the road development plans and emphasising the Central Road Fund at this stage may not be advantageous. The Committee will consider this subject in its meeting at Bangalore.

(12) Stabilized Soil Roads Committee

The Committee had been constituted at the instance of the Council of Scientific and Industrial Research to inspect the stabilized soil roads already laid in the Punjab and other places and to give an assessment of the usefulness of the technique on the basis of service value given by these roads in relation to the first cost and subsequent maintenance, and in the background of prevailing traffic, climatic and subgrade moisture conditions.

The Committee would then make necessary recommendations for different areas in the country. The Committee would also suggest steps which might be taken for introduction of this type of road construction in various parts of the country.

The Committee held meetings on the 7th January and the 27th April 1958. The recommendations made by the Committee were placed before the Council at their meeting in August 1958.

The Committee had expressed the view that the technique of stabilized soil road construction adopted in the Punjab had been a success and the same specification could be adopted in other States also, under similar conditions and circumstances. The Director, Central Road Research Institute would draft a detailed resolution on the subject to be passed by the Council.

The Committee was to inspect the stabilized soil roads built in the southern States before making further recommendations. It is expected that these inspections will be made after the Bangalore Session.

(13) Community Projects Roads Maintenance Committee

The Committee held its meeting on the 6th January 1959.

As the mileage of roads constructed under the Community Project and National Extension Service Schemes forms a considerable percentage of the total mileage of roads in the country, it was felt that there was a need for a satisfactory arrangement for maintaining these roads.

The Committee studied the practices prevailing in connection with the construction of these roads as well as their up-keep which vary from place to place. At its last meeting, the Committee finalised the "Recommended Practice for the Maintenance of Road constructed under Community Project Administration and National Extension Block Services". The Recommended Practice was for-

warded to the Government of India, Ministry of Transport & Communications, Roads Wing with the request to forward it to the Ministry of Community Development and State Governments for adhering to the standards laid therein. The Ministry of Transport & Communications have taken necessary action.

The Recommended Practice was also circulated to members of the Council for their information.

(14) Traffic Engineering Committee

The Committee held its meetings on the 10th January 1959 and the 22nd and the 23rd October 1959.

The Committee has finalised the questionnaire on 'Parking and Loading of Vehicles' for circulation to Corporations and Major Municipalities. The questionnaire will be issued shortly.

The Committee considered road-signs. The consensus of opinion was that there was room for improving the road-signs in vogue. It was, therefore, decided that the new set of road-signs along with a detailed explanatory note should be forwarded to the Government of India, Ministry of Transport & Communications, Roads Wing for further necessary action.

It was also decided that as introduction of additional road signs and amending existing road signs will involve amendments of Motor Vehicles Act, the I. R. C. should publish the existing road signs.

The other subjects under consideration with the Committee are: (i) nomenclature for traffic engineering terms; (ii) (a) traffic marking and markers; and (b) traffic signals; (iii) street and highway lighting.

A Traffic Study Week under the auspices of ECAFE was organised at Bombay in October 1959. The Indian Roads Congress was represented at this Study Week through its eight delegates.

(15) Prevention of Ribbon Development Committee

The Committee held a meeting on the 9th January 1959.

The following recommendations of the Committee endorsed by the Executive Committee at their meeting held on the 13th March 1959 were forwarded to the Government of India with the request to take necessary action themselves and also to advise the State Governments to do the needful in the matter.

- (i) Taking into consideration the delay that is bound to take place in enactment of Highway Bills, the Central as well as State Govts. should immediately take steps to enact separate Bills to deal with the prevention of ribbon development;
- (ii) High priority should be given to the preparation of up-to-date and correct land plans for roads. For this purpose it would be necessary to appoint special revenue officers to deal with this matter in an expeditious manner;
- (iii) As even the enactment of separate Bills for prevention of ribbon development was bound to take time, and as the situation with regard to ribbon development was getting worse day by day, the Central as well as State Governments should, pending the enactment of such legislations, freeze the land adjoining various roads;
- (iv) In order to limit access to main highway, it was desirable that future development of villages and towns should be done on group development basis. This would also mitigate the chances of future ribbon development.

The reply of the Government of India is awaited.

15. MISCELLANEOUS

(1) PAPERS

26 Papers were received during the year. 8 were already in hand. Out of these 34 Papers, 10 were accepted for publication, 1 was published as an article in T. C. M. R., 13 were rejected, 5 were returned to Authors for revision and 5 were kept for consideration for the next Session.

The first and foremost objective of the Society is the advancement of the science of road building, towards which contribution of good Papers by members is essential. Members are requested to constantly bear in mind that the knowledge they have acquired must be passed on to their fellow Members and that a record must be kept for the benefit of posterity in the Journals of the Congress or the Transport-Communications Monthly Review.

The Council may also suggest to Members, especially the senior Members, that they should encourage the taking of notes and photo-

graphs during the progress of important works with the object of writing Papers for the Journal of the Congress and for contributing articles to the Transport-Communications Monthly Review.

**(2) POINTS ARISING OUT OF PRESIDENTIAL ADDRESS—
23rd SESSION**

The Executive Committee at their meeting held on the 13th March 1959 considered the various suggestions made in the Presidential Address of the 23rd Session and as decided by them various recommendations dealing with the road finance, increasing the number of motor vehicles, organization of Public Works Departments, All-India Transportation Board, mechanization in road construction, improving the conditions and status of engineering personnel have been forwarded to the Government of India.

(3) PANEL DISCUSSION ON SURFACE DRESSING

A questionnaire on surface dressing was discussed during the 19th and 20th Sessions of the Indian Roads Congress held in June 1955 and January 1956 respectively. The discussions and written replies were studied by the Central Road Research Institute and they have sent tentative specification for single coat bituminous surface treatment. The specification has been circulated to various binder interests. It will be later placed before Specifications and Standards Committee for further consideration.

(4) XIth INTERNATIONAL ROADS CONGRESS

The Executive Committee at their meeting held on the 13th March 1959 suggested a delegation of ten representatives of various interests to attend the Eleventh International Roads Congress held at Rio de Janeiro in September/October 1959. The Government of India, however, reduced the number of delegates to five in view of the foreign exchange involved. The names of delegates who represented India at the Conference are given below:

- (1) Shri H. P. Sinha
- (2) „ U. J. Bhatt
- (3) „ S. R. Mehra
- (4) „ N. G. Dewan
- (5) „ L. R. Patel

(5) SILVER JUBILEE OF THE INDIAN ROADS CONGRESS

As the Society completed 25 years of life in December 1959, the Executive Committee decided to celebrate the Silver Jubilee Session this year. In order to celebrate this occasion in a befitting manner, the following special publications have been brought out:

- (i) A Souvenir containing the history of the Indian Roads Congress, messages, articles on road development, road research, etc.
- (ii) A publication “Bridging India's Rivers”.
- (iii) T.C.M.R. Silver Jubilee Number.

In addition to this, four issues instead of three issues of the Journal were printed.

Special types of badges (one for use during Silver Jubilee Session and the other for permanent use) have been issued.

In order to meet the expenditure in connection with the Silver Jubilee items, an appeal for donation was issued to all members. It is gratifying to note that this has met with generous response.

*Appendix***LIST OF JOURNALS**

1. African Roads & Transport.
2. American Highways.
3. Annual Reports of the Institution of Engineers (India), Bombay Centre.
4. Automobile News.
5. Better Roads.
6. British Constructional Engineer.
7. British Road Federation (Bulletin).
8. Bulletin Technique De la Suisse Romande (in French).
9. Bulletin of the Central Building Research Institute, (India)
10. Bulletin of the Institution of Engineers (India).
11. Bulletin of the Permanent International Association of Road Congresses.
12. Bulletin of International Association for Bridge & Structural Engineering.
13. Burmah-Shell News.
14. Central Board of Irrigation and Power Abstracts.
15. Commonwealth Today.
16. Concrete Quarterly.
17. Contractors Record and Municipal Engineering, U. K.
18. Cement (in Dutch).
19. Chartered Civil Engineer (Bulletin of the I.C.E., U.K.)
20. De Ingenieur in Indonesia (in Dutch).
21. De l'Institut Technique Du Batiment et Des Travaux Publics (in French).
22. Documentare Technica.
23. Engineering News of India.
24. Geophysical Digest.
25. Highways and Bridges and Engineering Works.
26. Highways Current Literature.
27. Highways Research Abstracts.
28. Indian Journal of Power and River Valley Developments.
29. Indian Minerals.
30. Insdoc List of Current Scientific Literature.
31. International Road Safety & Traffic Review.
32. Irrigation and Power (Journal of the Central Board of Irrigation and Power).
33. Indian Railways.
34. Indian Standards Institution Bulletin.
35. Indian Construction News.
36. Journal of New Zealand Engineering.
37. Journal of Scientific and Industrial Research.
38. Journal of the Institution of Engineers (Australia).
39. Journal of the Institution of Engineers (India).
40. Journal of the Institution of Highway Engineers, U. K.
41. Journal of the Institution of Military Engineers, India.
42. Journal of the Institution of Municipal Engineers, U. K.
43. Journal of the Institute of Transport, U. K.
44. Journal of the Institute of Science, Bangalore.
45. Journal of the Japan Society of Civil Engineers, (in Japanese).
46. Journal of the National Buildings Organisation.
47. Link Belt Speeder News.
48. La Technique Rottiere.
49. Le Strade (Italy).
50. Magazine of Concrete Research.
51. Main Roads.
52. Motor Transport.
53. Modern Casting & American Foundrymen.
54. News-Letter of I. R. T. D. A.
55. Norsk Vegetidss Krift (Norway).
56. Premier Automobile Journal.
57. Proceedings of the Institution of Civil Engineers, London
58. Power Engineer.
59. Public Roads.

60. Quarterly Technical Bulletin (Indian).
(Ministry of Railways).
61. Reinforced Concrete Review, U. K.
62. Research & Industry.
63. Road Abstracts, Road Research Laboratory, U. K.
64. Road International.
65. Road Safety in India.
66. Roads and Road Construction.
67. Science and Engineering.
68. Shovel News.
69. State Transport Review, Bombay.
70. Strassen und Tiefbau (in German).
71. Strasse und Autobahn (in German).
72. Strasse und Verkehr (Swiss).
73. Surveyor and Municipal and County Engineer, U. K.
74. Texas Engineering Experiment Station News, U.S.A.
75. The Crushed Stone Journal (American).
76. The Highway Magazine.
77. The Indian Concrete Journal.
78. The Indian and Eastern Engineer.
79. The Engineering Journal (Canada).
80. The News in Engineering (at the Ohio State University).
81. The Structural Engineer, U. K.
82. The Texas Highways, U. S. A.
83. Traffic Engineering (U. K.)
84. Wegen (Belgium)
85. Western India Automobile Magazine.
86. World Construction.

**Minutes of the 56th Council meeting of the
INDIAN ROADS CONGRESS
held at Bangalore on the 2nd February, 1960.**

The Council met with Shri U. J. Bhatt in the Chair.

Antia, Dr. F. P.	Khanna, G. C.
Apte, M. P.	Mahadevan, M. R.
Barua, K.	Lal C. Verman, Dr.
Basu, K. N.	Mathur, B. D.
Bohera, S. S.	Meeran, M.
Bhatia, K. M.	Mehra, S. R.
Campbell, H. H.	Mukand, J.
Chanda, R. P.	Nambiar, K. K.
Chaugule, Y. K.	Narke, S. P.
Chathunny, T. S.	Nayak, S. C.
Durrani, N.	Prasad, B.
Fielder, C. J.	Sinha, H. P.
Iyengar, C. L. N.	Thakur, D. S.
Jagdish Prasad	Tripathi, S. N.
A. J. D'Costa	Secretary.

The following co-opted members attended

Antia, K. F.	Nadirshah, E. A.
Banerjee, J. K.	Premartne, H. R.
Bazaz, S. L.	Sujan Singh
	Vagh, B. V.

The following attended by invitation

Bhalla, R. S.	Hardyal
Ganguli, Dr. M. K.	Nagarsheth, M. P.
	Trehan, J. M.

1. Co-options and Invitations.

The Council approved the action taken by the Executive Committee in co-opting and inviting certain members to attend the Council meeting.

2. Confirmation of the Minutes of the 55th Council Meeting.

The minutes of the 55th Council meeting held at Bangalore on the 28th January 1960 were confirmed.

3. Office-Bearers.

The following were elected to hold office till the next General Session :

President	...	H. P. Sinha
Vice-Presidents	...	S. C. Nayak Dr. F. P. Antia K. M. Joshi
Secretary	...	A. J. D'Costa

At this stage, the newly elected President, Shri H. P. Sinha took the Chair.

The Council placed on record their appreciation of the fine work done by the outgoing President and other office-bearers and the Secretariat of the Indian Roads Congress.

4. Venue of the next General Session of the Indian Roads Congress.

The Council accepted with thanks the invitation of the Government of Madhya Pradesh for holding the next Session of the Indian Roads Congress sometime towards the end of November 1960 at Bhopal.

Shri H. R. Premaratna, Director of Public Works, Ceylon, stated that his Government had earlier requested the Indian Roads Congress to hold one of their Sessions in Ceylon but unfortunately it had not been possible for the Indian Roads Congress to accede to their request so far. He extended an invitation of his Government to hold the Twenty-Sixth Session of the Congress in his country and hoped that the Council of the Indian Roads Congress will keep their invitation in view. He also hoped that the Government of India will agree to this proposal.

5. Committees :

The Convenors of Committees were appointed as under :

(1) Specifications & Standards Committee.	...	Goverdhan Lal
(2) Bridges Committee.	...	S. L. Bazaz
(3) Test Track Committee.	...	C. E. (Road Development), West Bengal.
(4) Research Organization Committee.	...	H. P. Sinha
(5) Soil Research Committee.	...	S. R. Mehra
(6) Education Committee.	...	E. A. Nadirshah

(7) Provincialization of Local Bodies Engineering Services Committee.	...	A. S. Adke
(8) Papers Committee.	...	H. P. Sinha
(9) Manufacture of Road Making Machinery and Mechanization Committee.	...	R. S. Bhalla
(10) Organisation Committee.	...	H. P. Sinha
(11) Road Operation Cost Committee.	...	Jagdish Prasad
(12) Local Committee of the Test Track Committee to supervise Delhi-Mathura Road Tests.	...	Director, C. R. R. I.
(13) Cement Concrete Road Surfacing Committee.	...	E. A. Nadirshah
(14) Road Transport Development Committee.	...	Dr. F. P. Antia
(15) Traffic Engineering Committee.	...	D. G. Bhagat
(16) Prevention of Ribbon Development Committee.	...	H. P. Sinha
(17) Community Projects Road Maintenance Committee	...	K.K. Nambiar
(18) Stabilized Soil Roads Committee	...	K.K. Nambiar

The suggestion to give representation to the Indian Standards Institution on Committees Nos. (1), (2), (5), (9), (13), (16) and (18) was noted.

6. Kijometre Stones.

The design of kilometre stones prepared by the Specifications and Standards Committee was approved (subject to necessary modification in respect of thickness which would depend upon the material used) for publication as finalised standard of the Indian Roads Congress.

7. Points arising out of the Inaugural Address by Shri Raj Bahadur, Minister of State for Transport and Communications, Government of India.

The Council greatly appreciated the assurance given by the Minister of State for Transport and Communications, Government of India that the recommendations of the Indian Roads Congress for the formation of a Road Board at the Centre, will be given due consideration after a complete scheme giving in detail the outlines and functions of such a board are submitted to the Government of India. The Council appointed a Committee consisting of President, Indian Roads Congress, U.J. Bhatt, K.K. Nambiar, B.V. Vagh and S.R. Mehra with powers to co-opt two more members and examine

the matter in association with the Executive Committee and submit their report. This Committee may also consider ways and means of speedy execution of works and make necessary recommendations.

8. Miscellaneous.

- (1) Arising out of the minutes of the 55th Council meeting held at Bangalore on the 28th January, 1960, the Council considered the following two proposals of Shri S. R. Mehra, viz.,
 - (a) suggestion to entrust the Member-Secretaryship of some Committees to the Assistant Directors of the Central Road Research Institute.
 - (b) suggestion to amend the composition of the Executive Committee so as to include the Director, Central Road Research Institute as an ex-officio member.

As regards (a), it was explained that the Council at their 38th meeting held at Simla on the 26th April 1952 had decided that all Committees of the Indian Roads Congress should have Member-Secretaries who should be officers of the Roads Wing. It was also explained that according to the present practice under the rules, the Executive Committee or the President under authorization from the Executive Committee appoints members of Committees or Subcommittees in consultation with the respective convenors as far as possible. The Council expressed the opinion that this practice may be continued. It should, however, be possible to include as Member-Secretary any official of the Central Road Research Institute or other organizations for suitable Committees and Subcommittees on the recommendation of the Convenors.

As regards (b), the proposal was discussed at length and members of the Council expressed their views both for and against the proposal. But as there was no unanimity of opinion, Shri Mehra withdrew his proposal.

- (2) A suggestion was made that the question of increasing the number of seats on the Council from 4 to 6 under Rule 9-j may be considered. The Council decided that this suggestion should be examined in detail by the Executive Committee.

TOUR NOTES

24th Session, Bangalore, January-February 1960.

Some interesting bridge works are in progress on the West Coast Road. Big projects like the Sharavati Valley Hydro-Electric Project are in progress. There are the Jog Falls. But these places being far away from Bangalore, visits to such distant places could not be arranged.

Visits were arranged to the three important undertakings under Public Sector which are technically very interesting. They are :

- (1) Hindustan Machine Tools Factory.
- (2) Hindustan Air-crafts.
- (3) Indian Telephones Industries.

These places need no introduction.

• A visit was also arranged to Mysore City and the famous Brindavan Gardens.

• The Brindavan Gardens are laid on the banks of the Cauvery River near Krishnaraja Sagar. The Krishnaraja Sagar is formed by impounding the waters of the Cauvery River by a masonry dam.

• The Garden is famous for its beautiful layout, for its fountains and the colourful illumination.

ROAD FACTS OF MYSORE

Mysore State has 26,852 miles of road for an area of 74,861 sq. miles of the State. The road mileage per sq. mile is 0.36 miles which is a handsome figure compared with other States.

The State, as formed on States Reorganization consists of areas coming from five different administrative units, viz., from Bombay State (4 Districts), from Hyderabad State (3 Districts), from Madras State (one District and a Taluk), from Coorg State (whole area of Coorg District) and the whole of old Mysore State.

The areas coming from old Mysore State, Coorg and Madras are fairly well served by roads. The areas from Bombay and Hyderabad States are comparatively poor in roads. The roads in Bombay-Karnatak and Madras-Karnatak are classified according to Nagpur classification. In other areas roads are not classified.

The objectives of the Nagpur Plan were that in a highly developed agricultural area, no village should be more than two miles from 'a road' nor more than five miles from a main road, the average distance from a main road being generally less than 2 miles in most cases. Similarly in non-agricultural area, no village should be more than 5 miles from a road, nor more than twenty miles from a main road, the average distance from a main road being six or seven miles in most cases.

According to the above objective, Mysore should have the following mileage of the roads :

Main roads	...	11,903 miles
Other roads	...	12,595 „
Total	...	24,498 „

It would be seen from the figures of the existing road mileage given below that the mileage targets of the Nagpur Plan (1943) have on the whole been exceeded, though we fall short with regard to main roads.

Main Roads.

(1) N. H.	...	559 miles
(2) State Highways	...	3,805 „
(3) M.D.R's	...	4,925 „ (approx.)
		9,289 „

Other Roads.

O.D.R's.	...	6,600 miles (approx.)
V.R.'s.	...	10,983 miles
		17,583 „

Total road length : 26,872 miles

The break up of the existing road mileage into various type of surfaces is given below :—(figures as on 31st March 1959).

Type	Milage	Percentage
C.C.	346.63	1.30
B.T.	3,470.16	13.00
W.B.M.	12,367.17	46.00
Unmetalled	10,668.08	39.70
Total	26,872.04	

The road mileage for Mysore based on the report of Chief Engineers on the Second Road Development Plan are given below :

National Highways	...	1,515 miles
State Highways	...	4,320 miles
Major District Roads	...	8,350 miles
Other District Roads	...	10,248 miles
Classified Village Roads	...	11,650 miles
Total		36,083 miles

The table given below gives a comparative study of the road mileage of Mysore State with those of other Indian States.

Sl. No.	States and Territories	Total mileage	Area (in Sq. Mi.)	Population (in lakhs)	Road mileage (per sq. mile)	Road mileage (per lakh of population)
1	Mysore ...	26,852	74,861	194.0	0.346	103.9
2	Andhra ...	19,305	1,05,677	312.6	0.183	61.77
3	Assam ...	9,810	85,062	90.4	0.1030	103.02
4	Bihar ...	32,837	67,113	387.8	0.4800	84.72
5	Bombay ...	3,998	1,90,668	482.7	0.1700	70.40
6	Kerala ...	8,444	15,006	135.5	0.5604	62.31
7	Madhya Pradesh	17,319	1,71,250	260.7	0.1011	66.43
8	Madras ...	24,042	50,128	299.8	0.4790	80.19
9	Orissa ...	11,738	60,250	146.5	0.1900	80.12
10	Punjab ...	10,087	47,062	161.4	0.2100	62.05
11	Rajasthan ...	21,922	1,32,148	159.7	0.1700	137.26
12	Uttar Pradesh	33,733	1,13,422	632.2	0.2970	53.30
13	West Bengal	21,538	33,927	263.0	0.6100	81.97
14	Jammu and Kashmir	1,765	85,861	44.10	0.0190	40.00
15	Delhi ...	320	573	17.4	0.5584	18.0
16	Other Union Territories	1,694	26,799	23.80	0.0064	71.8

During the First Five-Year Plan 408½ miles of new roads have been formed, 1109 miles have been upgraded and 10 major bridges have been constructed in Mysore State.

The development programmes of National Highways and other roads in II Plan Period (1956-61) are detailed below :

National Highways.—Three routes of National Highways traverse through this State, covering a total length of 559 miles. They are National Highway Nos. 4, 7 and 9. Their description, their length and the break-up of their length into type of surfaces are given below :

Sl. No.	N.H. No.	Description	Total length M. F.	Cement concreted M. F.	Black- topped M. F.	Metalled length M. F.
1	4	Passing through Kolar, Bangalore, Tumkur, Chitaldrug, Dharwar and Belgaum.	434 1	16 4	414 5	3 0
2	7	Passing through Attibele, Bangalore and Chikballapur.	77 7	...	71 2	6 5
3	9	Passing through Humnabad in Bidar District.	46 4½	...	46 4½	...
Total ...			558 4½	16 4	532 3½	9 5

The annual maintenance cost of these roads is nearly about Rs 13.00 lakhs.

Under the II Plan, approved by the Government of India, nearly Rs 54 lakhs are proposed to be spent, out of which Rs 20 lakhs are for new works.

During the Second Five-Year Plan so far, the following works have been done :

- 1 W.B.M. renewal and Black topping N.H. 4 in Chitaldrug Division.
- 2 Black topping and widening of formation to 38 ft for N.H. 4 in Davangere Division.

- 3 Black topping miles 245/2 to 353/1 of Poona—Bangalore road (N.H. 4) in Dharwar Division.
- 4 Widening formation to 38 ft in various divisions for N.H. 4 and 7.
- 5 Black topping mile 67 to 85 of N.H. 4 in Tumkur Division.
- 6 Widening B.T. surface mile 34/0 to 44/4 of N.H. 4 in Tumkur Division.
- 7 Widening concrete surface in mile 5/0 to 17/0 of N.H. 4 by B.T. shoulders in Bangalore Tumkur road in Bangalore Division.
- 8 Reconstruction of Hudgi bridge on N.H. 9 in Bidar District.
- 9 Reconstruction of culvert No. 291 on N.H. 9 in Bidar District.
- 10 Widening Batti tank bund in mile 168 in Davangere Division on N.H. 4. (Job No. 1160 MY 4).
- 11 Reconstruction of bridge No. 400 on N.H. 9 in Bidar District.

Following new works are in progress :

- 1 Widening culverts and bridges.
- 2 Constructing a new bridge at mile 10/3 of Bangalore—Madras Road (N.H. 4) in place of a damaged bridge on Y tank bund.
- 3 Widening existing B.T. surface from mile 17/4—28/4 of Bangalore—Madras section of N.H. 4 (Job No. 1263 MY 4).
- 4 Widening the B.T. surface mile 28/4 to 43/0 of Bangalore—Madras section of N.H. 4 (Job No. 1200 MY 4).
- 5 Widening the B.T. surface in mile 43/0 to 71/2 of Bangalore—Madras section of N.H. 4 (Job No. 1250 MY 4 and 1651 MY 4).
- 6 Widening the asphalted width from 12 ft to 22 ft from mile 25/0 to mile 36/0 of Bangalore—Devanhally Bagepally section of N.H. 7 (Job No. 1217 MY 7 and 1270 MY 7).
- 7 Widening the tank bund of Hebbal tank mile 5/2 to 6/4 of Bangalore—Devanhally Bagepally section of N.H. 7.

Following new works are to be taken up in the current year or in the year 1960-61 :

- 1 Reconstruction of the bridge across river Vedavathi at Hiriya (N.H. 4).
- 2 Reconstruction of a minor bridge No. 360 at mile 103 of N.H. 9.
- 3 Reconstruction of the bridge at mile 87/6-7 of N.H. 4 and improvement of its approaches.
- 4 Construction of Malaprabha bridge on N.H. 4 in Belgaum Division.
- 5 Diversion outside Nipani town.
- 6 Diversion outside Hubli town.
- 7 Diversion near Harihar to avoid two level crossings.
- 8 Improving the curve in mile 58/0-1 and mile 83/0 in Tumkur Division N.H. 4.
- 9 Improvement to Tavadihat in mile 172/0 of N.H. 4.
- 10 Widening tank bund from mile 13/5 to mile 14/7 of N.H. 4 (Bangalore—Madras section).
- 11 Widening culverts and minor bridges in Davangere, Chitaldrug, Tumkur, Bangalore and Kolar Division for N.H. 4 and N.H. 7.
- 12 Widening the carriageway to two lane from Belgaum to Hubli mile 213/5 to 272/3 of N.H. 4.
- 13 Concreting miles 9/1 to 17/4 of Madras—Bangalore Road section of N.H. 4.

Discussion on Paper No. 213*

“ Some Studies in Soil Mechanics as Applied to Roads in West Bengal ”

By

S. N. GUPTA & P. L. DE

Friday, January 29, 1960.

Shri S. R. Mehra (Chairman) called upon Shri S. N. Gupta, Joint Author, to introduce the Paper for discussion.

Shri S. N. Gupta, while introducing his Paper, remarked that when the first experimental stretches with stabilized soil were laid in Bengal in 1951 they had doubts about its success, their experience however has shown that even in West Bengal having heavy rainfall this method had proved more economical in many places and an inescapable necessity in others. He also stated that though they had a permanent Roads and Buildings Research Laboratory in the State, the method of construction was still mostly manual and hence dilatory and needed to be improved.

In regard to the classification of soils, for highway engineering Shri Gupta strongly recommended the adoption of P.R.A. system in preference to the unified classification system finalized by the Indian Standards Institution.

Discussing the road pavement failures, Shri Gupta stated that the investigations conducted by them had conclusively brought out the necessity of (i) providing adequate compaction of the embankment in general and the subgrade in particular, (ii) adequate thickness of pavement for the present day traffic loads, and (iii) keeping the water off directly by water repellent treatment and indirectly by adopting soil stabilization methods.

In the end, Shri Gupta felt that there was scope for further augmenting the pace of education in soil mechanics in the country and sooner it was done the better.

Shri D. C. Chaturvedi, referring to para 3.3.1, requested the Central Road Research Institute to make available early the results of their study about moisture content under pavements as it would

* Published at pages 27 to 69 of Vol. XXIV-Part 1 of the Journal of the Indian Roads Congress, October, 1959.

be of great help in working out economical designs for road pavements.

He felt that 2 cu. ft. soil sample might be in excess if it was to be taken at frequent intervals. So he asked the Authors to suggest the interval of sampling in normal cases. Also, the liquid limit of 65 for embankment soil suggested by the Authors appeared to be on the high side, and he wondered if it could be adopted in this country.

Shri Chaturvedi did not agree with the Authors that the thickness required for concrete pavement depends on the amount of reinforcement as it did not play any part in providing rigidity to the pavement.

In the specification given in para 7, it was seen that the Authors were using dry density as the criteria for designing admixture of soils for base course. He asked the Authors if P.I. and sand content were also considered as in case of Mehra's method of soil stabilization.

Referring to para 8.2.2. relating to strength of soil-cement cylinder for determining percentage of cement, Shri Chaturvedi wanted clarification about the type of traffic and its intensity suitable for the specifications. He had found that grafting of stone on soil-cement layer improves the adhesion of black top coat to the soil-cement surface.

Regarding para 9.2., he suggested another reason of failure, viz., alternate wetting and drying of deleterious salts like carbonates and sulphates which might have caused subgrade failure.

Dr. H. L. Uppal remarked that providing about 15 in. of compacted layer, recommended by the C.R.R.I., as part of the calculated thickness of the road pavement, would add cost equivalent to an additional thickness of about 1 to 2 in. of hard crust only. This would have far reaching effect on the economy of road construction especially in areas of high water table such as West Bengal, Bihar, parts of Assam, U.P. and Punjab.

In regard to failures of road pavements on embankments, Dr. Uppal stated that investigations in the past had indicated that failure was due to a combination of both inadequate thickness on weak subgrade as well as settlement in the body of the embankment. He added that proper compaction not only of soil but also of the subgrade was necessary before putting on a rigid pavement. Compaction of embankment layer by layer would prevent settlement when it got soaked. Further, for compaction of soil it was not only necessary to have a high compaction but also least variation from place to place. For this purpose he advocated the use of light machinery which would also be economical.

Dr. Uppal stated that use of 5 to 10 per cent cement for soil stabilization seemed to be rather high and was probably applicable to conditions in other countries. Experiments conducted in India had shown that soils after proper blending and suitable compaction could be stabilized with as small concentration of cement as 2.5 to 3 per cent. This was now being appreciated by other countries who are now recommending use of smaller percentage of cement for stabilization of soil for lower layers of pavements of roads and runways.

Dr. Uppal did not agree with the Authors that addition of granular material would lower the plasticity index of soils. It was the fine sand fraction, not coarser than 40 U.S. mesh, which helped lower the P.I. of the soils.

Regarding the compressive strength of a soil-cement mixture suitable for bottom and top layers of 250 and 400 lb per sq. in. respectively, recommended by the Authors, Dr. Uppal stated that the proper approach would be to find out the load transmitted by a vehicle at various depths and to provide sufficient strength of soil-cement mass to withstand those load stresses. In fact, while stabilizing soil with cement, two factors, viz., its resistance to weathering effect and the resultant strength, had to be taken into consideration. The former condition could be satisfied if a strength of 150 lb per sq. in. in the field was attained on 4 in. by 2 in. block after 7 days curing, while the strength would depend on the type of vehicle likely to use the road.

As regards stabilization of clayey soils with cement, Dr. Uppal stated that use of higher concentrations of cement would make it uneconomical. He suggested that the clayey soil should first be made friable with small concentrations of lime and the resultant material then treated with comparatively smaller quantities of cement than originally required.

Since the Authors themselves had admitted that compaction of soil was very economical, it was not understood why they did not try digging of the existing crust and providing 15 to 18 in. of the compacted soil and then relaying the hard crust instead of providing 8 in. thickness of compacted hard stone as mentioned in the Paper.

Shri L. R. Chadda thought that the solution of road failures caused by weakening of the subgrade due to capillary moisture was, to effect some improvement in the strength of the subgrade under saturated conditions by incorporating small percentages of hydrated lime varying from 2 to 3 per cent which would result in appreciable increase in the C.B.R. of the order of 30 to 40 per cent for soils with P.I. ranging from 15 to 25 and for less clayey soils between 1 to 2 per cent. The cost of soil compacted with 2 and 3 per cent

lime worked out to about Rs 15 and Rs 19 per 100 cu. ft. respectively, when the cost of lime was taken as Rs 3 per maund.

Shri M. P. Dhir stated that structural rigidity of concrete slab would depend on the product of elasticity modulus and the cube of the thickness of slab and not on the elastic modulus alone as stated by the Authors in para 5.2 of the Paper.

Regarding the usefulness of sub-base under the rigid pavement, Shri Dhir stated that sub-bases were provided not only for reducing the load stresses but also for other considerations, for example, in case of very poor subgrade soils where concrete could not be laid directly and also for counteracting the frost action or pumping of the poor subgrade soils.

Referring to para 5.3, regarding the recommendations of about 25 to 33 per cent reduction in the flexural strength of soil-cement construction when designed as a flexible pavement, Shri Dhir suggested that for big projects, where feasible, McLeod's method or Burmister's analysis might be used for evaluating such semi-rigid pavements.

Shri D. K. Laroia stated that proper compaction of road fills was a very important aspect of road construction and did not agree that fills got sufficiently consolidated under traffic if one or two rainy seasons were allowed to pass. He cited the example of failures on G.T. Road in U.P., vide I.R.C. Paper No. 203 by Messrs H. G. Verma and D. C. Chaturvedi, where C.B.R. values of the subgrades in various stretches have been shown to vary from 2.5 to 9.1. If such differences could occur in the C.B.R. values on one of the oldest roads having been consolidated under the traffic for decades, the differences in C.B.R. values of new fills could certainly vary very much.

Referring to para 3.3, regarding the importance of ground water table in the stability of a road, Shri Laroia cited the example of certain western districts of U.P., where ground water level rose to within 2 ft of the ground level instead of the normal 15 to 20 ft, and stressed that occurrence of similar conditions should invariably be taken into account while designing road pavements. In such cases the only safeguard needed was to provide an additional properly compacted fill of about 12 inches which did not cost much while the trouble and expense otherwise were bound to be very much more.

Regarding results of failure given in Table 1, Shri Laroia asked how the thickness of crust decreased to $8\frac{1}{2}$ in. in the two portions that failed against $11\frac{1}{2}$ in. found in the other portions which did not fail though the initial specification was the same. Referring to failure of 3rd furlong of 4th mile of Balighai-Mohanpur Road,

vide Table 1, the speaker said that with P.L. of 21 and water content of 24.4 per cent the natural state of the soil appeared to be plastic and that was the reason of failure. But the reason of failure of 7th furlong of 2nd mile was not clear as the C.B.R. value at 35 per cent moisture content was no doubt very low but the natural water content was only 23.7 per cent and the C.B.R. value at this moisture content would be very much higher. Perhaps the crust thickness was not adequate or perhaps the water content increased to above 23.7 during some periods. It would be instructive if it were clarified as to which of the reasons accounted for the failure.

Shri Laroia also did not agree with some of the deductions made by the Authors on page 39 of the Paper in regard to earthwork done by machines as compared to manual work. He stated that if these observations were assumed to be correct, it would mean that a reduction of dry density from 108.7 to 98 lb per cu. ft. and increase of moisture content from 25.7 to 26 reduced the C.B.R. value from 3.7 to 3, thereby meaning that higher dry density did not play a very important role in the bearing capacity. He was of opinion that more experimental data was needed for confirmation of these deductions.

In the end Shri Laroia mentioned that it was seen from the Paper that failures mostly occurred in clayey soils and clayey gravels and sands which contained too much of clay and could not be easily compacted. Special attention for compaction of clayey soils was, therefore, required.

Shri A. K. Deb stated that unless adequate attention was given to thorough compaction of the entire road embankment, mere adequate subgrade compaction immediately before laying the pavement and providing necessary pavement thickness corresponding to the strength of the compacted subgrade would not be good enough for prevention of road failures.

In regard to the use of the C.B.R. method for flexible pavement design, Shri Deb stated that the design thickness according to this method was based on the maximum wheel load and did not take into consideration the intensity or the effect of repetition of loads. However, the chart presented by the Authors in Fig. 1 showed pavement thicknesses against intensity of traffic. He asked the Authors to indicate the source of this design chart.

Shri N. Mohan Rao agreed with the Authors in regard to the need for soil surveys, sampling and testing of soils at different points and locations, and added that it was essential that the sampling done should have area significance. This could be done only when the soil surveys were coupled with pedological and geological information also.

In regard to para 2, page 36, dealing with pavement design and investigations of failures on N.H. 2, Shri Rao felt that the statement made therein could be misinterpreted to mean that if a very thick pavement had been provided based on the C.B.R. design, the failure could have been averted. He stated that the C.B.R. test as designed and applied was mainly aimed at evaluating safety against shear failure and did not ensure safety against settlement failure, i.e., that independent of C.B.R. thickness requirements, there was need to compact all layers to the maximum density. In this connection he referred to para 9.3.2 regarding the investigation of 56th and 57th miles of the G.T. Road, wherein it is stated that heavy subsidence took place in these two miles and that failure was due to low bearing capacity of the subgrade, which was corrected by increasing pavement thickness. He wanted to know whether the subsidence was followed by lateral heaving as also the difference in the types of failures on N.H. 2 and G.T. Road.

Referring to the statement made by the Authors that soil-cement could be expected to give equal service with less thickness than in the case of flexible pavements, Shri Mohan Rao stated that to appreciate such general statements, it was essential to have further information by way of percentage of cement, strength, etc. Similarly, in the case of Barasat-Basirhat road, 15 in. of flexible construction was compared with 9 in. of soil cement plus 1½ in. premixed carpet. He, however, felt that unless curves are evolved based on their own findings in the light of several years of observations, conclusions of this type might not be quite convincing.

Shri T. K. Natarajan felt that it would have added greatly to the value of the Paper if the Authors had mentioned something about the scope and limitations on the validity of the C.B.R. design procedure. No doubt, for the cases set forth in the Paper this procedure proved to be an expedient tool in estimating the structural adequacy of the pavement, yet it leaves an impression that the C.B.R. method is a perfected and infallible tool in design. It was, therefore, necessary to have fuller realisation of the implication of the C.B.R. test for its proper application, especially in view of some of the disquieting experiences, such as the erratic C.B.R. values in the case of soils with particles larger than ½ in. size, the effect of annular surcharges on some of the less plastic soils and also the non-uniform density resulting from static load compaction which, in certain circumstances, led to increased pore water pressure resulting in decreased C.B.R. values even with increase in density.

Concerning the investigation on ground water and waterlogging conditions given in para 3.3.1, he specially wanted to point out that, in submerged conditions cohesionless soils were more drastically affected in their bearing capacity than cohesive soils, both according to theory and practice. He, therefore, emphasised the necessity

proper drainage in situations where waterlogging and flooding existed. Here, also, there seemed to be a widespread misunderstanding in regard to the use of C.B.R. method as there was general impression that adequate pavement drainage was of little or no consequence because the pavement was designed on the basis of baked C.B.R. values and, as such, it could not be susceptible to damage by flooding. In this context, two facts were noteworthy, i.e., the soaking procedure of the C.B.R. did not necessarily ensure saturation and, secondly, there was great difference between saturation and surcharging of the subgrade through flooding. For example, in sandy soils flooding of submergence reduced the confining pressure in the soil thereby worsening the settlement and the strength characteristics of the soil.

Referring to para 5.3, classifying soil-cement as a semi-flexible pavement, Shri Natarajan stated that mechanically stabilized soil and bitumen stabilized soil had very poor flexural strength and, as such, by definition they behaved like flexible materials. But in the case of soil-cement, its flexural strength, corresponding to an unconfined compression strength at an age of 7 days of about 250 lb per sq. in., which is the common strength of material required for use in road base, was of the order of 50 lb per sq. in. One method of considering whether the soil-cement of this strength acted as a flexible or a rigid material would be to estimate the thickness of the base required to prevent a flexural failure. Using Westergaard's method of analysis of stresses in a concrete slab, 24 in. thickness of soil cement was needed for a subgrade with 'K' value of 100 lb per cu.in. for a wheel load of 9,000 lb compared with a thickness of 6 in. for concrete with a flexural strength of 500 lb per sq. in. Since much smaller thicknesses of soil-cement had been found to behave successfully in practice, it was only a logical inference that flexural failure must usually occur so that the soil-cement acted as a flexible base material.

Shri G. Gupta referring to para 3.2 regarding purpose of soil exploration, asked if the economy of construction and the question of water stagnation could not determine the depth of borrow pits, as more than 2 ft depth rendered the land permanently unfit and more than 3 ft depth would make earthwork uneconomical and difficult.

Regarding designing the slope of cuttings and embankments, he stated that mere character of soil probably did not give the requisite data unless proper investigation was done to find out suitable hydraulic gradients for different types of soils, their character of compaction and the character of flood in respect of its duration, current, wave action, etc.

Regarding compaction of embankments, para 4.1.2, **Shri Gupta** felt that there was generally no time to resort to natural compaction.

tion. Besides, in high embankments even one season's wetting was not enough and it was better to use pump and hose pipe and rolling.

In regard to failure described in Table 1, he asked if it was not advisable either to raise the road level another foot or to have a thick layer of sand to reduce capillary action. Unless the embankment work was very hurriedly done, it did not seem probable that lack of compaction would result in such collapse especially when 2 years had already passed. The same applied to other cases.

Regarding the design of pavement thickness, Shri Gupta stated that suitability of wearing surface depended on two conditions, viz., (a) breaking up of aggregate by concentrated semi-static loads such as bullock-cart wheels, and (b) mobility of aggregate under high speed traffic of trucks, etc., through the effect of dynamic friction and suction.

He agreed with the Authors that improvement of subgrade by granular stabilization was found very effective and quoted the example of a road in Orissa encircled by three rivers (submerged state) where it was not possible before granular stabilization to even cycle on the slushy and black cotton type surface during monsoons.

In most of the cases of road failures mentioned in the Paper, the C.B.R. tests indicated the necessity of thicker pavements. The Authors had also ascribed road failures to natural settlement of the newly made bank and the alternate expansion and contraction of black cotton soil. But, Shri Gupta felt, there might be some other causes also such as insufficient compaction of the metalling which lead to failure of macadam pavements.

Shri K. K. Nambiar stated that the Paper attempted to compress within narrow confines a rather inexhaustible subject, namely, the application of soil mechanics to the field of highway engineering, thus resulting in the omission of details in some of the important sections such as site investigation and soil survey, stability of slopes, etc. It would perhaps have been more profitable and added immeasurably to the value of the Paper if its scope had been limited to Pavement Design and Investigation of the Failures of Roads which, in fact, appeared to be its main theme.

In para 2.1.1 about principal soil types, no mention had been made of gravel which was an important constituent of soil of the coarse-grained type.

Referring to para 4.1 regarding compaction of embankments, Shri Nambiar stated that the practice of leaving an embankment to weather and settle could be dispensed with altogether, thus shortening the period of construction and resulting in appreciable savings

in the overall cost if the construction was carried out in layers and the soil compacted under controlled conditions. However, to insist that soils with certain particular gradings alone should be used in the work would make it unduly expensive or wholly impracticable.

In regard to the use of boulder soling on the N.H. 2 to Durgapur Barrage having a weak clayey subgrade susceptible to moisture changes, Shri Nambiar stated that boulder soling on such soils invariably sank into the subgrade when the latter was weakened by moisture. He, therefore, strongly advised against the use of rubble soling for such roads.

He was doubtful whether the failures described in para 4.1.3 could be attributed entirely to inadequacy of compaction of the subgrade. An examination of the results of the tests for Balighai-Mohanpur road, for example, revealed that a far more important reason for the failure was the ingress of moisture into the subgrade and its consequent weakening. In the undamaged portion, due to the higher density of compaction and greater thickness of surfacing, the subgrade did not lose strength to the same extent. Further, to maintain a stable subgrade, the water table should not be allowed to rise to a level less than 4 ft below the formation. For clayey subgrades, it was important that the road should have an impermeable surface so that the entry of water into the subgrade is prevented.

Referring to para 5.1.2, Shri Nambiar stated that the Group Index method of pavement design was purely an empirical one, the thickness of construction being determined from past experience for similar wheel loads and soils giving similar results in classification and identification tests. The design curves in this method were based on certain assumptions with regard to compaction and moisture and if these conditions were not fulfilled, the use of this method would not be justified for design of the pavement. The method was found to be of value in providing an approximate estimate of the thickness of construction required.

Referring to para 5.2 regarding rigid pavements, he agreed with the Authors that a high bearing value of the subgrade did not produce a corresponding reduction in the stresses in the concrete slab, because although the downward deflection of the slab was greater for a low than for a high modulus of subgrade reaction, the deflection was spread over a much wider area. On this basis, therefore, the soil might have little effect on the stresses in the concrete when the slab was uniformly supported.

In regard to para 5.3, as to whether soil-cement should be treated as a flexible or a rigid pavement, Shri Nambiar remarked that Shri Natarajan of the C.R.R.I. argued that calculation using Westergaard's analysis indicated that the flexural strength

of soil-cement was inadequate to prevent its cracking and so soil cement was a flexible material. He did not agree with Shri Natarajan's conclusion of soil-cement being a flexible material as accumulated evidence from actual field experience confirmed that, in view of its appreciable flexural strength, soil-cement should be considered to be a type of construction intermediate between the rigid and flexible pavements.

Referring to para 6.2 about lack of practical data regarding use of material like alkathene, Shri Nambiar stated that plenty of literature was available on the use of alkathene for subgrade protection and it had been extensively used in Germany and Switzerland.

Referring to Dr. Uppal's point about using concentration of cement as low as 2 per cent for soil-cement, Shri Nambiar stated that every mixture of soil and cement was not necessarily soil-cement. It was a distinctive structural material with well-defined characteristics of its own. The treatment of soils with varying amounts of Portland cement could produce a wide range of engineering materials suitable for construction purposes, the most widely used material being hardened soil-cement utilizing local soils to produce a strong and durable paving material at low-cost. Sometimes, however, small quantities of cement might be used as an admixture to change certain undesirable characteristics and "modify" the soils into a more favourable construction material. Such a mixture of soil and cement was known as "cement modified soil".

Further, he remarked, grafting of stone metal over a soil-cement base as suggested in para 8.2.3, was not a very satisfactory arrangement. For developing a bond with the base such a procedure was unnecessary. The correct approach to this problem was in the selection and application of an appropriate priming agent so that a firm bond with the base might be developed.

Referring to road failures, Shri Nambiar remarked that first of all it should be defined as to what exactly constituted the failure of a pavement as there was a tendency to use the term 'failure' to describe all kinds of phenomena. However, cases referred to in paras 9.3.1 to 9.3.5, attributed to lack of adequate thickness of pavement, on examination of test results suggested that improvements to the drainage facilities and provision of an impermeable surfacing would have protected the subgrade soil and increased its bearing capacity adequately to carry the required traffic, without notably adding to the thickness of the pavement.

Shri K. Ramaswamy Reddy commented that the various road failures analysed in the Paper emphasised the need of understand-

ing the scientific background involved in modern road construction and suggested that some of the important field identification tests of soils like the dropping test, sedimentation, dry strength and shaking test might also be included in the appendix.

In investigating the causes of failure of Baligahi-Mohanpur road, he added, it would have been advantageous if the good as well as the bad reaches were selected as close as possible to have a correlated comparison. Test results contained in Table 1 attributed the road failure to the inadequate compaction of the road fill. But the existing thickness of pavement being about 11½ in. in the good reach and 8½ in. in the bad reach, the cause of failure might also be due to the inadequate thickness of the pavement itself. Further, in regard to the road from N.H. 2 to Durgapur Barrage, the method of construction adopted or any other field control tests were not mentioned. In Madras, he explained, it was the practice to construct an embankment in layers of not exceeding 9 in., and if such a procedure had been adopted, loose pockets as described would not have developed.

Referring to Table 2 relating to test results of subgrade soils, Shri Reddy stated that in such cases where it was doubtful whether the embankment had not undergone full settlement, the maximum dry density value should have been obtained from standard compaction test and the percentage compaction of the fill calculated by the following formula :

$$\text{Percentage compaction} = \frac{\text{Field dry density-loose dry density}}{\text{Maximum dry density obtained in standard compaction test-loose dry density}}$$

In the absence of any such calculation, the conclusion drawn that the embankment was not fully consolidated required some justification.

Shri Reddy felt that the suggested reduction of 25 to 33 per cent made in para 5.3.1 in regard to the design of soil cement as a semi-rigid pavement was not necessary in view of the likely increase of loads on the roads in the next decade. Based on his own experience on Ramnad-Mandapam road, Shri Reddy agreed with the Authors' suggestion of adopting a compressive strength of 400 lb per sq. in. for the top layer.

Dr. M. L. Puri wanted to know if it was possible to calculate the required thickness for a semi-flexible pavement by the use of Burmister's theory as applied to two-layer system. Burmister's analysis, no doubt, did not take into account the plasticity of the material, but this limitation could perhaps be overcome to a great

extent by actually measuring the distribution of the stresses in the subgrade by the use of pressure cells and applying the required correction factors to Burmister's analysis.

Shri Zafer Mohiuddin wanted to know if there was any method to specify the type or nature of the pavement once its thickness requirement was determined by the C.B.R. or any other method. It was essential that not only the subgrade was strong but that the pavement itself should be strong enough to resist the high shearing stresses under the heavy axle loads.

There appeared to be two schools of thought, he added, as regards the shear planes under a loaded area, that is, circular and log-spiral curve failures and he wanted to know as to how these would affect the thickness of the pavement.

Shri Mohiuddin suggested that the Road Research authorities should conduct studies and research on all the conventional types of pavements in different regions of India and suggest improvements by reducing the thickness as, he believed, the conventional types were generally and unnecessarily thick. This would go a long way in reducing the cost of road construction in the country.

Shri C. N. Nagaraj observed that 2½ to 5 per cent of cement was found to be good enough for stabilization of some alluvial soils. This was based on the fact that the soils tested by them were broadly similar to those mentioned in the Paper.

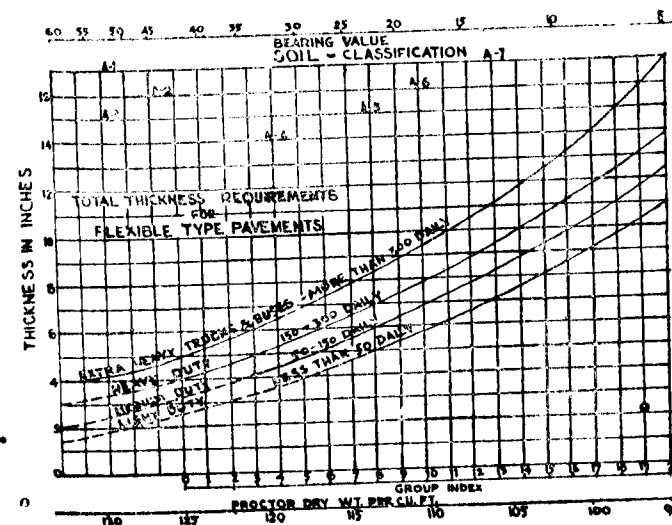
In regard to the use of C.B.R. values which were suitable for the soils and conditions of climate, etc., of other countries, he suggested the need for correlating the C.B.R. values with actual road failures in this country. He understood that the Central Road Research Institute had initiated work on this and the results of their investigations were awaited.

Shri K. L. Sethi * stated that the Authors themselves appeared to be reluctant to adopt any of the tests in regard to field investigation of soils mentioned by them in the Paper. He drew their attention to a very simple apparatus, 'Uppal's Syringe', which was used successfully in the field during the selection of soil for 5,000 soil stabilized houses in the East Punjab after partition. With this apparatus the soil could be easily classified into clay, silty or sandy.

Shri G.C. Sharma stated that it was not clear from the Paper whether a soil profile along the centre line of the proposed alignment of Calcutta-Durgapur Expressway was prepared to indicate various types of soils, though Plate I showed only the group index and

* This and the following comments were received in writing.

plastic characteristics of a few soil samples at different depths. The soil profile was of primary importance for construction of an expressway and would indicate undesirable types of soils like peat, muck, swamp, etc., concealed under the bed as also the water table



levels in various seasons, based on which the height of embankment in fills could be designed. Further, the results of particle-size analyses and index tests were of considerable value in providing an insight into the probable behaviour of the soil in the field.

He also suggested that a concise table for all kinds of soil samples at various depths showing the mechanical analyses, particle-size distribution, chemical analyses, such as organic matter in per cent soluble in H_2O_2 , percentage of carbonates soluble in HCl, moisture content, L.L., P.L., P.I., soil classifications, etc., should have been furnished along with the Paper.

Shri Sharma felt that the dry density of the soil used in 7th furlong of 2nd mile being only 85 lb per cu. ft. was unsatisfactory. Also, it was not clear whether the new embankment was constructed in 9 in. layers of soil properly rolled and all lumps and earth clods completely broken before another layer of earth was thrown over it as big lumps of earth, if allowed to remain inside the fill material, take time to settle. Besides, the period of only one monsoon allowed for compaction of embankment with less rainfall intensity of the area appeared to be inadequate for 5 ft deep embankment unless compacted with mechanical equipment. Therefore, the failure of

road surface stated to be 8½ in. thick, was not due to inadequate thickness of hard crust but due to poor compaction of subgrade and fill materials in the embankment. The settlement in certain sections of N. H. 2 to Durgapur Barrage was also due to less compaction of fill materials. It was observed in the Road Research Laboratory, Harmondsworth, that there would be no serious settlement within the embankment provided the soil in the mass of embankment was compacted to a density corresponding to not more than 10 per cent of air voids and the moisture content of the soil generally not exceeding the plastic limit. Here, also, a suitable mix of soils on 'Triangular chart method' should have been designed, spread over the existing subgrade after rolling and then the traffic allowed to pass. This would have quickened the consolidation of the soil mass if mechanical compaction on controlled method was not possible.

Shri Sharma was of opinion that the above two cases were mainly due to subgrade failure and the deformation was caused on low modulus of deformation, insufficient strength of soils, poor compaction, settlement due to consolidation of subgrade, volume changes and removal of soil from the subgrade by seepage of water or by other agencies. He also pointed out that the distribution of moisture in the subgrade was an important factor for foundation failure.

Shri Sharma added that the prediction of settlement in highway embankment was a very important factor, specially in a high fill embankment, and suggested the following formula:

$$\text{Settlement} = \text{thickness of layer times } \frac{(e_1 - e_2)}{1 + e_1} \quad \dots (1)$$

where e_1 = void ratio of the natural ground before loading.

e_2 = void ratio of the natural ground after loading.

The ratio of settlement could be determined from the type of soil in which excess water was drained off and reduced the air voids under the pressure of the fill materials as per following formula used to determine the time of settlement.

$$t = \frac{Th^2}{C_v} \quad \dots (2)$$

where t = time of settlement;

T = Terzaghi time factor;

h^2 = longest vertical drainage path;

C_v = average coefficient of consolidation.

He also suggested the Newmark chart for vertical stresses due to embankment loads to determine embankment settlement. Though the process was very laborious involving complicated mathematical computation, still it was better to examine it as the road proposed was to be an Expressway with high embankment fills.

Referring to Fig. 1 and the Appendix indicating variation of design thickness of flexible pavement as obtained from C.B.R. tests and group index method, Shri Sharma stated that the chart in Fig. 1 might be modified and developed on the following lines and then the results compared:

- (1) C.B.R. and Proctor density tests to be made in soil;
- (2) C.B.R. tests to be correlated with the bearing capacity;
- (3) Consideration of repetition of critical loading instead of wheel loads alone;
- (4) Relationship of C.B.R. bearing value and P.R.A classification to be established.

He also supplied a typical chart prepared by Missouri State Highway Department on the above principles.

Shri Sharma further added that the most important factors influencing the flexible pavement design were load, total thickness and subgrade bearing value. The equivalent wheel load method (EWL) worked out by the California Highway Department to assess the traffic requirement was the most satisfactory method to determine the past as well as the future traffic on consideration of repetition of axle loads over the flexible pavement. Curves might be drawn on C.B.R. values with the total axle loads calculated for the life of the road.

Referring to para 8.2.2, Shri Sharma stated that the quantity of cement required to produce satisfactory soil-cement mixture for each type of soil could be determined by (1) classification of soil and (2) preparation of trial mixtures containing varying proportions of soil to cement to assess the optimum moisture content and maximum density.

In Appendix 2, the Authors had stated that there was lack of grip in between the premix carpet and soil-cement base. It was not known whether a tack coat was provided or not to have proper bonding between the two. An experiment carried out in the Road Research Laboratory, Harmondsworth, showed that the premix surfacing was affected more by variation of binder content than by any other constituent. There was an optimum binder content

above which the surface became smooth, slippery and plastic and below which the premature disintegration occurred.

Referring to Appendix 8 in the Paper, Shri Sharma stated it did not show clearly the grading of soils mixed with sand nor indication of basis of proportioning the soil and sand at 1 : 1 and 1 : 2 was given. In order to obtain relatively high shearing resistance in base course, three things, viz., hardness of aggregates, grading of materials and plasticity index of soil fines and the density of compaction were necessary. As the stresses imposed by traffic penetrated deeply into the base and subgrade, they diminished rapidly with depth. Therefore, it was uneconomical to employ high quality materials in the lower section of the base as was done in the case of serial 3 of Appendix 8.

Shri Sharma concluded that in India more low cost roads were needed and, therefore, soil stabilization would play a very important role in the field of highway engineering. So, he suggested that the Standards and Specifications Committee of the Indian Roads Congress should examine and prepare specifications for adoption in the country.

Shri P. L. De (Joint Author) in reply to the comments of Shri D.C. Chaturvedi stated that they had also tried stabilization of soil with lime and got good results in the laboratory.

Regarding specifications, in the original experiment only dry density was used but in the new specification they were also specifying the P.I. and the sand content.

As regards N.H. 2 failures, some speakers had enquired about the difference between the failures under paras 4.1.3 (ii) and 9.3.2. Shri De stated that actually the first one was not on the National Highway but on a link road newly constructed where the embankment was high and the earthwork was newly laid. In one case they had recommended higher thickness of pavement as a remedial measure for failure instead of digging out the existing road and compacting the subgrade. In fact, the road was already constructed and it was not considered advisable to dig out the whole road and again compact the embankment, though it might have been slightly cheaper.

In regard to the differences in the results given in the Table in Appendix 5, Shri De replied that these were due to the nature of soils and not due to moisture content because tests were done in different locations.

Shri A.K. Deb had asked about the source of C.B.R. curves. Actually, what he referred was standard C.B.R. curve for airfield pavement and not for roads.

Shri S. N. Gupta (Author) in his reply to Shri D. C. Chaturvedi's comments that 2 cu. ft. of soil might be in excess if it was to be taken at frequent intervals, stated that for the purpose of identification only, about $\frac{1}{2}$ lb (one cigarette tin full) sample is collected at close intervals (say one furlong) but for the purpose of detailed stabilisation tests it is necessary to collect about 2 cu. ft. of soil whenever there is a change in type.

Grafting of stone on soil-cement layer, as suggested by Shri Chaturvedi, had been successfully tried in West Bengal also.

Alternative wetting and drying of deleterious salts might cause subgrade failures, but in none of the cases studied in the Paper, the subgrades contained detrimental percentages of such salts, hence this point had not been mentioned in the Paper.

As suggested by Dr. H. L. Uppal, due consideration is being given to compact the embankment in layers and thereby reduce the crust thickness whenever this is found economical. The Authors were grateful to Dr. Uppal for suggesting the economic and convenient methods of embankment and subgrade compaction.

The Authors did not agree with Dr. Uppal regarding the sufficiency of 2.5 to 3 per cent of cement for stabilising soil, for use in top layer under conditions prevailing in West Bengal. This little percentage of cement would no doubt improve the C.B.R. value of the soil and might be adopted for the base course provided sufficient thickness of wearing course was laid over such base. The examples cited in the Paper were not, however, for the base course. In this connection Shri K. K. Nambiar's comments might be of interest.

The Authors had included fine sand as granular materials, mostly passing 40 U. S. sieve and hence the lowering of P. I. by their admixture with soil.

The Authors appreciated Dr. Uppal's suggestions for lowering the limits of compressive strength for soil-cement as theoretically required. However, as there is always a lag between the actual achievement in the field and the laboratory test results, the higher limits of 250 lb per sq. in. as the compressive strength to be attained in the laboratory had been maintained as suggested by the Road Research Laboratory of England in the book "Soil Mechanics for Road Engineers". The use of small percentages of lime for rendering highly clayey soils friable, as suggested by Dr. Uppal, was being tried in West Bengal in the later experiments.

With reference to the suggestions offered by Shri L. R. Chadda, Shri Gupta stated that the use of hydrated lime for improving the C.B.R. value of soil was being studied in West Bengal.

Shri M. P. Dhir's suggestions regarding analytical methods of evaluating semi-rigid pavements might be justified for big projects. However, the reduction of 25 to 33 per cent over flexible pavements had been recommended by many Authors and found to be satisfactory in the trials conducted in West Bengal.

Shri D. K. Laroia was correct in opining that the C.B.R. values of old subgrades might also have wide variation which was primarily due to variation in the type of soil and disturbance of the subgrades. However, controlled compaction would no doubt reduce this variation.

The thickness of the crust as mentioned in Table 1 was measured in damaged portions after the failure had taken place and the existing thickness was low due to the pushing out of material under traffic causing depression in the wheeled track and heaving up at the centre and at the edges.

The C.B.R. value of the subgrade at 7th furlong of 2nd mile was very low when measured at 35 per cent moisture content and might have been somewhat higher at 23.7 per cent moisture content as existing in the subgrade. But it might be seen from Table 1 that the measurement was made in February when the subgrade had dried up sufficiently whereas in rainy season it must have contained much higher moisture content.

Regarding the doubts of Shri Laroia about the reduction of dry density from 108.7 to 98 lb per cu. ft. and the corresponding reduction of C.B.R. value from 3.7 to 3 only, it might be stated that with a dry density of 98 lb per cu. ft. there were lot of voids which were not all filled with water as the moisture content in both the cases were nearly the same. That means the C.B.R. value of 3 at 90 lb per cu. ft. dry density was not at saturation. At saturation moisture content, the C.B.R. value would be much lower than 3 which means higher dry density does play an important role in the bearing capacity.

In reply to **Shri A. K. Deb's** query about the source of the C.B.R. design chart given in Figure 1, the Author stated that these curves had been recommended by the Road Research Laboratory of U.K. and the ready source is I.R.C. Paper No. 205, "The Importance of Subgrade Compaction in the Economic Design of Flexible Pavement" by S. R. Mehra and Dr. H. L. Uppal published in Vol. XXII-3 of the Journal of the Indian Roads Congress.

In reply to **Shri N. Mohan Rao's** comment regarding para 2, page 36, the Author mentioned that it had been clearly stated in the paragraph that the C.B.R. value would not help much and rather be misleading in this case and no importance had, therefore, been given to the C.B.R. value.

With regard to the failure on the 57th mile of G.T. Road the Author stated that in this case the failure was due to weak subgrade and not due to settlement of the embankment which was a very old one.

Shri T. K. Natarajan's various suggestions regarding further advanced research and study on the subject were noted by the Authors with great appreciation.

In reply to **Shri G. Gupta**, the Author stated that the soil exploration would give valuable information about the type of soil at different depth, but the question of economy of using soil from particular depth would depend on various considerations. Moreover, the existence of any hidden soft layer at lower depths would give valuable warning and suitable precautionary measures must be taken before the construction particularly if the embankment be very high. Other points and suggestions of Shri Gupta were noted with interest.

Shri K. K. Nambiar had commented that to insist on soils with certain particular gradings alone for use in embankment work would make it unduly expensive or wholly impracticable. The Authors did not mean such insistence. The idea was to make a judicious selection of the locally available soil. If the situ soil be extremely bad and relatively better soil be available within reasonable distance it might, in the long run, be economical to use the imported soil.

The Authors agreed with **Shri Nambiar** on the advice against the use of boulder soling on clayey subgrade susceptible to moisture changes.

In para 4.1.3, the failure was primarily due to inadequate compaction of the subgrade because this allowed ingress of excess moisture and ultimate weakening of the subgrade. To keep the water table more than 4 ft below the formation would mean very high embankment in most areas of West Bengal.

The Group Index method of pavement design as described in para 5.1.2 is in fact an approximate estimate of the thickness of construction required and was only adopted in the early stages when facilities for C.B.R. tests were not available. For the sake of interest a comparison had been made in the Paper without any intention of giving the least preference to this method over the C.B.R. method.

Shri Nambiar's concluding remarks that improvements to the drainage facilities and provision of an impermeable surfacing would have protected the subgrade soil and increased its bearing capacity.

adequately to carry the required traffic is correct. But in absence of readily available facilities for such protections, greater pavement thickness had to be suggested. Experiments were in hand regarding the feasibility of using impermeable surfacing materials.

Regarding **Shri K. Ramaswamy Reddy's** suggestions on the selection of damaged and undamaged spots at closer spacing, the Authors stated that as varying degrees of damages had taken place over a long stretch a worst damaged and best undamaged spot had to be located quite apart. So long as the traffic conditions were the same, there did not seem to be any objection in selecting the spots as done—the original thickness in both the damaged and undamaged portions were $11\frac{1}{2}$ in. and the existing thickness of $8\frac{1}{2}$ in. in the damaged portion was due to loss of materials by shifting under traffic.

Dr. M. L. Puri's suggestions are noted with interest. Facilities for measuring the distribution of the stresses in the subgrade by use of pressure cells were not available to the Authors.

The suggestions offered by **Shri Zafar Mohiuddin** for conducting studies and research on the different pavement types in different regions of India is worth consideration.

With regard to **Shri C. N. Nagaraj's** opinion on the adequacy of $2\frac{1}{2}$ to 5 per cent cement for soil stabilisation, he invited attention to **Shri Nambiar's** comments on this point.

In reply to **Shri K. L. Sethi's** suggestions for the use of "Uppal's Syringe" for field identification of clay, silt and sand, the Author stated that there are several simple but useful methods of field identification of soil (vide Report on the ECAFE Seminar on Low Cost Roads and Soil Stabilization held in new Delhi in January 1958) which were being widely adopted for soil survey in West Bengal.

Regarding **Shri G. C. Sharma's** query about the soil survey for Calcutta-Durgapur Expressway, the Authors stated that from the data shown in Plate I, the various types of soil at different depths along the alignment could be indicated. The water table is also shown there. The Plate, however, only shows a typical example of the method of representation and is not a complete picture. It was not possible to furnish in such a short Paper all the properties of the various types of soils met with. **Shri Sharma's** suggestions regarding controlled compaction in layers was welcome. However, it was not yet feasible to ensure this for all roads under construction. The formulae shown by **Shri Sharma** were already well known, these had been used by **Ray Webler** in his Paper "Description of a

method of predicting fill settlement using void's ratio" published in Highway Research Board Bulletin No. 173, pages 80-93, 1958.

The correlation of C.B.R. values with other soil properties as suggested by **Shri Sharma** was by itself a separate problem of research which was receiving due attention. With reference to the lack of grip in between the premix carpet and soil-cement base as mentioned in Appendix 2, the Author stated that a tack coat was provided.

Referring to Appendix 8 in the Paper, the details asked by **Shri Sharma** had not been given in the Appendix because such details had already been furnished in a previous Paper by the Authors. In serial No. 3 of Appendix 8, the reversal of the specification was done only for experimental purposes.

Shri S. R. Mehra (Chairman) winding up the discussion, stated that the Paper being very interesting had evoked a lot of discussion and had forcefully brought out two points.

* The first was the necessity for properly designing the thickness of the pavement and for using the cheapest possible material at the bottom and using more expensive material on the top, starting with ordinary locally compacted soil and ending up with hard type of stone.

* The second point was that in case it was not possible to design the pavement, it should be made absolutely obligatory to compact a reasonable thickness of about 12 or 15 inches underneath before imposing the pavement on top.

Regarding the very important point raised by **Shri Nambiar** as to the modified soil and soil-cement, he thought the whole point was as to what was the material expected to do and it should be designed in relation to the engineering properties which it was required to satisfy. Once that aspect was taken into account, there should be no confusion as to whether it was modified soil or soil-cement.

Discussion on Paper No. 214*

**"Design and Construction of Training Works over
River Ghogra at Ayodhya"**

By

N. C. BHARGAVA

Saturday, January 30, 1960.

Shri G.C. Khanna (Chairman) called upon Shri Shitala Saran to introduce the Paper in the unavoidable absence of the Author.

Shri Shitala Saran introducing the Paper on behalf of the Author (Shri N. C. Bhargava) stated that he had also been associated with the work as the design of the training works was done in the Design Organization of Uttar Pradesh P.W.D. The river training works for the proposed bridge over Ghogra at Ayodhya were a prelude to the construction of the main bridge. Ayodhya being of great religious importance, the necessity of a permanent crossing there had always been felt very keenly, but due to paucity of funds the project was being postponed for the last many years. The khadir of the river being extensive, the training of this mighty river had necessarily to be a costly affair as could be seen from the cost of Rs 75.11 lakhs.

Shri Saran then described some of the salient features of the work, dealt with at length in the Paper, e.g., the necessity for change in the alignment and laying of guide bunds, erection of balli spurs to deflect the flow of stream, laying of apron in deep water on Ayodhya side, the quantities of boulders, earthwork used on the works, etc.

Shri Saran stated that though originally intended to be completed in one season, the extent of work involved was so huge that it was later decided to split up the work in two working seasons, i.e., one season for Ayodhya side bund and the other for Lakarmandi side bund.

During the construction of Lakarmandi side guide bunds it was found that the existing pontoon bridge was totally inadequate for transport of materials across the river from Ayodhya side, this

* Published at pages 71 to 115 of Vol. XXIV—Part 1 of the Journal of the Indian Roads Congress, October, 1959.

necessitated the construction of three pile bridges of a total length of 1,200 rft in a record time of 35 days. Shri Saran added that great difficulty was experienced in the extraction of piles after the bridges had served their purpose, so much so that some piles had to be left over to be extracted in the dry season. The construction and maintenance of about $4\frac{1}{2}$ miles length of temporary approach roads was another headache, more so in the absence of adequate number of chequered and pierced steel plates.

Shri Saran concluded that the work had stood very well during the last two floods, though a flood of the intensity for which it had been designed had not yet been received to see its effect.

Shri D. C. Chaturvedi referring to para 6.1 regarding the use of clay for overtopping the sand embankment, asked the Author if possibilities of using soil-cement were explored for the work and also in place of flat brick soling laid on top of bund.

Referring to the tests carried out in the Uttar Pradesh P.W.D. Research Institute on samples of Lohgra and Chunar stones, which revealed that Chunar sample was not durable, Shri Chaturvedi enquired if the Author had observed any difference in the behaviour of these stones.

He also enquired about the method of compacting the $4\frac{1}{2}$ in. brick ballast layer consolidated to 3 in. described in para 6.8.

Shri K. F. Antia stated that on the Western Railway in difficult reaches where pitching was disturbed by strong currents, the practice was to grout the pitching and it had been found eminently successful on river training bunds of several bridges. He felt that if grouting of pitching was undertaken, at least at strategic points, it might be possible to reduce the thickness of the pitching.

In regard to para 6.2 about permeable spurs not being able to prevent earth from being washed away, Shri Antia stated that permeable spurs were eminently suitable for protection work and he cited the case of a bridge on Kosi river on the Kharagpur-Asansol railway line, where the river had made more than a 90 deg. bend and was trying to cut back behind the bridge. Permeable spurs consisting of ballies were driven into soft soil by tying ropes at the top for shaking them into position with loads to help sinking and the space in between the ballies was filled with brushwood weighted down with boulders. Within one season, silting of over 5 ft depth of water took place and sand was found flush with the top of the spurs. Shri Antia felt that in the case of Ghogra river the washing away of the earth would have been prevented if the brushwood had been weighted down sufficiently with boulders and the interstices were reduced.

Regarding peculiarity of training bunds, Shri Antia mentioned another example on the West Cost line of the Western Railway. Due to the vagaries of scour of the river under Narbada bridge, after every monsoon a hydrographic survey had to be carried out to locate a pot-hole which reached 75 ft below the bed level and shifted its position after every monsoon. Investigations carried out at the Poona Research Station revealed that the cause of the pot-hole was the end of the spur, about $\frac{3}{4}$ mile away, which had purposely been kept below the high flood level. What happened was that high flood water used to come not only along the river but the backwater behind the spur also used to top the spur. The result was that eddies used to be formed resulting in a pot-hole and the position varied with the position of the eddies. It might lead one to conclude that under certain conditions the ends of the bunds should not be kept below H. F. L. with a view to protecting them from sudden destruction.

The trial and error method described in para 8.2 for diverting the subsidiary channel was, he felt, not the proper way of tackling the job. Whether it was a branch or a main stream, to try and place a block across it was to ask for trouble. This could have been avoided if permeable spurs had been put down at strategic points; better still, if some investigations had been carried out at a research station. In Bombay, Shri Antia stated, for protection of a sea-wall tetrapods had recently been used and the possibilities of using small size tetrapods might be investigated for interlocking pitching at strategic points. He was not sure whether the results would be successful but it was just an idea for consideration.

Shri A. Banerjee stated with reference to para 3.1 that it would be of interest to know from the Author what formula was adopted for calculation of discharge and what was the value of constant. If Dicken's formula was used, for a catchment of 33,500 sq. miles and a value of constant of 800 the discharge would have been nearly 20 lakh cusecs.

In comparison with the widths of 3,000 to 3,600 rft for the three existing railway bridges on the same river, the regime width required for a discharge of 1,000,000 cusecs worked out to be 2,667 ft. Shri Banerjee requested the Author to explain the reasons for adopting a waterway of 3,100 rft which was higher than the calculated regime width and that provided for the three railway bridges. The active stream said to be 4,000 rft should not be the reason for adopting increased width of waterway when guide bunds had been provided. He also asked whether there were any guide bunds provided for the railway bridges and how those bridges were behaving with the openings provided.

Concluding, Shri Banerjee enquired if any model studies of the project were taken up before finally deciding on the waterway and

guide bunds and whether cross-sections of the river were taken after the year 1957, during and after construction and how far the river had since scoured itself to attain a stable channel.

Shri K. K. Nambiar stated that the Paper gave a very interesting account of the difficulties experienced in the construction of training works and methods adopted to overcome them. He, however, felt that in order to fully appreciate the basis of the design it would have been useful if a key map showing the course of the river, the width of the khadir and the location of the railway bridges both upstream and downstream had been given.

With regard to the mention in the introductory remarks that a full bridge would have been costlier, Shri Nambiar remarked that looking at the cost of bridging in Uttar Pradesh given in the recent Annual Number of "Indian Builder", he did not think that the proposed bridge would have cost more than Rs 2,000 per foot, even if it had been a bridge of $1\frac{1}{2}$ mile length which was said to be the width of the khadir, i. e., the cost would come to Rs $1\frac{1}{2}$ crore. For 2 mile width of khadir, the cost would have been about Rs 2 crores.

Moreover, no mention was made in the Paper about the construction of approach bunds; in fact, bell-bund system would not be complete unless approach bunds restricting the waterway and two guide bunds were provided to flume the river through the restricted waterway.

He, therefore, wanted the Author to give the rationale of the bridge design, whether the restriction was absolutely necessary, how much saving was effected by this and when the cross bund was to be constructed, and whether allowing flow through the guide bunds without the cross bund would not affect the scour around the moorhead and defeat the basic concept of bell-bund system.

He wondered whether the existence of the railway bridges downstream and upstream having 3,000 and 3,600 ft waterway had compelled the designers to adopt the restricted waterway.

Shri R. P. Chanda asked in regard to the discrepancy in the quantities of boulders collected and laid in aprons, etc., whether the Uttar Pradesh P.W.D. allowed for any sinkage allowance for boulders and other materials. As the material must have been collected months earlier, there was bound to be some sinkage and there could also be manipulations in the method of stacking. If there was a sinkage allowance, he asked, whether the same was also used in paying the contractor.

Referring to para 6.6 Shri Chanda stated that laying aprons in deep water was a difficult problem. He asked if the estimates of

the contracts provided separately for labour payments in laying boulders in dry ground, in shallow water, in water upto 8 ft depth, and in water deeper than 8 ft, or whether there were two items, one for upto 8 ft and the other for more than that. If there was no such provision, how the rates were arrived at, and whether the initiative and method of dumping boulders in water upto 8 ft or more rested with the contractor. He wondered whether higher rates had been allowed for this type of work which needed lot of imagination and anticipation.

The speaker wanted the Author as well as Shri Chaturvedi to explain whether there were any standard specifications for stone boulders used in pitching and aprons. He was not clear whether there was any standard laid down by the Indian Roads Congress about the properties of stone required.

In places where the river was extremely tortuous and shifting its course, Shri Chanda enquired what length of the river upstream could be stabilised by means of a guide bund whose length was probably little over the length of the bridge.

About the mention of an approach bund by an earlier speaker, Shri Chanda thought perhaps he meant a marginal bund along the river upstream so as to keep the river in position and he wanted to know whether the river was likely to misbehave beyond the reach of effect of the guide bund.

Shri H. H. Campbell stated that from his experience he had found that asphalt could be used very satisfactorily for pitching of both side bunds and guide bunds, commonly known as groynes and it was not necessary to dress the pitching while using asphalt. He referred to Baron Van Asbeck's book on "Bitumen in Hydraulic Engineering" showing a photograph, taken as far back as 1937, of grouting work done on the river Tegos in Portugal. Conditions there were similar to the asphalt grouting work being done in India. The grouting could either be done with neat asphalt or bitumen, or else with bituminous mastic. In this connection he quoted a lot of work done by them on the Torsa, Teesta and Jaldhaga rivers in West Bengal, which had survived the first few monsoon periods. Further, one big advantage in using asphalt was that one did not have to use water in the making of grout for apron work in a dry area.

In regard to 3 ft thickness of pitching mentioned in para 5.3, they had found 18 in. thickness quite satisfactory, out of which only 9 in. needed to be grouted and the bottom section filled in with gravel. As regards the quality and size of boulders used, Shri Campbell had found that 9 in. overall size stone was satisfactory for such a work.

Referring to para 6.6, he stated that quite a large amount of work was being done under water, particularly in Holland. A sufficiently hot mastic could be quite satisfactorily poured to a considerable depth into water as it would flow all round the stones and hold them together in a solid matrix, although in actual practice the mastic did not adhere to the stone.

In the case of river bank protection, it was not an essential property that the protection should be completely impermeable because the main requirement of protection was against erosion. However, he could not agree with Shri Antia's suggestion for the use of tetrapods which were doing a very good job in Bombay for coastal protection. But for river bank protection, he felt, one would get washing away of the bank behind and a more dense protection was required.

As regards sinkage, asphalt was flexible and would allow for sinkage and it was also easy to make good a sunk patch by adding a little more on top.

Shri R. Thillainayagam stated that the Author would have given more details about the three railway bridges up and downstream of the training works so that they could compare the functioning of the proposed bridge with those already in existence.

Regarding the foundation of the launching apron designed to withstand a scour equal to 2 times the normal scour depth, he stated that the I.R.C. Specifications, Section 109 (b), specified that twice the scour depth was to be adopted only at the noses of piers. As regards upstream noses of guide bunds, it should be about 2.75 D. He wanted to know why this was not adopted in that case.

As regards sizes of boulders used for pitching, etc., normally in Madras State they did not use anything less than 1 ft size. In his opinion, 6 in. size was very small.

Shri R.K. Mathur agreed with Shri Antia that instead of trying to divert the stream "with a bang" (line 3, page 93), a series of permeable spurs would have successfully done the job.

Regarding certain discrepancies observed in the quantities of boulders collected and laid in aprons and pitching work, Shri Mathur asked the Author what was the nature of the discrepancies so as to benefit the engineers engaged in similar type of work.

Shri Shitala Saran, replying to the comments on behalf of the Author, stated that he quite agreed with the Author that because of shortage of time the guide bunds were started in the month of January as sometimes floods came in the river Ghogra in early May

and being hard pressed for time whatever suggestions were put forward were all tried simultaneously. Also, because they were not sure of any of them, they could not be tried separately.

The Author to whom the comments were referred to for elaboration added that the present standard methods of designing training works, in the light of experiences gained in the last couple of decades, specially in breakwaters needed to be changed. But this could be done only if extensive experiments were carried out in research laboratories. For the Ghogra training work there was no time for such tests and, as such, the orthodox specifications and methods of design were adopted.

In reply to **Shri A. Banerjee** he gave the break up of the catchment area, i.e., 8,000 sq. miles for hilly area, 6,000 sq. miles for tarai area and about 19,500 sq. miles in the plains, and the value of *C* for these areas was 800, 500 and 240 respectively. With these figures the discharge came to about 14 lakh cusecs.

As to why a regime width of 3,100 ft was adopted against a calculated width of 2,607 ft, **Shri Shitala Saran** explained that due to the restriction of flow, about 10 per cent extra had to be provided for. Regarding the downstream railway bridge, it consisted of 17 spans of 200 ft each but the river flowed only under 7 spans though there were guide bunds on both sides.

Regarding **Shri Nambiar's** suggestion about approach bunds, **Shri Saran** stated there was no point in making guide bunds without approach bunds. The work was done simultaneously but they had not raised the bunds to full level as the design of the bridge had not been finalised and the approaches were kept only 5 ft above H.F.L. for which the guide bunds had been designed.

Regarding his suggestion of cost of Rs 2,000 per running foot for an unrestricted bridge, he stated that the bridge was being designed for a discharge of 14 lakh cusecs and the scour from H.F.L. was of the order of 99 ft, with the result that the wells had to be taken down to about 140 ft below the bed and each well cost about Rs 4 to 5 lakhs. Naturally, making such a bridge would be very costly.

Shri Saran added that the railway bridge with 3,000 ft waterway was about 60 to 70 miles downstream and had very rigid bank on one side, but the flow was concentrated between a few hundred feet of the length of the bridge.

Regarding **Shri Chanda's** observation about sinkage, **Shri Saran** explained that in the first tenders invited 30 per cent was permitted. But the tenders received being very high, later on it was decided to pay on measurement basis.

Regarding doubts whether payment was made separately and whether there was any discrepancy in measurements of boulders, the Author had clearly stated on page 78 of the Paper that boulders for each grid were stacked separately and measured before laying and strict supervision was exercised throughout the operations.

Regarding **Shri Campbell's** suggestion about using asphalt, **Shri Shitala Saran** stated that he had not come across any bridge work where asphalt was used for pitching.

The Author to whom the report on discussions was sent felt inclined to agree with **Shri Campbell's** contention. Though the technique was new to this country, grouting of pitching and apron with asphalt and sand, with a view to reduce the thickness, while providing adequate flexibility, was becoming increasingly popular in the continent for breakwaters and sea-walls. It would be worthwhile if, to begin with, this technique was tried on small training works in India also.

Regarding **Shri Thillainayagam's** observation about the scour theory of 2.75 *D*, the I.R.C. Code did not provide for this provision. It was on certain model tests carried out that the requisite depth was fixed. Model testing was not done for this bridge.

Shri G. C. Khanna (Chairman) winding up the discussion thanked the Author and **Shri Shitala Saran** and informed the house that the latter had drawnigs with him showing the alignment of the flow of the river and was prepared to answer any other question if members were interested.

The Chairman also felt that the cost of the guide bunds was on the high side and that some economy could have been exercised by using lesser thickness and width of apron as the velocity of the river was not much. He, however, did not agree with **Shri Nambiar** that the bridge should have been built for the full khadir width. In Punjab, some bridges were built for the full khadir but gradually the waterway was reduced and lesser lengths of bridges provided.

The Chairman endorsed **Shri Antia's** solution for diversion of the channel. In irrigation, all headworks were built on dry land and the stream was diverted after completion of the headworks. He wished the Author should have consulted the irrigation authorities about the method adopted by them. He also cited the example of **Harike Barrage** in the Punjab, where to counter the same difficulty they had put in rails encased in stone boulders and properly tied and wrapped to stop the flow. In such cases there should not be any time gap, otherwise the whole work could get washed away.

Discussion on Paper No. 215*

"Investigation into Causes of Cracks in Certain Concrete Pavements"

By

BRIG. S. K. BOSE

Saturday, January 30, 1960.

Shri E.A. Nadirshah (Chairman) regretted that the Author, Brig. S.K. Bose, was not present to introduce his Paper for discussion. He, therefore, requested Shri A.K. Deb, who was earlier attached to the Military Engineering Services to introduce the Paper.

Shri A.K. Deb in his introductory remarks stated that Brig. S.K. Bose presented a Paper to the Indian Roads Congress in 1956 on "The Influence of a Superimposed Layer in increasing the Load Bearing Capacity of a Rigid Pavement" and all those formulae and procedures adopted by him for calculating the stresses due to wheel loads and working stresses had been used in the present Paper also. The problem of increasing the load bearing capacity of existing runways was a pressing need due to the advent of very heavy planes for which the pavements were not originally designed. In 1949, the then Engineer-in-Chief invited a testing team from the U.K., for determining the K value, i.e., the modulus of subgrade reaction for all the airfields in India. Those data were utilized by Brig. Bose in the Paper. Only about two years ago, a load testing frame, as per details of the one brought by the U.K. team, had been manufactured in the E-in-C's Branch and an Airfield Inspectorate team was since testing the airfields in India for the necessary data required for future airfield pavement design as well as for increasing the strength of present ones. In the light of his previous findings on the actual behaviour of concrete overlays as well as bituminous overlays on two airfields in India, Brig. Bose tried to show the validity of his approach to the design of overlays by actual calculations in each case.

Shri Deb concluded that not being associated with the Paper he would naturally not be in a position to answer most of the points that might be raised during the course of discussion and the same would be referred to the Author for reply.

*Published at pages 117 to 141 of Vol. XXIV—Part 1 of the Journal of the Indian Roads Congress, October, 1959.

Shri D.C. Chaturvedi observed with reference to para 2.3.3 dealing with a correction applied to allow for decrease in bearing strength, that the Author should explain why the plate test could not be carried out under saturated conditions. As for factor of safety of 1.5 assumed for the flexural strength, he thought it should be 2.

The edge stresses in the concrete slab, Shri Chaturvedi stated, were higher than interior stresses and the same should have been calculated. Regarding the effect of decrease or increase in the K value, not being much marked on the stresses induced in the slab, he referred to the "Soil Mechanics for Road Engineers", where it was stated that a change from 200 to 50 lb per sq. in./in. in K value increased the maximum stress by 10 per cent or less. However, the increase in stresses when K value decreased from 250 to 100, vide para 2.4.2, was about 50 per cent. The large variation might be explained by the Author.

Referring to para 3.5, regarding new slabs in the extended portion standing up well without any cracking, Shri Chaturvedi asked the reason for this behaviour.

To strengthen the runway with a concrete overlay of 6 in. thickness, he remarked, it was not understood why 6 in. thickness of cement concrete was adopted when 3 in. premix carpet was behaving satisfactory. On the other hand, the thickness of concrete pavement could have been reduced due to greater rigidity of cement concrete compared to flexible construction.

Shri M. P. Dhir while welcoming the analytical approach adopted in the Paper for assessing the adequacy of concrete pavements, stated that all along, the flexural strength of concrete had been estimated indirectly from compression tests. Though the method was fairly approximate, it was always better to determine the flexural strength directly from beam specimens. Secondly, the values of both the modulus of elasticity and the co-efficient of linear thermal expansion assumed in the Paper appeared to be low. For a cement concrete of 600 psi, flexural strength, values of modulus of elasticity would lie somewhere around 5×10^6 psi and thermal co-efficient of linear expansion 5×10^{-6} per deg. F. respectively rather than 3×10^6 psi and 3×10^{-6} per deg. F. as adopted in the Paper.

On page 123, the load stress on the interior of the 4 in. slab had been shown as 760 psi, but on actual substitution in the formula given it worked out to 1,100 psi. It might be noted, however, that if the same stress was determined from Westergaard's modified formula, which allowed for greater concentration of reactions around the load than the deflections, a value of 777 psi was obtained. The discrepancy might be clarified.

Moreover, in view of the radius of loading 'a' being relatively large, additional stress component should be added as recommended by Westergaard in 1943 for airfield loadings. For the 4 in. runway slab, the additional stress came to about 66 psi.

With reference to para 2.4.3, it might be of interest to note that the temperature stress from Thomlinson's theory would work out to about 70 psi as against 87 psi determined from Westergaard's analysis for the same conditions.

Shri Dhir observed that the overlay design for rigid pavements was comparatively more complicated than that for flexible pavements and that precise formulae verified by actual field performance were not yet available for the design of rigid overlays. However, Dr. Henry Marcus of the Bureau of Yards and Docks of the U.S.A. Navy evolved equations from which maximum tensile stresses due to the wheel loads could be estimated in both the overlay and the original slabs. The main assumptions made were that the slabs interface was smooth and that the two slabs shared the bending moment in proportion to their rigidities. For 6 in. overlay slab calculations, on page 134, the value of E_s , i.e., modulus of elasticity for subgrade, should be 4,425 psi and not 5,312 psi, as shown there. There was some mistake in the multiplication, probably. Moreover, for determining the equivalent E , 'a' was taken as 7.4 in. This should actually be taken as 15 in. ('a' of 7.4 in. would be on the top of the overlay slab but at the interface its value for determining the composite K value should be 15 in.). On incorporating these corrections, the composite K value worked out to 750 lb per in. cube rather than 1,113 lb per in. cube as given in the Paper. The maximum interior load stress in the top 6 in. slab would then come to 563 psi and 470 psi respectively for Westergaard's original and modified formulae.

Since the 4 in. slab was obviously too weak to carry the wheel load of the order of 37,500 lb, stress analysis could be eliminated. Instead, the stress analysis of the 11 in. slab, used at Poona Runway extensions and which had stood well, would have been of greater interest. The maximum combined tensile stress for this slab for the 24,000 lb wheel load and for the given temperature conditions worked out to about 574 psi even for the higher values of modulus of elasticity and the linear co-efficient of thermal expansion. This was against the anticipated 28 days flexural strength of 600 psi. Shri Dhir offered to supply details of these calculations if required.

Shri Z.S. Shah referring to para 4.2, suggested to follow the practice of Europe to smash the broken slabs completely and then use the pieces to build up adequate depth of base for a flexible

pavement. Certainly it would have removed any danger of cracks re-appearing on the asphalt overlay.

He added that though the 2 in. bitumen macadam and 1 in. sheltercrete wearing surface gave good results, yet it was time that scientific methods were used for the design of asphaltic carpets for roads and runways. He would suggest the use of the Marshall Design Method with the following limits for airfields:

Stability 1,800 lb maximum

Max. flow 16

Voids in mix 3-5 per cent

Voids filled with bitumen 75-85 per cent

Shri P. L. De referring to correction for saturated subgrade as mentioned in para 2.3.3 by means of consolidation of laboratory C.B.R. test values, wanted to know if the validity of this relationship had been experimented with or if there was any reference in any literature where some such correlation was done.

In para 2.3.5, it was assumed that the value of K under worse condition of saturation was not much different from that determined in the driest condition of June as rainfall in Poona was only 24 in. It would be of interest to know the actual difference in the moisture content of the subgrade in June and in the monsoon and whether such difference, if any, had influence on the K values or the C.B.R. values. Particularly in this case, as the subgrade was originally not well compacted, the effect of even a little increase in moisture content might be greatly reflected on the K value or the C.B.R. value. The moisture contents corresponding to the values given in Table 1 should have been noted.

He wanted to enquire whether eleven in situ C.B.R. tests in 1955 and the moisture content and the C.B.R. values shown in Table 3 were carried out in different seasons and whether there was any information about the moisture content of the subgrade in each season.

Shri M. Meeran remarked that on page 124, it was stated that the concrete slabs at the time of observation of the cracks were subjected to fatigue caused by repetition of loads and reversal of stresses due to temperature changes, etc. Normally, in structural members and in machine parts with very high revolutions of the order of several thousands per minute, the effect of reversal and repetition of stresses had got to be taken into account for the purposes of design. But in the design of members in static structures like buildings, pavements, and for that matter even in highway

bridges, it was not necessary, generally, to take into consideration the repetition and reversal of stresses. Wohler's experiments proved that fatigue failures by repetition and reversal of stresses required several millions of repetitions before fracture could occur for certain ranges of stresses and that when the stress was within certain particular range, failure never occurred. He, therefore, did not think that any reversal or repetition of stresses brought about in the pavement either by the temperature stresses or the repetition of loading on the pavement, could have contributed any effect to cause failure of the concrete slabs.

Reference to pages 127, 128 and 129, showed that the cracks had occurred mostly at the corners. The reason given was the combination of stresses, etc., and also due to the failure of the subgrade not being capable of presenting a uniform bearing resistance. These cracks, he felt, were more due to the lifting up of the corners of the slabs. The remedy should, therefore, be to provide some normal reinforcement to resist the corner restraint stresses.

Further, Shri Meeran thought that it was not wise to provide staggered expansion joints in concrete overlays. Even without overlay slabs, their experience had been that if there was any staggering of the expansion joints, there appeared sympathetic cracks sooner or later.

Shri K. V. Thadaney observed that the Author had given very little details of construction or the conditions under which the two jobs were carried out and added from his personal knowledge that both the runways were constructed during the war in 1944. Each job had to be finished in 3 to 4 months and, therefore, sufficient attention was not paid to the proper execution of the works. Poona runway was laid over moorum soil and a base of 6 in. very badly consolidated water-bound macadam was provided. The whole job was simply rushed through. They put the metal and rolled it a few times and put moorum and they thought that was a proper base. In ordinary road construction, when laying a new road, they provided a water-bound macadam base, allowed it to settle down for six months or a year and then over it a rigid or a flexible pavement was laid, because of expected tremendous deformation of the surface and its settlement. In this case, road laying machinery was loaned to the army authorities and it was fitted with vibrating beams, which helped obtain a strength of concrete of over 600 lb per sq. in.

Further, the Author mentioned only 0.6 water-cement ratio, actually it was between 0.4 and 0.5. Even the flexural strength assumed by him was on the low side. Although they did not carry out tests, definitely they would have got about 4,000 to 4,500 lb

strength and thus it would be quite safe to assume a flexural strength of 800 lb per sq. in.

Shri Thadaney agreed that the thickness of concrete provided was inadequate. But he felt that the cause of cracking was not only due to inadequate thickness of concrete but because of the settlement of the metal base. He was of the opinion that for all the runways where there was no possibility of subjecting the base to some traffic consolidation, it would be advantageous to use soil-cement base.

In the case of Hakimpet runway, he thought it was the poorest type of concrete work he had ever seen. The work was being done by the Nizam's State Railway, and they had the moorum base which was dressed up and in certain places, where dressing was too much, they just packed in a little moorum and laid the concrete. The concrete itself was the coarse aggregate something between 3 to 1 in. and there was no fine aggregate, i.e., there was no smaller size of aggregate and water was plenty. It was something like 6 to 7 gallons per bag batch, with the result that the concrete was just laid and floated; there was no need to compact it. The joints were provided by leaving 1 to 1½ in. thick planks which were removed the next day. Shri. Thadaney brought this to the notice of the Chief Engineer of the Nizam's State Railway who said that they did not have any graded aggregate and proper men to do the job and, therefore, they had to be satisfied with this quality in order to finish the work in three months.

Shri C. L. N. Iyengar observed that linking of the design concept and the actual performance of a pavement was becoming more and more complicated in view of the wide range of variables in traffic and other factors, more particularly in airfield construction, as many airfields constructed some years ago were for wheel loads of very small magnitude and had now to carry highly increased loads.

In the case brought out by Brig. Bose for discussion, even a pavement which had been strengthened on same basis was showing some signs of distress. Therefore, this raised another point as to whether the strengthening layer had behaved in the way assumed in the design or whether the strengthening was not done to the required degree. But, in the scope of Paper, the Author only tried to prove that the overlay portion had been stressed beyond its capacity. No conclusive evidence was provided as to whether the failure was purely of the overlay or the overlay plus the existing pavement combined. In the Paper, however, Brig. Bose assumed the total depth of the two layer system to be 10 in., but the enquiries and recent excavations of the existing pavements showed that the old

pavement was 5 in. and not 4 in. as stated. During the recent examination it was also found that the bond between the two layers obtained by spreading a thin layer of cement grout was not effective at all and the upper layer could be levered up with very little effort. Several tests taken by the Concrete Test Hammer on the existing underlay slabs showed that the cube strengths of the old concrete at 28 days could not have exceeded 2,000 psi as against the strength of the overlay of over 4,000 psi. Therefore, the calculations worked out by assuming the strength arbitrarily at 3,500 psi would need to be corrected and the safe loads as modified would prove to be even smaller than what was given in the Paper. However, for the method adopted for estimating the stresses in the overlay it would have been preferable to employ a more widely accepted method than the Burmister's method. The A.C.I. Committee who recently produced a report on overlay for concrete pavements still seemed to give heavier weightage to the empirical method employed by the Army Corps of Engineers in U.S.A. and indicated that a method proposed by Dr. Marcus and Palmer might ultimately prove to be more rational when subjected to adequate field verification. He referred to an article "Resurfacing of Concrete" in the Silver Jubilee Number of Transport-Communications Monthly Review.

In the calculation, the value of modulus of subgrade reaction was taken as that of the soil below 6 in. granular base course and not the value as at the top of such construction. This appeared to be incorrect. It was also favoured by many authorities that estimates of the modulus of subgrade reaction should be done without disturbing the equilibrium moisture conditions below the pavement. This was best done by plate bearing tests directly on the top of concrete and against a given load, not merely the deflections of the plate but also the deflections of the surrounding area of the concrete.

Brig. Bose reported that the same overall thickness performed satisfactorily at Poona Airport and it would be interesting to know as to whether it was purely due to the intensity of operation of the heavy aircraft or whether due to proper bond between the two layers at that place.

In regard to the evaluation of the performance of concrete pavements, Shri Iyengar observed that merely the appearance of a few cracks or other deficiencies need not be classified as pavement failure. A number of defects might appear and yet the surface would be slightly affected, if at all. The cracks and other defects were only warning signs that the operational conditions had exceeded the design expectations. Therefore, the stage at which the indications should be reckoned as total failures was more on the basis of experience of the operation of pavements.

Shri K. S. Sankaran referring to para 2.3.3, regarding correction for saturated subgrade and especially the formula, stated that to find the K value for the worst condition they could very well soak the subgrade and find out the plate bearing value for that. He had found out the K value by finding out the C.B.R. for saturated and optimum moisture content. Shri Sankaran was not aware what was meant by "optimum moisture content." Moisture content at which subgrade had been compacted and the laboratory compaction were quite different. Shri Sankaran felt that the Author could have very well avoided this paragraph entirely in the Paper because it would be very misleading to engineers who go through it and try to use it.

Regarding overlays, Shri Sankaran stated that he had never come across, even in the U.S.A., any place where the overlay thickness was more than that of the base slab. He did not know how the Author had an overlay of 6 in. of concrete, probably he could have very well done using a bituminous overlay.

He agreed with Shri C.L.N. Iyengar in the point of K value for the subgrade. They had about 6 in. water-bound macadam and could fully make use of that and get a modified K value for that. Brig. Bose in his calculation for these overlays by using Burmister's equation found the modified K . Assuming that K value of water-bound macadam was 500, the K value for the combined subgrade and water-bound macadam worked out to 325. Of course, it might not alter the design criteria or the stresses much, but it was better that they thought in terms of the supporting power that was got from the water-bound macadam.

With regard to specifications for these overlays, it has been clearly stated in the laboratory that the overlay concrete should, as far as possible, be of the same quality as the existing concrete. Apart from the same consideration we have shrinkage and creep factors, but it is better that the overlay concrete should be of the same order as the existing slab. He did not know why the Author designed for a different strength than the original concrete.

Dr. M. L. Puri stated that a wheel load of 37,500 lb with tyre pressure of 75 lb per sq. in. was definitely very high for a 4 in. thickness of the pavement. It was not understood why for strengthening the pavement, the thickness of the overlay was not properly designed, when there were empirical formulae recommended by Portland Cement Association and United States Corps of Engineers, which had given very good results in the U.S.A. However, one important conclusion drawn from this Paper was that it should be absolutely essential to properly design the thickness of the overlays.

Dr. Puri added that the modulus of subgrade reaction was determined by the Author by plate bearing test or the C.B.R. test by

exposing the subgrade. Load Classification Number Method, commonly known as the U.K. method of rigid pavement design, had been found in the U.K. to be very useful for determining the load bearing capacity of the existing runways and it did not necessitate exposing of the subgrade for the determination of the K value. He thought that method would have given better results and should have been used in this investigation to find out the load bearing capacity of existing pavements.

Shri A. C. Sharma, in the absence of details about the 6 in. stone base course originally laid underneath the concrete slab of the Poona runway, asked if it was water-bound macadam, and whether the R.C.C. slab was found partially fixed with stone base or separated.

Referring to para 3.1, Shri Sharma wanted that details of anchoring of new overlay of 6 in. over the existing 11 in. thick surface should have been given. In his opinion, some neat cement grouting should have been done by drilling 1 in. diameter hole, say, one in each slab, to safeguard against any loose pockets in the subgrade as appeared from a perusal of drawing No. 1.

Secondly, the existing surface should have been well scarified and neat cement rendering should have been done before laying the 6 in. additional thickness.

Regarding joints, Shri Sharma asked the Author to clarify if old joints had been completely taken and cleaned and filled again.

Shri N. Mohan Rao, referring to para 2.3 regarding value of modulus of soil reaction stated that it was not clear to him as to what was meant by the term "the most representative value" stated therein.

Regarding displacement used in rigid pavement design, the description given on page 120 gave an idea that if it was not possible to attain 0.05 in. displacement, one could reduce the displacement also. In case, the necessary load reaction was not readily available it might be possible to reduce the size of the plate; but it was always preferable to go at least to 0.05 in. if not more, if the result should have some meaning.

In para 2.3.3, referring to correction for saturated subgrade, there appeared to be some mistake, i.e., instead of "original test", it should be "consolidation test". The Author has also stated that the C.B.R. test might also be used for this purpose. He would like to know whether the Author had any data of his own or of others working in this field using C.B.R. test for estimating plate bearing value at saturation.

Lastly, with regard to the type of cracks and pattern of cracks, it was noticed that the incidence of cracks was most prominent on runway ends rather than in the middle portions.

This stands to reason in as much as the ends of runways were stressed more than the middle portions. It was still the practice in this country to adopt uniform design thicknesses for the full length of the runway, overlooking the fact that runway ends were stressed more than the middle portions. A start should be made in this direction in all new runway construction jobs. Only then this type of failure predominant at the ends could be avoided.

Shri K. K. Nambiar pointed out an error in the equation on page 122, para 2.4.2 to find the radius of relative stiffness, where l was given =

$$\sqrt[4]{\frac{E \times h^3}{12(l - \mu^2) \times K}}$$

He thought that it must be $1 - \mu^2$ and not $(l - \mu^2)$, may be it was a printing error.

Regarding construction of the overlays, Shri Nambiar stated, there was an article contributed by him in the Silver Jubilee Number of the Transport-Communications Monthly Review which described the correct method of laying the overlays and the specifications to be adopted. The surface of the old concrete road should be made perfectly clean by treating it with a certain amount of commercial hydrochloric acid of a specified concentration, 28 per cent or so, and then cleaning all the traces of the acid before the cement slurry was applied. If that precaution was taken, the overlay would act integrally with the base and would contribute in a great measure to the strength of the slab.

Shri Z. S. Shah earlier stated that in the case of bituminous overlay over a cracked concrete slab, there was no point in trying to lay a bituminous overlay on a cracked concrete slab, and that the best thing could be to smash it up and then lay the bituminous overlay on top of that. Shri Nambiar observed that in such a case much heavier overlay would be needed than it would be otherwise. Besides, before subjecting the concrete pavement to the extreme punishment of "smashing up", he suggested a more conciliatory palliative such as grouting the cracks with bitumen before the overlay was laid, in which case perhaps the appearance of cracks or the duplicating of the crack pattern might not happen. He would like some experiments to be carried out on this to see whether the cracks in the concrete slabs got duplicated in the bituminous carpets also.

Shri Sarup Singh remarked that in the lining on the Nangal canal, concrete 'sleepers', 10 in. $\times$ 6 in., built below the joints of the slabs with a view to prevent the travel of the moisture from the surface to the subgrade were used. This technique had worked well and there had been no settlement of the slabs.

Regarding the thickening of the corners of the slabs to prevent buckling, he had tried it in his own house and it had worked satisfactorily.

Shri R. Krishnamachary* stated that in para 2.3.1 the Author mentioned that dial gauges were fitted with the jack. The gauges should have been fixed on the plate by means of an independent datum bar, fixing gauges to jack would lead to erroneous results and jerks.

Referring to para 2.3.2, he stated that the Author had not stated whether a proving ring was used for recording loads. This being a sensitive ring, the exact loadings would be better recorded.

Density data of moorum was not given. These types of soils generally did not show much of elastic deformation. Recovery for successive loadings was very little for moorum soils.

In para 2.4.3, the diurnal temperature for Poona as given by Meteorological Department was 35°F. whereas the Author had given as 28°F. This data may kindly be checked.

In Table 3, para 2.4.5, the density values of subgrades should have been given to give a better idea to judge the variation of C.B.R. values.

Shri V. Venkatasubramanian stated that observations were carried out over a period of 8 years on the Poona runway pavement. The 30 ft by 10 ft by 4 in. thick concrete slab laid over a 6 in. thick stone base had been subjected to considerable traffic having single wheel load of 37,500 pounds with 75 pounds per sq. in. tyre pressure. With the strength of the concrete as assumed in the Paper, the wheel load had been found to cause a maximum stress of 760 pounds per sq. in. in the interior of the slab. With the same conditions the edge and corner load stresses must have been still higher, causing corner and edge breaks. However, since the pavement had actually withstood considerable traffic with wheel loads of 37,500 pounds before showing signs of distress, and since transverse cracks were numerous, it looks as though the seat of trouble lies elsewhere. Also, the actual strength proper-

* This and subsequent comments were received in writing.

ties of the concrete and the subgrade appeared to have been considerably underestimated.

He further stated that it was not clear whether the K value used in the computations of the load stresses takes into account the strength imparting power of the 6 in. stone base course. A plate bearing test on the 6 in. stone base course would give a value considerably higher than the assumed value of 250 pounds per cu. in. for the subgrade modulus especially since the subgrade consisted of moorum, and the general topography permitted of good natural drainage of storm water.

The stresses due to temperature differential had been worked out based on the results of temperature observations in the United Kingdom. Actual temperature measurements were carried out at the Indian Institute of Technology, Kharagpur, during the summer and winter of 1959, on a 33 ft by 12 ft by 4 in. concrete road slab well bonded to a 4-in. water-bound macadam base over a 6-in. Telford soling of laterite stones. A plate bearing test on the macadam base immediately after the heavy monsoons gave a value of 400 pounds per cu. in. for the subgrade modulus. The ratio of the amplitude of the surface temperature variation to the amplitude of the air temperature variation varied within very narrow limits of 1.35 in summer and winter, and the ratio of the temperature differential and the amplitude of surface temperature variation also varied between 0.7 and 0.9. The maximum positive temperature differential for the 4 in. slab recorded in the summer of 1959 was 9° Centigrade. The results of these studies are being reported elsewhere.¹

The values reported for the warping stresses from Bradbury's formula might not represent the true stresses in the slab due to the temperature variation. In a thin slab laid over a 6-in. stone base course, warping stresses due to the temperature differential may not be as important as the end restraint stresses.² The slab is tied down to the stone base by bonding, and the high resistance offered by the stone base will retard the contraction of the slab leading to transverse cracks.

Shri Venkatasubramanian thought that the major reason for the development of these transverse cracks was due to the complete absence of contraction joints. If load and temperature stresses were

1. "Temperature stresses in thin bonded concrete pavements," by V. Venkatasubramanian, Paper submitted to the International symposium on concrete and reinforced concrete in hot countries; held in July 1960 at Haifa, Israel.

2. "Introduction to Highway Engineering," by J. H. Bateman, John Wiley & Sons, New York, 1948, Figs. 119 (a) and (b) on pages 302-303.

The modified K value is then considered in designing the thickness of overlay pavement with the help of Westergaard's revised formula.

Design of overlay pavement based on empirical formula of U.S. Corps of Engineers

Questions had been raised on many occasions how far the approach to the design of overlay mentioned above compares with the U.S. Corps of Engineers' formula based on empirical data.

This empirical method reproduced below was published in 1943.

Where a concrete slab is laid directly over an existing slab, the thickness of the concrete overlay may be determined by the formula:

$$hc = \sqrt{h^{1.87} - Che^2} \quad \text{where}$$

hc = thickness of the overlay slab.

h = thickness required of an equivalent single slab placed directly on the subgrade with a working stress equal to that of the overlay slab.

hc = thickness of existing pavement

C = Coefficient depending on condition of existing pavement (C values are 1, 0.75 and 0.35 for good, initial corner cracks, and badly cracked slabs respectively).

If we apply this formula in respect of an existing concrete slab 6 in. thick, the thickness of overlays are given below for values of $C = 1$ and $C = 0.75$

Required thickness of an equivalent single slab	Overlay thickness	
	$C = 1$	$C = .75$
10 in.	6.25 in.	7 in.
11 in.	7.25 in.	8 in.
12 in.	8.25 in.	8.75 in.

For the facility of comparison of results, the following example is worked out according to the two different methods discussed above.

An 8-in. concrete slab overlays on an existing concrete pavement of 8 in. thickness both having the modulus of elasticity of 3×10^6 pounds per sq. in. The existing slab is supported on a subgrade having the modulus of elasticity $E_s = 3 \times 10^6$ pounds per sq. in. and K value of 170 pounds per in. cube. Assuming a slab 15 ft in breadth and 20 ft in length, Poisson's ratio of 0.15 for concrete

and subgrade, flexural strength of concrete is 750 lb per sq. in. and design factor 1.5, area of contact of wheel load is 15 in. in radius, temperature variation in Poona is 28°F . and amplitude for surface temperature of concrete is 22.4°F . and temperature differential = 21.5°F . The desirable wheel load is 49,500 pounds (see examples 11 and 12 in Ref. 1).

It is intended to apply this wheel load of 49,500 lb and obtain the thickness of the overlay pavement, according to the empirical formula. In the above noted example, Westergaard's original formula was used. It is, therefore, intended to use the same formula here.

The required thickness of an equivalent single slab to support 49,500 lb is determined thus. Assuming 10 in. thick equivalent single slab, $l = 35$ and $b = 14.69$. $l/b = 2.4$.

The maximum temperature stress for a 10-in. slab will be 133 pounds per sq. in. The allowable strength of concrete is 500 lb per sq. in.

Available flexural strength to take up wheel loads = $500 - 133$ or 367 pounds per sq. in.

$$Si = 0.31625 \frac{P}{h^2} \left[4 \log_{10} (l/b) + 1.069 \right]$$

$$h^2 = \frac{0.31625 \times 49500}{367} (4 \log_{10} 2.4 + 1.069)$$

Therefore, $h = 10.51$ in.

The thickness of the overlay according to the empirical formula is

$$hc = \sqrt{h^{1.87} - Che^2}$$

Assuming $C = 1$

for $hc = 8$ in.

$$= \sqrt{h^{1.87} - 64}$$

= 4.1 in. According to the Design Chart given at Fig. 22, page 36, Ref. 2, the minimum thickness is shown 5 in. for this value.

On the other hand, the thickness of the overlay according to the design method suggested by the Author is 8 in. which is thicker than that obtained by the empirical formula.

The effect of a base course under concrete pavements

Burmisters' analysis of stresses and displacement of a layered system shows that the load bearing capacity of a pavement is

dependent not so much upon the absolute value of the modulus of elasticity as on the ratio of the modulus of elasticity of the pavement to the modulus of elasticity of the subgrade. If this ratio is low, the strength properties of the subgrade have a large influence on the supporting capacity of the system. On the other hand, if this ratio is high, which is generally the case with a concrete pavement, the strength property of the pavement has a large influence on the supporting capacity of the system. It has been shown in worked out example (Example 2, Ref. 1) that by introducing a base course of thickness twice that of the pavement and having modulus of elasticity 10 times that of the subgrade, the vertical stress on the subgrade is reduced by 2.4 per cent of the applied load.

The use of a base course of dry macadam or soling, which is an essential part of the flexible pavement, has no justification for provision under rigid pavement as it adds to the cost without giving a corresponding addition to the supporting capacity. Its use for the purpose of increasing subgrade support (K value), in order to reduce the slab thickness, is never justified. A sub-base is needed to prevent damage from one or more of the following causes:

- (a) Frost action,
- (b) Swell and shrinkage in clayey soil,
- (c) Pumping of fine grained soil.

When used to prevent damage from the causes noted above, the resulting increase in K value for good soil (say $K=250$) is small. For a 6-in. sub-base over a soil having $K=250$, the value of K on top of the sub-base is $K=275$ (Ref. 2, Fig. 2 and page 20). The use of soil-cement and soil-cement-modified soil to produce better subgrades is used in attainment of control of swelling and shrinkage of high-volume changing soil, prevention of pumping on fine graded soil or for prevention of damage by frost action, (Ref. 2, p. 22).

Behaviour of 11 in. thick concrete slab

It was stated earlier in para 3.5 that the extension of the runway was done by laying plain concrete slabs 11 in. thick in panels of five ft squares. On these extended portions from the ends of runways the wheel load including its dynamic effect due to engine vibrations was fully transmitted to the pavement slab. Although the overlay pavement was showing cracks in several panels, under wheel loads of 24,000 lb and tyre-pressure of 140 lb per sq. in., these 11 in. thick slabs were standing up well. The cal-

ulation of permissible wheel load on these slabs shows that the actual load is within the permissible limit thus:

The tyre-pressure of 140 lb per sq. in. for a wheel load of 24,000 lb gives a contact area of 171 sq. in. The radius of the contact area is 7.4 in. and $\frac{a}{h} = 0.67$.

Since ' a ' is less than $1.724 \times h$, $a = 18.984$.

$$b = \sqrt{1.6a^2 + l^2} = 0.6751 = 7.1 \text{ in.}$$

$$l = 34.3 \text{ for } K = 250 \text{ lb per in.}^3$$

$$\begin{aligned} \text{The permissible load } P &= \frac{Si \times h^2}{.31625 (4 \log_{10} \frac{34.3}{7.1} + 0.633)} \\ &= 41,740 \text{ lb.} \end{aligned}$$

* [Note:—The maximum temperature stress in Poona for a 8-in. concrete slab has been worked out at Example 8, Ref. 1 and is 138 lb per sq. in. For a 16-in. slab the value is 129 lb per sq. in., see Example 11, Ref. 1. For 11 in. slab, it is taken as 133 lb per sq. in. The flexural strength available to take wheel load is $500 - 133 = 367$ lb per sq. in. = Si]

Individual Remarks

Shri D. C. Chaturvedi suggested a factor of safety of 2 instead of 1.5 taken for the runway. He requested him to refer to selection of safety factor (Ref. 2, page 11) regarding corner loading, see also I.R.C. Paper 179, para 4.3.

The increase in the maximum stress due to lowering of K values is given in para 2.4.2 for a particular case. This effect could be seen by studying standard design charts (Ref. 2, Fig. 7). He wanted to know the maximum stress in the extended portion of the runway which was already given.

Shri M. P. Dhir suggested determination of flexural strength of concrete directly from the specimen. This was possible when one had got a portable concrete saw for cutting a beam from the existing slab. The Author had a stationary concrete saw and it was decided that the determination of flexural strength from the values of compressive strength would be desirable. The allowable flexural strength of concrete used in the original slab was determined as 300 lb per sq. in. (see para 2.4.1). He was not clear how Shri Dhir assumed it to be 600 lb per sq. in. Therefore, the values of modulus of elasticity and thermal co-efficient of linear expansion of

concrete assumed in the Paper was justified, more so, as several speakers pointed out that this pavement was built during the last war as a rushed job. There was a misprint in the formula quoted at page 123. The Author used the revised Westergaard's formula.

The Author did not agree with the suggestion that the value of radius of contact ' a ' which is 7.4 in. on the overlay should be 15 in. at the interface and the latter value should have been taken. The basis of approach to the evaluation of the strength of overlay had already been explained.

Shri N. M. Thadani based his views on the causes of failure of the pavement due partially to settlement of metal base course which he thought was not properly rolled. The function of a base course under a concrete pavement had been explained earlier. It had very little bearing on improving the strength of the concrete pavement. Considering that the average K value of the subgrade is 250, the provision of a metal base course under the concrete slab was a sheer waste of money.

Shri C. L. N. Iyengar stated that the thickness of the slab was 5 in. The Author could claim much more knowledge about the thickness of the original pavement than the speaker. Nowhere it had been stated that the strength of concrete was determined arbitrarily. The speaker must remember that the strength of concrete revealed by concrete test hammer 12 years after the construction had to be evaluated to 28 days' strength for ease of comparison of results.

The Author had already explained that the metal base course under this airfield concrete pavement was redundant. That was why the plate bearing tests were carried out on the subgrade and not on the metal base course.

Shri K. S. Sankaran remarked that even in U.S.A., the overlay thickness never exceeded pavement thickness. He was requested to see "The overlay of rigid pavement" by R. R. Phillippe and C. H. Christiansen, Proceedings of the Thirteenth Annual Meeting of the Highway Research Board, 1951, the result of which was given in abstract form in my previous Paper (Ref. 1, page 548).

The reason for having an overlay concrete slab with a higher value of modulus of elasticity than the existing concrete slab had been clearly explained in his previous Paper (Ref. 1, pages 504 and 543).

The points raised by **Shri Puri** and **Shri Sharma** had been already covered. The Author had tried to show a different approach to design of overlay. If **Shri Puri** thought that the Load Classifi-

cation Number Method would provide a more rational approach to the problem, he should give details to the Author.

Shri N. Mohan Rao remarked on the plate bearing test. The displacement of 0.05 in. on a 30-in. diameter plate is the basis of determining K value according to Westergaard. Smaller diameter plates, say 18 in., could be used where due to incapacity of the loading frame 0.05 in. displacement under a 30-in. diameter plate cannot be obtained. But the value of K obtained on 18 in. diameter plate has to be correlated to that of the standard size plate.

The words "original test" in the text mean the test value obtained before the specimen was subjected to saturation.

Shri K. K. Nambiar pointed out an obvious printing error in the formula for determination of relative stiffness l . It should read $(1 - \mu^2)$ and not $(l - \mu^2)$ printed. With regard to his suggestion of improving the bond of the overlay slab with the existing pavement, by a treatment of hydrochloric acid solution, the Author did not agree with it. The transfer of stresses at the interface can only be ensured by inserting vertical bars between the 2 slabs at frequent intervals but this method would make the process of laying of the overlay slab a difficult one.

Shri R. Krishnamachari enquired about the fixing of dial gauges. Photos 3 and 4 clearly reveal how the dial gauges were fixed and, therefore, detailed descriptions were not given. The apparatus used was obtained from U.K. and gave direct reading. The variation of diurnal temperature of Poona was obtained by the Author from the Meteorological Department, Poona, from records of over 40 years and the graph was produced shown at Fig. 10, I.R.C. Paper No. 179, from which the value of temperature variation was obtained.

Shri Venkatasubramanian presumed that since the slab stood up for a considerable time, the entire calculation had been underestimated. That presumption was not correct. The heavier wheel loads of 37,000 lb came when the slabs were at least 9 year old thereby gaining more strength due to aging. The cracks were observed closely following the use by this type of aircrafts. The pattern of cracks, shown in Plate I, did not occur at construction joints which were provided in the overlay slabs.

Shri E. A. Nadirshah (Chairman) in his concluding remarks stated that the Paper had brought up an important point that most of the runway pavements were constructed to sub-standard and sooner or later would require certain treatment.

The Author himself stated in the Paper that in spite of the fact that the slab was 4 in. thick (which figure was corrected by **Shri**

Thadani to 5 in.), it had stood very well. This showed the performance of concrete pavements. He was inclined to agree with Shri Thadani when he said that water-cement ratio was 0.5 and not 0.6 as given in the Paper.

Unfortunately our Engineers though they were capable of designing concrete slabs of proper thickness to suit certain conditions, were more or less compelled to adopt a sub-standard design purely from point of view of economy. He would like to know whether for sub-standard pavement, dummy joints would not come to their rescue. He also wanted the Author to give some idea about the cost of such pavements, as in the whole Paper no reference had been made to the cost of the original construction as well as that of overlay construction.

Shri Nadirshah was also inclined to agree with Shri Thadani that the cause of cracking might also be due to defective base of rubble packing which could not be properly compacted. Soil-cement base would have served the purpose better. Another suggestion would be to make a weaker concrete base instead of the rubble base or soil-cement base.

The Chairman then thanked the Author for bringing out such an interesting Paper and to the various members for taking part in discussions.

References

1. The Influence of a Super-imposed Layer in Increasing the Load Bearing Capacity of a Rigid Pavement"—I.R.C. Paper No. 179, Journal of I.R.C., 1954-55, Vol. XIX.
2. "Design of Concrete Airport Pavement", Portland Cement Association, Chicago, R. 147 (1955).

Discussion on Paper No. 216 *

"Flood Discharge Estimation for Small Catchments"

By

B. BALWANT RAO

Saturday, January 30, 1960.

Shri S. C. Nayak (Chairman) called upon the Author to introduce his Paper for discussion.

Shri B. Balwant Rao (Author) in his introductory remarks stated that with a view to systematize and give a dependable data and to eliminate, as far as possible, the chance factor in calculating the flood discharge, the study described in the Paper was taken up to derive the flood discharge from a consideration of the movement of clouds with the passing of time. An attempt was made to fix the value of coefficient K on a rational basis.

This method of calculating the flood discharge, he added, was applied in many cases in the Highways Department of the Andhra Pradesh and had given reliable results. Flood discharges for two small catchments for 3 and 4 sq. miles situated very near each other when calculated in the usual manner with the empirical formulae gave discharge in the proportion of their areas. But actually when calculated on the basis of H.F.L. recorded at site, the smaller catchment gave a higher discharge than the bigger catchment. This was because it was found that the slope of the catchment was more and the shape was conducive to better flow.

Though the data given in the Paper was based on study conducted in Andhra Pradesh, Shri Balwant Rao felt that the results derived were of a general nature and could be applied to other places as well for solving similar problems.

Lastly, he drew the attention of members to certain printing errors for necessary corrections in the Paper.

Page 223, para 1.8, line 3... "This" should be struck off.

Page 226, Table 1 ... The asteric should be against item 1.

Page 228, para 2.11 ... In Manning's formula, S should be raised to the power $\frac{1}{2}$ instead of $\frac{3}{2}$.

* Published at pages 221 to 233 of Vol. XXIV — Part 2 of the Journal of the Indian Roads Congress, November, 1959.

Page 238, Table 8 ... 4.12 instead of 9.12 in column 2.

Page 241, item (4) para, line 3 ... 'a and' should be omitted.

Page 247, para 4.4 ... Instead of "average I ", substitute " I average".

Page 273, para 2 ... Instead of "exclusive" substitute "excessive".

Page 278, Example 6. $T_c = 1.90$ hours instead of 2 hours.

Shri D. K. Laroia stated that the variation in the intensity of rainfall during the time of concentration and of the movement of the storm centre over the catchment while assessing the values of various constants had not been taken into account in the Paper.

The formula $I_c = \frac{1+a}{T_c+a} i$ for finding out the critical intensity of rainfall, he stated, was an empirical one and its accuracy could be judged only by the results obtained by its use. The values of 'a' worked out and plotted in Figs. 8 and 9, pages 239 and 240, did not appear to give consistent results for lower intensities of rainfall. For example, for a catchment having a time of concentration of 5 hours, the critical intensities worked out to 0.49 and 0.42 in. against hourly intensities of 1.0 and 1.25 in. respectively. Obviously, for a higher hourly intensity the critical intensity could not be lower. It appeared that the simple relationship assumed between the critical intensity I_c and the hourly intensity 'i' that is, $I_c = i \frac{1+a}{T_c+a}$ did not hold good for storms of Andhra Pradesh and perhaps the above relationship raised to some power should have been tried.

Further, in Fig. 8 the points were so scattered upto 2.5 in. intensity that it was not possible to give a reasonable shape to the curve, and if the two points between 3 and 4 in. intensities were ignored, it would not be possible to draw any curve at all.

Shri Laroia also pointed out certain discrepancies in the values of 'a' as given in Table 8 and plotted in Figs. 8 and 9. There also appeared to be some confusion in the dates regarding storm data as given in Tables 8 and 10.

Moreover, he remarked, the values of 'a' were determined from only a few known storms and he suggested that to obtain the highest floods, the curves should be so drawn that the largest values of critical intensities were obtained. The mean curves as drawn in Fig. 9 were likely to give much lower value of flood discharges.

In regard to time of concentration, Shri Laroia stated that the values of ϕ were found experimentally to lie between 0.7 and 17, while in Table 15 the values were suggested from 2 to 28. Assumption of higher values was likely to give longer times of concentration and thus lower flood discharges. According to Richard and Dawson, ϕ was inversely proportional to the intensity of rainfall. But the suggested values in Table 15 were higher compared to values derived from the relationship for lower intensities. Perhaps, in the experiments conducted, the ground was not completely wet initially, which resulted in variation in the suggested values of ϕ .

In Table 19, arbitrary constants were recommended to be added to the value of K , determined from Strange's table, in order to allow for heavy rain intensities. As the high intensities of rain were expected to last only for an hour or so, it needed consideration whether any such addition was really justified for catchments of several hours of time of concentration.

- Referring to paras 6.5 and 6.6 regarding an hourly loss of 0.88 in. of rain noticed in the experiment conducted with a fairly heavy rainfall of 1.55 to 3.30 in. per hour, Shri Laroia observed that this loss would tally with Strange's table at an intensity of 2 in. of rain per hour. As such, there appeared to be no justification for making any further addition to the values given by Strange.

- Shri Laroia sent the following further comments in writing:

Fig. 12 was plotted on the data of one storm for each area, while it was likely that coefficients on the basis of other storms might be higher.

In para 6.3, the effect of nature of soil on the yield was stated to have been taken into account while determining the time concentration for the catchment. This was not totally correct. The nature of soil affected the runoff in two ways: (1) a more permeable soil would directly decrease the runoff by greater absorption, and (2) the type of soil, configuration, etc., have to be taken care of by the coefficient of discharge K .

In regard to the probability for a 4-hour continuous rain for 16 in. rainfall being 1 in 4, vide para 1.9, Shri Laroia thought that the relationship being extremely complex it was not possible to work out the probability of such an occurrence unless it was assumed that rain always came in continuous spells of short equal intervals.

Some of the calculations in Tables 1 and 2 against discharges by Ryve's and Dicken's formulae were incorrect, e.g., it should be 3840 against 4640, 5250 against 6380, 19000 against 23000, 6670 against 8156, 9600 against 8000, 13570 against 11500, 59600 against 41500, and 18000 against 15200.

From the discharges in Table 5 by area velocity method, it appeared that the stream had a very rapidly changing cross-section with the result that the water surface slope varied considerably from place to place. This method naturally applied only to such streams that did not vary so much and, normally, in alluvial soil such variations did not occur.

Shri A. Banerjee remarked that the approach of the Author was scientific no doubt, but it appeared that even the method given by him did not help much in calculating the discharges for big rivers.

The value of coefficient of discharge K was based on Strange's table and verified by field experiments. Was this experiment really conducted with the catchment of only 6.64 acres as mentioned by the Author? This, he felt, could in no way compare with the catchment of very big rivers of several hundred sq. miles, particularly when the nature of vegetation on the catchment, apart from other factors, had very important effect on the runoff. Secondly, the time of concentration was calculated from the maximum rainfall intensities in 12 years, while the bridges had to be designed for a maximum discharge of the past 100 years or so. This basis might result in severe underestimation of discharge.

Thirdly, there was the possibility of two or more storms occurring simultaneously in large catchments, though termed by the Author as 'small', which would change the entire aspect of runoff. Unless and until all the above aspects were thoroughly studied over a long period of years and experience gained with reference to different areas of the country, the estimation of flood discharges for big rivers by the method advocated by the Author would, in his opinion, remain very very approximate and they would have to stick to area velocity method for the calculation of discharges for big rivers.

Shri Zafar Mohiuddin stated that the Author attempted to apply rational flood formula $Q = KAi$ to large catchments by complex analysis based on hydrological data and the method of probabilities, with the result that too many factors and assumptions entered in the analysis and the problem was further complicated. Admittedly, this was a controversial subject and, in his opinion, there was no justification to adopt this formula, at any rate for the present when there was very little data available on the subject. Rightly speaking, the rational formula was applicable to small areas only, say, up to 5 sq. miles, and for periods of time less than two hours or so; even there some error was possible. But for big catchments, errors might be considerable because of the greater variation in the characteristics and conditions as compared to smaller catchments. Besides, there were two more assumptions:

(1) that the rainfall was uniform over the entire area, and (2) that the rainfall intensity was uniform throughout the time period required to produce maximum concentration of flow. Hence, in order to evaluate these factors correctly, collection of vast data and long record was required.

Shri Mohiuddin thought that Dicken's formula with $C = 1200$ used in the Telengana region of Andhra Pradesh had proved alright if the value of C was fixed on the basis of experience in a particular design and there were very rare cases of failure on account of inadequate waterway. He also felt that many more examples should have been given instead of four cases from Adilabad and five from Mehbubnagar district.

Referring to para 2.9 he stated that the case of Sutej river as presented by the Author, taken as far back as 1872, was hardly relevant to the discussion of small catchments. Erosion and silting was, of course, a routine phenomenon in most of the Northern India rivers and the changing value of ' n ' due to the turbidity of water might counterbalance the changing cross-sections of the river, thus keeping the discharge constant. However, the conclusion drawn by the Author about the chances of error on account of flood sections appeared to be doubtful.

Referring to para 3.5, **Shri Mohiuddin** stated that a map of Andhra Pradesh (Plate I) showing the zones of hourly intensities had been prepared on the analogy of variation of storms at Visakhapatnam and Begumpet rain gauge stations only and the graph (Fig. 10) showing the duration of storms as a function of average/hourly intensity was based on the study of only 10 rain gauge stations, which was a very meagre data.

Similarly, isohyetal map (vide Plate II) was drawn on the studies of average intensity of rainfall on certain stormy days. He wanted a clarification whether it would mean preparing as many maps as there were stormy days and the curves as plotted in graphs (Fig. 12) would go on varying for different storms.

Shri Mohiuddin stated that complicated and cumbersome formulae depending on a number of variables, constants, and assumptions by a few authorities, like Richard and Dawson, were mentioned for determining the time of concentration, that is, the time interval between the beginning of the rainfall and the moment when flow from the whole catchment reached the site. It would be interesting to note that the assumptions of one authority were contradicted by the other.

In Tables 20 and 21 and Fig. 22, only eighteen years record was taken to determine the recurrence intervals of storms. For this

purpose even fifty years record was not adequate to fix the pattern. In fact, it was doubtful if there was really any regular pattern at all.

Shri S. Gangopadhyaya referred to the statement in para 2.3 that "Dickens' discharge is only a function of area", and stated that Dickens' constant was not an absolute constant and it varied with many factors depending on nature of the country, rainfall, slope, etc.

It was stated in para 2.7 that the river cross-section silted up after the high flood, whereas in the example in Fig. 2 and in Plate II, it was shown that the river bed was more and more scoured after the highest floods. Such a case is unusual and required a separate study, as it was obvious that the river was not following general rules and the maximum scour depth could not be ascertained even if the discharge could be very accurately determined.

In Table 5, discharges at different cross-sections as obtained by area-velocity method were found to be varying by more than 300 per cent. In his view, the area-velocity method gave the most reliable results if velocities at H.F.L. could be ascertained with care.

Shri Gangopadhyaya, however, felt that it was really necessary to try to find out a suitable method for determining the discharge from the rainfall data for any particular stream, and it should be interesting if elaborate studies were made for evaluating constants for different parts.

Shri K. F. Antia stated that Shri Balwant Rao's contribution was of considerable value particularly to engineers who have had to cope with this problem on the east coast of the country, where the trouble, usually during the month of October, was not so much with big rivers but with small rivers. There was rather an unfortunate combination of adverse conditions, namely, cyclonic storms with heavy rainfall combined with a narrow coastal area backed by mountains. The time of concentration was small and it varied from stream to stream. Shri Antia was rather surprised that even today the method of determination of waterways was as indicated in para 2.1, viz., Dickens' and Ryves' formula and area velocity method. In regard to Dickens' formula providing a constant of 1,200 both for flat catchments and for steeper catchments, the Author had pointed out that it should be changed. But it was changed as long ago as 1930—exactly 30 years ago, by the Railways. He did not know why the change did not take place elsewhere.

In 1930 varying values were given to the "constant" in Dickens' formula, the variation being between 825 and 1600

depending upon the shape, the slope, the vegetation on the catchment, and so on.

Again, other methods brought into vogue and which proved to be considerably successful were not taken into consideration by the Author, viz., Lilly's method and Inglis' method. Shri Antia felt that this Paper was the beginning of a very important study which should be taken up either by the irrigation authorities or even by the road authorities to ascertain the formulae and the constants applicable to different parts of the country. They could not be uniform because there were so many variables from place to place, such as the rainfall intensity, the nature of soil, the topography, the runoff, the time of concentration, the shape, slope and vegetation of the catchment, etc. Such a study, he was sure would help engineers in the design of cross drainage for roads and railways and of water supply, irrigation and flood control projects.

Shri Y. K. Patil wanted to give some information from a Paper that he had read before the Central Board of Irrigation in the year 1945 dealing with the highest floods in the country. He had to use the empirical formulae as there were no other rational formulae existing then. With the idea to solve this problem he collected data from various books to compile the Paper.

He found that the constants in the empirical formulae varied very much. For example, there were 64 cases given in Buckley's Irrigation Pocket Book, where for the highest floods if 'C' was worked out by Ryve's formula, the constant varied from 76 minimum to 7920 maximum; in the case of Dickens' formulae, the constant varied from 58 minimum to 6340 maximum; in the case of Inglis' formula, also applicable to fan catchments, the constants varied from 460 minimum to 14000 maximum. It was, therefore, very difficult to choose the constants and the Engineer got confused as to what constants should be selected for his region.

Shri Patil found that the maximum floods depend on (1) area of catchment, its shape and size, (2) nature of the catchment whether wooded, hilly or plain, (3) surface detention, depending on the nature of the soil and its condition whether dry or wet, (4) intensity, duration and extent of rain, and (5) the time of concentration. Also, it was found that the time of concentration was the most essential factor in estimating the floods. The time of concentration was based on Lacey's value of velocity and the length of river. If length was not available, then the time of concentration could be calculated from $T = \frac{1.34 A^{\frac{1}{2}}}{f^{\frac{1}{3}} P^{\frac{1}{4}}}$, where A = catchment area in square miles, f = silt factor, P = intensity of rainfall. But if the length of river was available, then the formula stood as $T = \frac{0.95 L}{A^{\frac{1}{4}} \times P^{\frac{1}{4}}}$

(for $f = 1$). Discharges for 17 cases were worked out according to this formula and compared with actual observations. To site an example: On Naveli river at Kandla in Kathiawar, Gujerat, the observed discharge was 48,200 cusecs and the area of catchment 15 sq. miles only. According to Ryve's formula, the discharge worked out to 4,217 cusecs, according to Dickens' 7,620 cusecs, according to Inglis 24,000 cusecs, whereas according to Shri Patil's calculation it was 39,300 cusecs which was very near to the observed value. He offered to supply any further information required for practical application.

Shri N. M. Thadani observed that the quantity of maximum flood discharge was extremely difficult to evaluate as was quite obvious from the contents of the Paper. He thought it would be a long time before any finality was reached on this subject. He also wanted to relate this Paper with para 2.1 of Paper No. 217 at page 289 of the I.R.C. Journal, Volume XXIV-2, because the same subject was dealt therein under a different set of circumstances.

Regarding Dickens' formula, he wanted to say that it was one of the most elusive formulae ever invented for the evaluation of flood discharges. The so-called constant C varied from 500 to 1800 and one could take any of the values to obtain any flood discharge to suit the money available with him for building a bridge. Therefore, this formula must be used with a very great degree of caution. The other formula dealt with in the Paper was the area velocity method which, he felt, could be a very accurate method of evaluating discharge provided the highest flood level was accurately known.

In regard to the method recently evolved on the basis of rainfall data, Shri Thadani stated that the value of ' T ', the intensity of rainfall per hour was often not accurately available for areas where bridges were built. Unless there were self-recording rain-gauges it would often be found that the value of T was far from accurate, with consequential error in the value of the flood discharge.

Regarding Inglis formula $Q = \frac{7000 A}{\sqrt{A} + 4}$ given in Paper No 217, Shri Thadani stated that it was supposed to cater for floods that might occur once in 1,000 years, and if they were to build bridges of waterways calculated on this basis, he thought they would go bankrupt very soon. Inglis himself realized the extravagance of this formula and developed a modified formula in which 4000 was substituted for 7000. In his opinion, if the flood discharges were calculated by the formula $Q = \frac{4000 A}{\sqrt{A} + 4}$, reason-

ably accurate and workable values for flood discharges would be obtained.

Shri G. C. Khanna commended the value of the Paper as it would be of great advantage to bridge engineers for the determination of flood discharges of rivers. But Shri Khanna felt that the best method for determining the waterway for a bridge was to go back to the area velocity method which could give very accurate results, provided proper investigations were done in the field rather than depending upon the various empirical formulae.

Shri M. Karimullah Khan* stated that the Paper was a timely one in view of the large investigations being done these days for the construction of bridges on existing as well as new roads. The problem was also discussed to some extent in I.R.C. Paper No. 167 on 'Small Bridges and Culverts' by Shri Goverdhan Lal who recommended a value of 4 to 5 in. for area of intense and prolonged rainfall and 2 to 3 in. for other areas. The problem of flood estimation was very complicated and required not only careful study but also careful application of the knowledge.

Referring to paras 1.2 and 1.3 regarding the need for adopting rational method in preference to empirical methods, he pointed out that an average engineer was liable to commit mistake in choosing the correct coefficients and other factors required in the use of rational formulae and thereby the assessment of flood discharges might be wrong. In his view, empirical formulae were more suitable even for small catchments if a correct value of coefficient was adopted.

With regard to the definition of a small catchment, vide para 1.6, he drew the attention of the Author to the book "Irrigation Engineering" by K. R. Sharma, Vol. II, describing catchments of various sizes. He then suggested the following classification:

- | | | |
|---------------------------|-----|------------------------|
| (1) Very small catchments | ... | a. Upto 40 acres |
| | | b. 40 to 100 acres |
| | | c. 100 to 640 acres |
| (2) Small catchments | ... | 1 to 5 sq. miles |
| (3) Medium catchments | ... | a. 5 to 30 sq. miles |
| | | b. 30 to 100 sq. miles |
| (4) Large catchments | ... | 100 to 500 sq. miles |
| (5) Very large catchments | ... | Above 500 sq. miles |

Referring to paras 2.1 and 2.2 regarding the value of $C = 1200$ in Dickens' formula generally adopted in the Telengana region,

* This comment was received in writing.

he stated there appeared to be some mistake as in Tables 1 and 2 C gave a value of 1000. It, therefore, needed clarification. Further, it would have been better if the Author had worked out flood discharges for the stream in Tables 1 and 2 by the method suggested by him instead of giving examples of other streams so that a correct idea could have been made between the suggested and the conventional methods.

As regards reference to a Paper by Sarvashri P. R. Ahuja and Shenoy on the values of C in Dickens' formula, vide para 2.15, Shri Karimullah felt that the values as suggested were on the high side and cited the example of Kurud Tank mentioned in Paper on "The General Theory of the Storage Capacity and Flood Regulation of Reservoirs" by Capt. A. Garret, R.E., published by the Superintendent, Govt. Printing, India, in 1912, where value of $C = 1400$ was adopted. As Adilabad district happened to be adjacent to Central Provinces, a value of $C = 1400$ could be adopted for small catchments and equal to 1200 or 1000 for bigger ones.

Shri Karimullah mentioned that the examples worked out at the end of the Paper were for streams of sizeable catchment areas and the Author had not done so for small streams, say, upto 1 sq. mile catchment area.

It would have been better if the Author had clearly shown the use of various tables, etc., prepared by him on lines of I.R.C. Paper No 167.

The method suggested by the Author for estimating flood discharge in Andhra Pradesh could not be accepted outright unless it was examined by a number of experts in the field and in a greater detail.

Shri B. Balwant Rao referring to the comments offered by Shri D. K. Laroia regarding the value of " a " replied that, as already stated in the Paper, the values of " a " were obtained from the limited rainfall data available with him. It was also stated in the Paper that with the data available it was not possible to fix a suitable power to make more points to come within the equation assumed. It was because of this that the value of " a " was determined for two time intervals of less than one hour and greater than one hour. As limited number of points at higher intensities were available the graph had been plotted in the best possible way. As regards the critical intensity for 5 hours at 1.00 and 1.25 in. per hour it actually works out to 0.33 and 0.42 in. respectively and not 0.49 and 0.42 as stated. If this was meant for shorter duration, where the shape of the rainfall curve was determined by the value of " a " it was a different matter, showing that a high intensity burst might not produce the same average critical rainfall as compared to a lesser intensity with a broader base.

Regarding the value of ϕ , the constants given in Table 15 were the average of many experiments, adjusted and modified on the basis of actual reliable discharges which were recommended. The figures of 0.7 and 17 pointed out by Shri Laroia were the results from one experiment. It was very difficult to get uniform condition in all experiments and, therefore, the value suggested was only average and was susceptible of revision if more data were becoming available. This had been pointed out in the Paper.

As regards corrections to the value of K , the condition assumed was that of bleeding irrespective of the type of soil and it had effect only under low rainfall conditions and not when saturation condition had set in.

Fig. 12 was plotted for the heaviest storms known and, therefore, could be taken as representative.

Shri Balwant Rao agreed about the complexity of the duration of rainfall in calculating probability and stated that it was only a hypothetical problem to illustrate a point.

The discrepancy was due to wrong coefficient given as 600 and 1200 instead of 500 and 1100.

Replying to Shri A. Banerjee regarding the applicability of this value to larger catchments, the Author invited his attention to the first para of the Paper. For example, in the case of Kaddam Dam having a catchment of about 1,000 sq. miles, which was recently damaged due to heavy flood, the flood discharge worked out by this method was very nearly equal to the observed discharge. Big cloud bursts could be expected to take place in the areas of Adilabad and Coastal Andhra which might have a 1,000 sq. miles coverage, that is, nearly 30 miles by 30 miles. The selection of the size of catchment suitable for application of this method had been obtained by intersection of the curves of duration by a line based on time of concentration plotted from actual examples worked out. From this, it could be taken that heavy rains covered a greater area than rains of smaller amount like 7 in. or 5 in. per day which had been taken to cover areas of 400 to 300 sq. miles, and so on. Thus, with the quantity of rainfall reducing the size of the catchments continued to decrease and the applicability of the method also shrank.

As regards the reliability of the cross-section method, Shri Rao stated that one might not know the H.F.L. and the slope correctly. He cited the case of a bridge which had been washed away in the Andhra Pradesh. They got the H.F.L. line at the place of the crossing and to know the slope of the flood to determine the velocity they investigated the H.F.L. line on both upstream and downstream of the site and got the same H.F.L. line. That meant that it

was not possible to determine the slope unless special arrangements were made to observe it. The same difficulties were also pointed out by some speakers and H.F.L. records were most unreliable—especially if it was not an important stream.

Many things could be said for and against Dickens' formula, and the rational method proposed takes into consideration the condition of the catchment, shape, slope and everything possible that could be thought of, and its reliability had already been justified when examples were worked out.

As regards the points raised by **Shri Mohiuddin**, most of them were already answered in the Paper. Actually, there had been a number of failures of bridges in Mehabubnagar which were designed on the basis of empirical formulae and after that the officers from C.W. and P.C. proposed revised values of Dickens' formula to nearly double to suit that area. Shri Mohiuddin's statement that methods usually followed all these days was not quite justified as judged from facts.

About flood sections which were recorded in 1872, the Author wished to point out that they did not have similar data after that. It was taken to work out an example and to show the effect of variation of the cross-section of the flood.

About Shri Banerjee's point whether return periods of only 12 to 18 years were sufficient, he had already stated in his Paper that that was all the records available, and for the design of a culvert or a small bridge it was not worthwhile to go in for data of more than 10 or 15 years' floods.

About the use of Inglis' formula, as **Shri K. F. Antia** pointed out, it was only for catastrophic floods. Regarding Lilly's formula, again it took into account the average rainfall per year and it did not take rainfall characteristic of a particular rainy month which produces a heavy flood. The method discussed in the Paper was an improvement over Lilly's formula.

In reply to comments by **Shri M. Karimullah Khan**, the Author stated that he had already pointed out in the Paper the disadvantages of the empirical methods. The Paper was specially prepared for calculating flood discharge for streams in Andhra Pradesh. By knowing the location of the catchment, the designer could choose his coefficient and work out the flood discharge. Thus there was little chance of making mistakes in the choice of coefficients.

Regarding the time required for calculating discharge, the Author was of the opinion that it was worthwhile spending a few minutes more and be confident of the result than trying to get some figure and arriving at a wrong and wasteful design.

The definition of a small catchment as far as it concerned this study was fully explained in the Paper. The definition of small catchment as given by Shri Karimullah appeared to be empirical and was based on the personal opinion of an Author of a book and as such could not be accepted.

The size of the catchments which could be considered to be covered under 12 in., 7 in., 5 in. rainfall had been worked out as these data were available. The size of the catchments which could be considered coming under this category could be interpreted. For example, for catchments between 400 to 800 sq. miles, the area should receive rainfall between 7 in. and 12 in. For catchments between 300 sq. miles and below it was sufficient if the areas received less than 5 in. rainfall in a day.

Examples given in Tables 1 and 2 were actuals taken from examples worked out for designing bridges in Andhra Pradesh. The examples given at the end were illustrative and demonstrated the method for calculating the discharge by the data given in the Paper.

The investigations by the Author referred to in para 2.15 of the Paper were undertaken for streams in Andhra Pradesh and they were being followed by the Irrigation Department of Andhra Pradesh as quite suitable.

Considering the number of bridges and dams that were washed away recently, designed on the coefficient now being adopted, it should be sufficient to convince the members that the values of "C" suggested by the speaker were inadequate and it showed the risk of depending on the empirical formulae.

In conclusion, the Author said that discharges from many streams using the rational formula had been worked out by the Designs and Investigating Branch of the Chief Engineer (Highways) office, Andhra Pradesh and they were getting satisfactory results. He suggested to members to apply this method to catchments in their areas also and inform the Congress about their experience in due course.

Shri S. C. Nayak (Chairman) in his closing remarks, congratulated the Author on his excellent Paper which had also presented good material for further investigation. He further stated that all the calculations and research work done indicated that they should follow the regime of the stream. Precaution should, therefore, be taken except in the case of streams having sandy beds for considerable depth and where deep scour was expected, to adopt a linear waterway as nearly equal to the width of the stream from bank to bank as possible. This would be a safe course in conformity with the solution indicated by nature.

Discussion on Paper No. 217 *

**“Design and Construction of Prestressed Concrete
Bridges across Kunwary River”**

By

Y. K. PATIL & C. V. KAND

Saturday, January 30, 1960.

Shri K. K. Nambiar (Chairman) called upon **Shri Y. K. Patil** (one of the Authors) to introduce his Paper for discussion.

Shri Y. K. Patil (Author) in his introductory remarks stated that the area between the Chambal and Kunwary rivers was full of ravines and was inhabited by dacoits, creating the problem of law and order there. With the idea to give transport facilities to the police, these bridges were sanctioned. During the last one year, the police have been able to mobilise their forces and most of the dacoit gangs were liquidated. With the construction of new roads in this area, as programmed by the State Government, the dacoit problem would be practically solved. In addition, it would help raise the standard of the villagers when Chambal waters would irrigate about 7 lakh acres of this area.

The 3 bridges were designed according to the old I.R.C. Code. Similarly, the criteria for prestressed concrete were also not available at the time of accepting the tenders. So, the permissible stresses of design would appear to be higher than the stresses recommended by the revised criteria.

Regarding the floods and the hydraulic data of these rivers he explained why he chose to depend on the rainfall data. This particular catchment was not fan shaped nor a square, but rather a very elongated catchment. The ratio of width to length of the river was something like 10 to 1.

Shri D. C. Chaturvedi stated that it was not mentioned in the Paper if the concrete mix for the bridge was properly designed and whether the aggregates used were tested in the laboratory and asked the reasons for adopting volume batching in the case of high grade concrete used.

Referring to para 4.5 regarding strength of special grade concrete cubes at 28 days interval given as 5,000 lb per sq. in. he

* Published at pages 286 to 333 of Vol. XXIV—Part 2 of the Journal of the Indian Roads Congress, November 1959.

enquired if it was the average or minimum strength aimed in the field.

Regarding calculations for bearing capacity of soil to base the values of various factors on assumed value of ϕ was, in his opinion, not a correct approach to the problem. The data available from boring charts at the site of the bridge should have indicated the type of strata available at different depths. At least, the nature of strata excavated during sinking of wells should have been examined.

Shri G. S. Ramaswamy agreed with **Shri Chaturvedi** that it was high time that they deviated from the practice of prescribing concrete by nominal proportions and begin prescribing concrete mixes by strength, at least for prestressed concrete work.

With regard to the stress distribution diagram given in Fig. 4 on page 311 of the Paper for the 4-girder arrangement, he felt that in structures that were subjected to dynamic loads it was advisable to have some amount of residual compression in the bottom fibres under the action of dead live load and residual prestress, and the 22 psi provided in the design did not appear to be adequate. According to the provision in the Draft Code for Prestressed Concrete, they had recommended that a residual compression of 5 per cent of the maximum compression in the fibre should be left behind. This was very advisable in the case of rail-road and road bridges.

Referring to the 3-girder arrangement, **Shri Ramaswamy** stated that the section was not fully utilised, for example, the compressive stress in the top fibre was only 1170 psi as against a permissible value of 1667 psi. On the other hand, as far as the bottom fibre was concerned, the situation was alright, because, there was a residual compression of 165 psi which satisfied the requirement of 5 per cent of the maximum compressive stress being left as residual compression.

Shri Ramaswamy was of opinion that it should not be necessary to demand that every prestressed concrete bridge to be built in the country should be test loaded, especially when the design did not incorporate any new features. To demand a test load on the ubiquitous T beam bridge, hundreds of which had been built all over the world and in this country, did not appear to make any sense; it was a waste of time and money. If at all tests were undertaken they should be with a view to find out something which was not known and about designs which incorporated new features.

Regarding calculations of the cracking load, **Shri Ramaswamy** stated that the computation of the cracking load was one of the trickiest things because of the several uncertainties involved. For example, there was no reliable method of estimating the ultimate

tensile strength of concrete. Sometimes 1/10th of the allowable compressive stresses was taken as the tensile stress that the concrete could stand; the other basis was to relate it to the modulus of rupture and sometimes to the value specified at 8 times the square root of F_c where ' C ' was the cube strength of concrete.

Besides it was well known that the actual cracking load or the observed cracking load was very much lower than the computed cracking load. This was because of the presence of small shrinkage cracks in the concrete on account of, what is generally described as, stress crazing; and to avoid this a certain amount of mild steel reinforcement should be there in the section. From the details furnished in the Paper it was not possible to check and find out how much mild steel was there, nor was there any data furnished with regard to the age at which the prestress was transferred, which also had a considerable amount of influence on the presence of shrinkage cracks. For example, if the prestress was transferred after several months after the girder had been lying in the yard, then there were possibilities of small shrinkage cracks developing. Again, if the transfer was made at an early date, then the creep losses were likely to be excessive. So, when reporting Papers of this kind, it would be useful if the age at which the prestress was transferred was also mentioned. Also, it would be useful if aggregate-cement ratio, the water-cement ratio, and the ratio of coarse to fine aggregates used were also reported. The Central Building Research Institute were trying to compile data on the mix designs used for all the prestressed bridges, so that in due course the information could be made available in a handy form.

Shri Shitala Sharan stated that it appeared from the data given at page 294 that the waterway provided for all the three bridges was rather on very low side. As stated by the Authors, the streams were quasi alluvium and Lacey's formula was partially true, it would be interesting to compare the waterway required from Lacey's formula. For a discharge of 221,800 cusecs for Budhana bridge $Pw = 1,250$ ft against 479 ft provided which is only 38 per cent of Lacey's regime width. The cross-section of the stream and boring chart did not show very rigid banks and clayey strata. As the strata is sandy upto about 32 ft, it could be expected that Lacey's formula should give reasonable figures. Usually a restriction of more than 50 per cent was not considered desirable whereas in the case of these three bridges, the restrictions of about 38 per cent was rather high.

As the maximum scour depth was calculated by assuming the alluvial stream, it was presumed that the depth was calculated by Lacey's formula $D = 0.473 \left(\frac{Q}{f} \right)^{\frac{1}{3}}$. For the discharge figures

shown at page 294 and Table I A, D comes to 24.4 ft, 28.7 ft and 29.3 ft for Dimni, Budhana and Didi bridges assuming $f = 1$. But these figures are true only for flow in full Lacey's regime width which comes to 995 ft, 1,225 ft and 1,300 ft respectively for the above bridges. The modified normal depth of scour ought to have been calculated by the formula $D^1 = D \times \left(\frac{W}{L} \right)^{0.61}$ and it comes to

44 ft, 51 ft and 52.5 ft respectively. At noses of piers, the depth will be given by $2D$ and as such the design scour level for wells ought to be 88 ft, 102 ft and 105 ft below H.F.L. It appears that the design scour level as given at item 8 of page 294 has been taken as $2D$ which comes to 49 ft, 57 ft and 59 ft respectively. It, therefore, appears that by restricting the waterway too much the foundations have been designed rather on a very low side. For a flow of 38 ft depth of water in case of Dimni bridge to assume a normal scour of 24.4 ft is incorrect. He requested the Authors to explain the discrepancy when they state that maximum scour depth was calculated by assuming alluvial stream.

Grip length below scour level:

It has been stated on bottom of page 293 that depth of foundation below maximum scour depth should be only 4 ft which again appears rather on a low side. The minimum depth of penetration for a rigid body like the well is related to the horizontal forces and moments acting at scour level. Assuming the resistance from soil to vary linearly in proportion to displacement:

$$h^3 = \frac{12 Mo}{k} = \frac{12 ph}{k}$$

$$\text{where } k = Ws (Kp - Ka)$$

$$Kp = \frac{1 + \sin \phi}{1 - \sin \phi}$$

$$Ka = \frac{1 - \sin \phi}{1 + \sin \phi}$$

Ws = weight of soil in lb per cu.ft. For the particular case of Dimni bridge as given at page 303 the transverse moment Mo in direction of flow is 280 k per ft and $p = 5.3$ kips per ft width of well of 15 ft 9 in. diameter, H comes to 26.6 ft.

Thus a grip length of at least 27 ft is essential and not 4 ft.

Safe load on foundations:

At page 300, the value of Df has been taken as 37 ft which is incorrect because when the maximum scour has taken place $Df =$

2D. Similarly, although it has been stated that water table has been taken upto bed level, value of Y has been taken as 100. Submerged weight of sand ought to have been taken and this alone shall reduce the value of Y to by about half.

Taking value of $Df = 12$ ft (below scoured depth) value of q comes to only 4 tons per ft as against 8.8 calculated in the Paper.

Piers:

It has been stated at page 304 that the haunched portions between the outer walls of pier shaft and the cross walls are designed carrying all the load from girders. As a continuous R.C.C. bearing has been used the entire load from the girders comes through the entire length of the outer walls on either side and these ought to have been provided with suitable reinforcement. It is surprising to note that instead of 0.8 per cent reinforcement in columns, only $3/8$ in. at the rate of 10 in. c/c has been used giving only about 0.15 per cent reinforcement. Even if it is considered as a well column at least 0.4 per cent ought to have been used. The Author could throw some light as to why such a deviation from Code was permitted for a structure carrying heavy loads. Even $3/8$ in. bars ought not to have been used as the minimum longitudinal reinforcement for columns is $1/2$ in. The thickness of diaphragms of 6 in. for 38 ft height is also too slender.

Superstructure:

The thickness of 5 in. web for a depth of 82 in. is considered less as per Guyon's recommendation for which minimum thickness is given by $t = 4 \text{ in.} + \frac{82}{40} = 6 \text{ in.}$

It appears that the calculations of side shift factors are wrong—as shown in Table 3 as it will be seen that for the three girder system, the maximum reaction on outer beam shall occur when live load on the other lane is absent because any load in span A_2B_1 produces a negative reaction at A . Thus the figure of 0.727 would come to 0.815. Similarly for the inner girder against 0.852, it shall be only 0.792. It is also not understood as to why mean of outer and inner girder has been taken for this girder system. Both the outer girders shall be designed for 0.779 and only one central girder for 0.761. Thus average factor should be $\frac{2 \times .779 + .761}{2}$ and not $\frac{0.779 + .761}{2} \times \frac{3}{2}$. With this correction the factor for 7 ft 8 in. spacing given at page 309 shall come to $\frac{1.602 + .742}{2} = \frac{2.344}{2} = 1.172$.

The Authors have recommended an ideal spacing of 7 ft 8 in. for 3 girder system because of minimum side shift factor but in what the Author claims as the ideal spacing the entire structure has to be designed for a 17.2 per cent extra moments as compared to only 16 per cent in case of 8 ft spacing.

It would also be seen that assuming only a rigid deck the outer beams carry less load if spacing is increased. Thus for a rigid deck, the increase in spacing reduces the side shift factor and thus affects overall economy if the slab thickness is not increased unnecessarily. For the spacing of 7 ft 8 in. claimed by the Authors as ideal, the slab is to be cantilevered by 3 ft 10 in. as shown at page 309 and the bending moment in the slab would be heavy. A comparison of design bending moments in the slab for 8 ft, 8 ft 6 in. and 9 ft spacing are as follows:

Spacing	Reaction factor	Average factor	Design B.M. at cantilever end in.kip	At central support - ve B.M. in. kip	At centre of span + ve B.M. in. kip
8 ft	1.162	1.166	109.58	38.25	17.32
8 ft 6 in	1.152	1.179	69.77	66.77	34.42
9 ft	1.144	1.173	59.01	71.23	40.08

This shows that design bending moments are best for a spacing of about 8 ft 6 in. and gives uniform depth and steel arrangement both at cantilever ends and supports. Regarding the arguments of slight increase in length of piers, economy can be made by resolving to two circular column piers with a stiff cap supporting the bearings. This reduces the length of pier and dimensions of well also.

For example in this case the R.C.C. cellular piers can be replaced by two circular column piers of $7\frac{1}{2}$ in. thickness with 5 ft dia. at top and 8 ft at bottom spaced at about 12 ft 6 in. centres. The dimensions of well can also be reduced and a single well 18 ft 6 in. external diameter with 13 ft diameter dredge holes shall be more than sufficient. The volume of concrete per running foot shall reduce from 172 cu. ft. per ft height to only 135 cu. ft. thus effecting a saving of about 25 per cent. The cost of sinking a single circular well with a bigger dredge hole shall also be comparatively very much less as compared to the twin well. Thus a considerable saving could be made in the case of these bridges by adopting the above design of piers and wells.

Then in the end he invited the attention to the question of load distribution among the various beams in case of bridge structures. As had been demonstrated by a number of tests the multi-beam

bridge deck of 22 ft to 24 ft wide bridge behave as if cross beams were practically infinitely rigid with the result that by treating the deck as a continuous elastic structure resting over firm supports give results which are very far out. Both in case of Pennar and Kunwary bridges, equal deflections were obtained in all the beams under symmetrical loading. Bridge over Hindan at Ghaziabad in U.P. was tested for eccentric loading and the table given below shows the proportion of load carried by each beam under eccentric loading. The corresponding figures assuming a rigid and elastic deck are also given and it will clearly show that the assumption of a rigid deck gives results which are near the actual. Therefore, it is high time that structures in India are designed rationally in the way they behave rather than taking mean of two things which are poles apart.

		Outer beam	Inner	Inner	Outer
1. Suktel Bridge (I.C.J. 1959)	Actual	0.395	0.312	0.188	0.125
24 ft roadway	Rigid	0.396	0.299	0.201	0.104
4 beams	Elastic	0.166	0.633	0.225	0.024
2. Hindan bridge at Ghaziabad	Actual	0.976	0.667		0.357
24 ft roadway	Rigid	0.974	0.660		0.364
3 beams	Elastic	0.548	1.514		0.062
3. Hindan bridge Budhana	Actual	0.447	0.337		0.211
14 ft roadway	Rigid	0.582	0.333		0.088
3 beams	Elastic	0.516	0.483		0

Shri A. Banerjee asked why cross-section for Dimni bridge was taken only at 700 ft upstream for calculation of hydraulic data and not on the average of at least 3 cross-sections. Was there any record of observed velocity at or near the bridge site and how did that compare with that obtained from Kutter's formula? Manning's formula gave result very close to that obtained from actual observations. Rough calculations showed that with this formula the discharge would be in the region of 1.10 lakh cusecs for the Dimni bridge. Much emphasis appeared to have been given to rainfall data method leaving proper investigation by area velocity method which always gave very correct figures if the area cross section could be obtained just immediately after the flood, or if the available cross section after the flood could be increased by a certain percentage, say, 10 or 15 per cent, to find out the discharge from that.

In Table 1-A for the design discharge of 138,500 for Dimni, 221,800 for Budhara and 239,500 cusecs for Didi bridge, the linear waterways provided were actually 0.38 of the regime width as calculated by Lacey's formula. It appeared there was a particular reason for adopting or restricting the waterway to 0.38 of the regime width. He wanted the Authors to elucidate the point and if there was any particular reason for doing so.

In para 5 the maximum velocity was assumed to be 13 ft per second for the design of piers and wells. From Manning's and Kutter's formulae, the velocity would be not more than 6 ft per second, and with the increased discharge of 138,500 cusecs for Dimni bridge, the mean velocity worked out to be nearly 7 ft per second. Why was higher figure for the velocity adopted?

Shri Banerjee stated that hollow piers 38 ft high were used, whereas in the case of cross walls connecting the outer shells, no horizontal diaphragms appeared to have been provided. As the shells were only 12 in. thick, horizontal diaphragms should be there to stiffen the outer and inner shells.

He observed that whereas thickness of ribs of girders for Didi and Dimni bridges had been made 5 in., that for Budhara was increased to 5½ in. Since the overall depth of the girders for all the three bridges was nearly equal, i.e., 7 ft, it would be useful to know the reason for adopting different thicknesses of ribs for different superstructures of the same depth. Further, the thickness of 5 in. appeared to be very narrow from the practical aspect of concreting of girders. The usual practice was to adopt a thickness of not more than 4 in. plus $D/40$, where D is the overall depth of the girder. This would have given a thickness of about 6 in., which should have been adopted in this particular case.

He requested the Authors to throw light on the method of shuttering and concreting of girders, and asked whether any difficulty was experienced in concreting the webs of the girders or any cracks observed after opening of the shuttering.

Referring to Table 2-B he enquired why the size of abutment wells of the bridges was kept bigger than the pier wells and whether any effect of seismic force was considered in the design calculations.

He wondered why the side shift factor, as mentioned by the Author, was calculated by a method other than the recognised formula and requested the Authors to throw some light on their method of determining the distribution factors and to state the correctness and advantages of that method as compared to the conventional method.

In regard to the testing of the Dimni bridge where equal deflections were recorded in all the four girders (due, perhaps, to centrally placed super loads), Shri Banerjee stated that this statement would be surely erroneous for eccentrically placed super loads. He, therefore, requested the Authors to enlighten if any observations were made for eccentrically placed super loads.

Lastly, in regard to the economic aspect of the bridge structures, he stated that the Authors had pointed out more economy in a bridge with three girders as against that of 4-girder system. Yet Table 7, page 319, showed that the overall cost per sq. ft. of the roadway of Budhara bridge was more than that of Dimni having a 4-girder system of superstructure, although the cost per sq. ft. of the superstructure itself was less than that of the Dimni bridge, the foundations being nearly the same for both the bridges. It would be quite useful if the Authors could throw some light on the reason of this reversal of expected economy.

Shri S. Gangopadhyaya requested the Authors to elucidate how the actual depth of foundation was determined by observations of the resistance offered by soil during sinking as stated on page 294. Such resistance, he held, was the frictional resistance of soil on the skin of the well steining, but well foundations were designed mainly to stand on bearing power of soil. He did not agree with the method of determining the bearing power of soils, as stated by the Authors on page 300. Moreover, the unconfined compressive strength of clayey soil had been assumed here as high as 8 ton per sq. ft.; such high values he felt, were rarely met with in clayey soils. It was desirable to ascertain the bearing power by actual laboratory tests.

In regard to the 'side shift factor', he requested the Authors to explain why Courbon's or Momio's method was not considered suitable for designing the longitudinal and cross girder.

Regarding the load testing of well No. 3 of the Budhara bridge, Shri Gangopadhyaya stated that the soil was stiff clay and so the frictional value should be high and, as such, probably the well should have been tested with an additional load of nearly 300 tons over and above the reactions. It was also difficult to conceive that no settlement would take place on clayey foundations if the well was tested with full super loads.

Shri M. P. Apte remarked that besides discussing many theoretical points of great importance regarding the design of bridges the Authors had proposed the "rainfall data method" for ascertaining the flood discharge of the rivers. No doubt the Authors calculation for finding the run off of the catchment was very interesting. He, however, suggested that any formulae based upon statistical

analyses and the theory of probability would be true within certain limitations and to the extent the data was sampled scientifically. Mere observation of maximum intensities of rainfall was not enough. The maximum possible intensity of rainfall likely to occur during the next 60 or 70 years had to be calculated by carefully studying the rain cycle. The data available was generally not sufficient for such accurate analysis. He was, therefore, afraid that the Authors would before long experience a flood which would exceed their scientifically calculated figure, as happened in the Indore area which gave anxious times to the Chief Engineer in charge of the Chambal Dam.

Referring to the depth of scour as per I.R.C. formulae for alluvial rivers, Shri Apte stated that the Authors suggested that this formula need not have been used as the river bed consisted of cohesive material. The assumption of a cohesive bed in case of these rivers did not appear to be safe because one of the wells automatically tilted and shifted during the floods as mentioned on page 313. Such a phenomenon was more common in alluvial strata than in cohesive strata.

He requested the Authors to give some more information which actually weighed in taking the foundations deeper by 8 to 12 ft below the levels designed on the basis of alluvial bed after the experiments conducted by the Poona Research Station on the depth of scour near the piers.

Shri Apte observed that the Authors had not indicated how the linear waterway was fixed. On a rough calculation the linear waterway for the three bridges on the basis of alluvial strata worked out to 905 ft, 1,150 ft and 1,222 ft as against 376 ft, 473 ft and 500 ft adopted by them. The linear waterway was almost 40 per cent of the requirement on the basis of an alluvial bed.

Taking the normal depth of scour as 24.5 ft as calculated by the Authors on the assumption of an alluvial bed, the area of waterway provided was $376 \text{ ft} \times 24.5 \text{ ft} = 9,212 \text{ sq. ft.}$ only, as against 16,100 sq. ft. required. The waterway provided was thus only 57 per cent of the actual requirement. This meant that the velocity of current would be more than 20 ft per second which was far more than the assumed velocity of 13 ft per second even on the basis of a moderate discharge of 1,38,000 cusecs.

Therefore, if the actual discharge exceeded the discharge calculated as per rainfall data method, there would be tremendous velocity and a very high afflux in the river which were not accounted for in the design. He felt that a substantial reduction in the permissible waterway could be done in case of rocky or very hard river beds only and not in the case of so-called quasi-alluvial beds as done in the case of these three bridges.

Shri Apte stated that on page 313 the Authors had stated that the dredging in the wells was stopped when it became extremely difficult to excavate further, and wanted to know the criteria for this "extreme difficulty". Was it the difficulty of dredging or kentledge or something else? He also enquired how the difficulty in sinking was indicative of the bearing capacity of the strata or the scour depth, etc.

As for the test load of 668 tons, which was stated to be equal to the design dead plus live load, he felt that it appeared to be inaccurate and very inadequate for twin wells of 15 ft diameter, as the wells were tested after plugging. The wells were designed for a safe bearing capacity of 7 tons per sq. ft. which included stresses on account of moments due to horizontal forces. The test load should have, therefore, been calculated on the whole area at the rate of 8 to 10 tons per sq. ft. Alternatively, the test load should have been equal to $(\text{dead} + \text{live load}) \times \text{some factor of safety} + \text{the load required to overcome the friction between the well steining and the river bed}$.

Regarding the factor of safety against ultimate strength assumed as 2.14, it was not clear whether the design criteria of the Ministry of Transport were relaxed in the case of these three bridges because these criteria lay down the following safety factors:

For steel $2 (D + L)$ or $(D + 3 L)$

For concrete $2.5 (D + L)$ or $(D + 3.75 L)$.

Referring to the permissible tensile stress of 167 lb per sq. in. for $1 : 1\frac{1}{2} : 3$ special grade concrete, Shri Apte wanted to know whether there were any direct tensile stresses actually allowed in the design.

The thickness of the web of prestressed girders was only 5 in. and this included two legs of $\frac{3}{8}$ in. diameter stirrups and the main cable. He hoped there were no special difficulties in concreting on account of the same.

Shri Apte wanted to know whether the concrete as adopted with 60 per cent stones and 40 per cent mortar with a weak water cement ratio was better than $1 : 3 : 6$ concrete with 25 per cent plums and what were the tensile stresses allowed on concrete?

In regard to the side shift factor or the reaction factor, he stated that the Authors would be interested to know that this problem had now been theoretically solved by Engineers from the West and that more rational methods were now available for ascertaining the reaction factor.

Different Papers had been written on the subject of analysis of grids and related structures by Messrs Lazarides, Massonet, Newmark, Leonhardt, Thomas, Short, Guyon, Pippard and Morris, etc., in different journals. In particular, he invited attention to the contribution of Messrs A. W. Hendry and L. G. Jaeger in their latest book on the analysis of grid frameworks, published in 1958.

Referring to the cost of the bridge worked out as Rs 1,800 per foot length, he congratulated the contracting firm of giving such an economical design to the department.

Shri Ram Singh Agarwal remarked that it was rather strange that the mixes were not designed properly for the high grade concrete used in the prestressed structures. The batching was also done by volume as against by weight usually done in special grade cement. The water cement ratio had also not been given. He agreed with Shri D. C. Chaturvedi that the different tests should have been done.

- In regard to the sinking of wells, the Authors had not given any details and precautions that were taken to sink the wells properly without much tilts and shifts, as this information would have been useful to the working engineers. He also wanted to know the method employed to find out the correct tilts in the wells during the final stages of sinking of wells. Referring to the tilt development in one of the wells in Didi bridge which was left partially sunk before the monsoons, he asked details about the actual tilt before and after the floods so as to know the actual effect of the floods on that well, so also the depth to which the well was sunk before the floods and whether it was given a temporary cap or not.

The depth of bottom plugged concrete of wells kept at 3 ft 6 in. seemed to be rather less and it was also not known whether the plug was then tested for water tightness or not. The Author should intimate if the porosity test was carried out by dewatering of wells after bottom plug was concreted. If it was done, the details with results be given for the information of the working engineers. In the end, he asked if there were any standard specifications for this test adopted in his State.

Shri C.V. Padmanabhan referring to the distribution of load on the girders, vide page 305 bottom, wanted to know how the conclusion that it was rather difficult to calculate the maximum share of each girder exactly was arrived at. In this connection he referred to an investigation done by Messrs Morris and Little and reported in their Paper read before the Institution of Structural Engineers in which they had given the curves for distribution coefficient K with no torsion given by Guyon and also with full torsion developed by Massonet. These curves were used in the

investigation and from the values of K available the distribution coefficient for the girders could be had.

On page 308 it was stated that in the opinion of the Authors the three-girder system gave a more rigid structure than a 2-girder system. He did not understand exactly what was meant by more rigid system. In fact, if the rigidity of a structure only was taken into consideration, it could be varied, keeping the other features constant, by the spacing of the main beams and the section of the cross beams. Actually, in this case itself he had found that by

adopting the formula $\theta = \frac{b}{2a} \sqrt{\frac{I}{J} \frac{q}{p}}$, the required rigidity factor θ could be obtained by increasing the spacing in the main beams and the section of the cross beams, and it was possible that between 3-girder and the 2-girder systems, the latter could be made more rigid than the former.

In the case of economic spacing of girders it was stated that for a 3-girder system the main economic spacing was 7 ft 8 in. Actually, according to investigation referred to earlier, the most effective spacing for 3 beam arrangement worked out to 7 ft 3 in. With this spacing the side shift factor for a 22 ft wide roadway was definitely less than what the Authors had worked out. Similarly, for a 24 ft wide roadway, the same investigation suggested 8 ft centres spacing, which also gave a factor of side shift much less than what the Authors had worked out in the Paper.

Shri K. F. Antia remarked that he was constrained to raise the issue on hydraulic investigations because one of the speakers on Paper No. 216 pinned his faith on Dickens' formula with a particular constant. He felt that it might apply only to Indo-Gangetic Plain because of the terrain being almost the same throughout but it would not apply anywhere else in India. Actually, the best method, on information available at present, was to compare the results of 3 or 4 methods. On the Railways, discharge is worked out .1 by Dickens' formula with appropriate variables, viz., 0.2 by Lilly's method, 0.3 by Inglis' method and 0.4 for large rivers, by the section-velocity method. Shri Antia wanted to bring out an important point in Inglis' method which Shri N.M. Thadani touched upon while commenting on Paper No. 216, and particularly because Shri Apte also referred to it, vis-a-vis the Chambal Hydel Project. So far as reservoirs and schemes of similar nature were concerned, 7,000 would be the appropriate constant in Lilly's formula, but so far as cross drainage was concerned, 4,000 was a reasonable figure.

In regard to the permissible compressive stress at prestress given as 2,100 psi., he believed that the strength at transfer was

twice 2,100, viz., 4,200 psi, which would fit in approximately with the age of prestressing of 19 days as given in para 6.3. But he wanted to know that if prestressing was done immediately after placing of the slab concrete, would it not have had adverse effect on this slab concrete?

Shri Antia added that some correlation on the design statements in para 5.2 was desirable as in the first para the Authors had stated that the piers were strong enough for the vertical loads and then they considered the haunches and treated them as columns and found them satisfactory. Further on it was stated that the piers were designed to take the horizontal load. Shri Antia observed that everything must have been designed satisfactorily, but there seemed to be a lack of correlation between the three statements. Incidentally, he wondered whether the slenderness ratio was adequate if the haunched portions were treated as columns, when there were no horizontal diaphragms.

- Shri Antia wished to draw the attention of Author to a very practical way of distributing loads which had been brought out by Mon. Qurbon. This simple method which was likely to be incorporated in the I.R.C. Bridge Code, applied to bridges with spans more than twice the width. The fundamental conception was that the diaphragms were considered absolutely rigid.

- In reference to Morris and Little's method and Massonet's and Guyon's methods of load distribution mentioned by previous speakers, Shri Antia stated that Morris and Little's method was a combination of or a corollary to Guyon and Massonet's methods.

Referring to para 5.3, Shri Antia felt that it would have been more economical to use higher strength concrete for the beams and lower strength concrete for the slabs and to allow for variation in the modulus of elasticity. Though realising that the design was not that of a composite section, the advantages of such a design were so great that it was worthwhile considering this method in future designs.

Referring to para 5.3.1, Shri Antia stated that there were two criteria by which to control vibrations. One was to limit the depth / span ratio, and for this a rule of thumb method is to have the depth not less than 1/25th of the span for the combined slab and beam, or less than 1/30th of the span for the beams alone. Vibrations could also be controlled through limitation of deflections. If these two points were taken into consideration, vibrations could be avoided, and added that vibrations must not be accepted complacently.

Shri Antia did not agree with the Authors that a one girder bridge was not a practical proposition. He referred to the single

box girder which was becoming common, particularly in Germany and cited the example of Unkelstein viaduct in Germany.

An important requirement mentioned by Shri Antia and which did not appear in the Paper was that it had to be absolutely made certain that prestressed concrete girders were under-reinforced to guard against sudden failure.

Shri I. G. Qazi wanted to know if temporary capping was provided in the well which was partially sunk before monsoons and left in that state on account of floods. It was also stated that 10½ in. shift and some tilt was observed after floods in the same well and asked how much tilt was removed afterwards and in how much depth and whether the final tilt of 3½ in. was also reduced while doing further sinking.

In the same para it is stated that tilt being less than 1/60th of the depth was allowed. This is of the order of 1/160th. Will the Authors clarify if this is a misprint or there is some practice by which tilt up to 1/60th of depth can be allowed.

In regard to the artesian conditions in one of the wells requiring 10 ft plugging to withstand the upward thrust of the spring, he enquired if the plugging had become waterproof and if any observations were taken after dewatering the well.

Shri K. Ganguly stated that the stresses assumed for ultimate strength of concrete were on the low side for 1 : 1½ : 3 nominal mix and the distribution of loads between different girders had been calculated by a non-standard method. Distributions will not be average of firm and elastic support. Method of distribution coefficient or by application of basic function (H. Creager's book on Rigid Structures) may be employed to find the proper share of load to each girder.

Shri Ganguly added that it was not always economical to have 3 girder systems. In many R.C.C. bridges 2 girder system with cross girders integral with deck slab (7½ in. thick) had been economically used, which also increased the transverse rigidity of the deck system. Reinforcements in well steining provided at the centre of the section should have been divided and placed in both periphery to guard against constructional tensile stresses during sinking. Reinforcement at centre was of no use.

Shri Y. K. Chougule stated that the discharge of 138,500 cusecs worked out by the Authors by the rainfall data method for the Dimni bridge, appeared to be very near to the discharge arrived at by the area velocity method using Kutter's formula for arriving at the velocity. It was, however, known that the use of Kutter's formula gave very low results from the recognised phenomena that

abnormal rains occurred once in 30 to 50 years causing devastative damages to life and property, as was experienced in the Tapti Valley very recently. Inglis formula was being used in Bombay State for very important works. If this criterion was applied to the present case, it would be seen that the assumed discharge was only 57 per cent of the probable extraordinary discharge.

Similarly, the assumed discharge was much below that obtained by the Dicken's formula. It was, therefore, for consideration whether the data or the assumptions with regard to the numerous factors affecting the calculations by the rainfall data method could be fully relied upon.

Shri Chougule added that a free board of only 5.5 ft above the H.F.L. giving a safety of only 15 per cent as against the probable risk of 70 to 75 per cent appeared to be comparatively low for the deck girder type construction. It, therefore, deserved consideration whether the bridge could be designed as a submersible bridge if finances did not permit a full bridge or substitute it with the arched rib construction affording sufficient additional waterway below the soffits of the arches and the open spandrels to take care of any unprecedented floods.

He requested the Authors to give the special reasons for adopting the twin and circular wells in the design as sinking of individual separate wells was easier and more convenient than twin wells.

In regard to the mention on page 313, para 6.2 (b), that the dredging was stopped when it became extremely difficult to excavate further, Shri Chougule observed that from the boring results given on page 295 the probable strata met with at the bottom appeared to be only yellow Padma soil or that mixed with a little kankar. Excavation in that strata should not be difficult. In the absence of details about the definite strata actually met with at the bottom it was difficult to understand the nature of the difficulty met with in sinking. He enquired if at any stage of the well sinking boulders were encountered and what methods were used to sink the well through such strata.

In case the wells were not taken to the rock, he queried, whether results of comparatively low static loading used for testing the wells as against the heavy actual aggregate loads the wells were expected to bear could be taken to give an all time guarantee as vibrations and impacts of moving load might play a different roll.

Shri S. A. Balu stated that when the foundations had been taken to clayey strata it was not quite correct to adopt Lacey's silt factor for calculation of scour depth because Lacey's silt factor was

not applicable to cohesive soils. In cohesive soils, the scour depth would have to be determined by practical tests or by some other method. The remark of Shri Shitala Sharan regarding depths of foundations being inadequate was probably due to the fact that the scour depth had been calculated adopting Lacey's silt factor of 1.00, to silt whereas the foundation strata was stated to be clayey.

As regards the bearing capacity of the soil, he asked whether the pressure of 7 tons per sq. ft. was the maximum or the average pressure, as also what was the distribution of pressure on the bottom of the foundations. If 7 tons per sq. ft. was the maximum allowable pressure, the whole well should have been loaded to give a uniform pressure of 7 tons per sq. ft. on the bottom of the foundations when the foundation wells were tested.

He also wanted to know whether any cross current force had been taken into consideration for the design of the piers, and whether it had been designed as a fixed bulkhead or whether the passive pressure of the soil below the scour depth had been taken into consideration in the design of wells.

Shri B. Balwant Rao stated that the properties of high tensile steel used in bridges tended to vary considerably depending upon the method of their manufacture, packing and storing and other considerations. The value of E taken in this particular case was supposed to vary between 29 and 30 raised to the power of 10^6 lb per sq. in., but the elongation statement did not make it clear whether the elongations were based on the value of $E = 29$ or 30. Suppose the steel was tested giving a value of $E = 29$ and the calculations were based on $E = 30$, the elongations would not be sufficient and the beam would be under-stressed. Therefore, he wanted to know whether the high tensile steel was tested or not.

In Table 5 regarding extensions, for a rise of a manometre reading of 100 kg. per sq. cm., the extension was about 18/16 in. but the last item showed that for an increase of 40 kg. per sq. cm. the extension was as much as 26/16 in. He was doubtful whether an elongation of 26/16 in. due to that last jacking stress was really effective because it must be between the limit of proportionality and 0.1 per cent proofstress in which case it would not impart any prestress due to permanent set. If this was taken into consideration instead of getting a stress of + 22 as given in Fig. 4, they might actually have tension not allowed in designing a prestressed concrete beam, in service.

It was also not clear how the Authors had arrived at 0.1 per cent proofstress. Unless they prepared an accurate stress-strain graph it would not be possible to determine the limit of stress at 0.1 per cent proofstress.

Shri Rao asked if the friction losses assumed to be 20 per cent were based on some formula. Actually from the tests conducted it was not found correct to assume friction loss at 20 per cent unless a preliminary test at site was made and then corrections for this and deformation losses were given.

Dr. H. C. Visvesvaraya referring to the figure of 1667 psi given as the working stress for concrete, arrived at as one-third the cube strength at twenty-eight days, stated that such figures needed some engineering considerations. He had come across figures of stresses in some designs which were a few pounds in excess of the permissible stresses and on this score the design had been rejected. He stressed that a structure could behave only in one way and not the way they calculated and that was the only way in which a structure could be judged. It was, therefore, important to keep in mind the fundamental assumptions in the calculations before judging the results of the calculations. One need not work a concrete strength to decimal and there would be no harm done whatsoever if the working stress was chosen as 1670 psi or even 1700 psi in place of 1667 psi, keeping in view the fact that the calculations were only guides towards the understanding of the truth and not truths by themselves, and that immaterial of the variations in calculations, a given structure under a given condition would behave only in one way.

With regard to the factors of safety against first crack given as 1.44 and 1.55 with respect to the live load and the total load, Dr. Visvesvaraya stated that these figures were based on an assumed tensile strength of 500 psi for the concrete. There were two aspects to consider here: (1) The basis of the figure 500 psi itself which was obviously one-tenth the compressive strength and (2) the apparent tensile stress phenomenon in prestressed concrete. By the apparent tensile stress phenomenon which some of the experts would have already observed, was meant that at the stage of first cracking, if the tensile stress in concrete was calculated on the basis of the actual load at that stage, the calculated stress would be very much higher than the modulus of rupture, and hence this stress could be only "apparent". He drew the attention of members to a couple of Ph.D. theses in the London University discussing this phenomenon. It had also been corroborated by M. Guyon. This being a peculiar phenomenon could be explained by a rational and logical approach only to a certain extent, but from the available information it was clear that the apparent tensile stress at which the first crack appeared was very much higher than the calculated stress in prestressed concrete and thus the factor of safety on first cracking would be much higher than that calculated on the basis of the tensile strength of concrete.

Similarly, the factor of safety against ultimate strength had been arrived at 2.14. It might be of interest to know that he had occasion to check by calculations based on the 'Criteria for Prestressed Concrete Bridges' and the actual tests showed factors of safety very much higher than those calculated.

Regarding extensions of cables, in Table 5, there appeared to be some mistake in the elongation figures at left bank in addition to the mistakes already pointed out by others. The figure of $4 \frac{3}{16}$ in. before locking could not become $4 \frac{8}{16}$ in. after locking. Like the load deflection figures in Table 6, the close conformity between the calculated and the observed elongations, in spite of the approximate value of friction losses, was rather unusual and interesting to note.

In the end, Dr. Visvesvaraya observed that a comparison of the modulus of elasticity of concrete obtained from the load deflection curve derived from Table 6 with that assumed on page 299 showed considerable variance.

Shri T. N. Subba Rao stated that the Authors of the Paper had devoted a great deal to the economics of the 3-beam and 4-beam designs for the decking. It is admitted that for the range of spans, loading, roadway, type of bearing, and type of construction provided on these bridges, the 3-beam proposal was more economical by way of material consumption and constructional cost. But the same would not be the case if the roadway was 24 ft, type of railing was of R.C.C., loading also included class 'AA' tanker, decking was cross prestressed as per acceptable methods and if the spans were launched into position. Therefore, it was really a difficult matter to judge the economics of any particular prestressed beam slab system unless the various controlling factors, besides load distribution factors, were investigated from an overall standpoint before drawing any conclusions based on bending moment values. Different results are obtained as a result of improvement in design analysis, changing pattern of cost of primary materials, rising cost of overheads and other many important factors, and thus every problem has to be assessed on its own merits with due respect to local conditions and any generalisation would be far fetched.

A conspicuous feature of these three bridges is the provision of R.C.C. bearings. These bearings had stood the test of nearly four years and were behaving remarkably well. Similar ones designed to withstand upto 6,000 lb per in. run of bearing had been load tested both under normal and extreme range of temperatures prescribed by the I.R.C. and found to give the first cracking factor of safety of more than four.

He wished to point out that the term "Side Shift Factor" on page 306 is misleading. Side shift factor conveys the impression

that the values obtained had been based on the simple reaction values as in the case of R.C.C. bridges designed as per the I.R.C. Code. The correct term would have been "Load Distribution Factor" since this implies that the load value for which a member had been designed was arrived at after considering the distribution properties of the inter-connected system.

He fully endorsed Shri Ramaswamy's views on the subject of testing prestressed bridges. Testing of any structure should have a purpose and very little is derived from testing conventional structures whose behaviour pattern is well known.

At the time these bridges were designed, the draft criteria for prestressed work of the I. R. C. and the now well known and popular D.B. 11 method developed by the C. & C. A., London, were still under preparation. Perhaps, that would make it clear to many of the members, as to why the initial and final stresses adopted for steel and concrete, the coefficients chosen for estimation of deferred strains, the evaluation of ultimate load factor, the distribution of loading on the basis of rigid and elastic behaviour of the decking, etc., do not conform with present day practice.

H.T. steel and cables

The high tensile steel supplied to these bridges was imported from U.K., in coils of 4 ft so that the wire paved out straight for forming into cables. Every supply of five tons was supported by a test certificate showing percentage of carbon, sulphur and phosphorous, minimum elongation at failure on a two-in. gauge, electrically recorded stress strain diagram, 0.1 per cent proofstress, ultimate tensile strength and other details. As stated on page 299, the test certificates consistently showed that the ultimate strength was over 100 tons per sq. in., and the 0.1 per cent proofstress was not less than 80 tons per sq. in. The modulus did lie in the range of $29/30 \times 10^6$ lb per sq. in., but the actual extension prescribed for the cables was obtained directly from a representative stress strain graph.

The high tensile cables consisted of 12 Nos. 5 mm. wires grouped around a central core and enveloped by a 35 gauge sheathing, in accordance with the procedure followed in the well known Freyssinet System. The final cable stress adopted was 56 tons per sq. in., the losses were estimated as 15 per cent and the friction losses from 10 to 14 tons per sq. in. Therefore, the initial stress at the jack end varied from about 76 to 82 tons per sq. in., depending on the profile and length of the cable. Excepting for a few cables in each span, a stress of more than 80 tons per sq. in. was not exceeded.

Mixed design for prestressed concrete work

Neither weigh batching nor any particular grading was considered necessary. Excellent coarse graded sand was available naturally from the Chambal River bed. Hard blue granite supplied from quarries around Gwalior was used as coarse aggregate. Even a conventional 1:2:4 mix using these aggregates with 0.45 water cement ratio gave consistent cube strengths of over 4,000 lb per sq. in. at 28 days. Exhaustive number of cube tests were carried out by his firm during the construction of the nearby Chambal Bridge at Dholpur. With this knowledge, they just adopted a conventional 1:1½:3 mix, binding as per terms of contract, and periodical tests carried out on all the three bridge sites gave consistent results of over 6,000 lb per sq. in. at 28 days. Here again the water cement ratio used was 0.45. During the exceptionally hot and dry weather, the workability was increased by the addition of half a gallon of water per bag of cement in order to compensate evaporation losses. External vibrators placed approximately 6 ft apart were used for consolidating the beam concrete. Internal vibrator with 1½ in. dia. needle was used effectively for the deck slab.

Concreting of decking

The decking of all the spans was cast in situ. The beams in each span were cast one after another upto the bottom of the deck slab. It took approximately ten hours to cast each beam. The bottom and one side shuttering was erected in advance. The side shuttering on the other side was built up in three stages along the height as the concreting advanced. Richer concrete of 1:1:2 mix was used in the end anchorage zone. This permitted stressing of two cables in each beam three days after concreting, which, in his experience, had proved necessary to avoid shrinkage cracks developing on account of friction present between the beam concrete and the staging.

The staging for the deck slab was taken up as the beam concreting progressed. Soon after completion of the last beam, reinforcement was placed for the deck slab and it was concreted. These operations took approximately 7 days. As to how the work proceeded thereafter had been dealt with by the Authors. The above points had been mentioned since they are slightly at variance with the information given in the Paper.

The stressing of the second batch of 46 cables per span was commenced when the beam concrete had reached 80 per cent of the designed cube strength of 5,000 lb per sq. in. It was not necessary for the slab concrete to possess the same strength since the maximum fibre stress in it did not exceed 550 lb per sq. in. on stressing the cables. Considering other factors and unusual site conditions, the

concluded, after some preliminary cube tests, that on an average it was safe if the second stage cables were stressed 7 days after concreting the deck slab.

A few cases of wires snapping no doubt occurred during prestressing in each bridge. In such cases, they discarded the broken wire and stressed the remaining ones to a corresponding reduced gauge pressure. Such instances are rare but do take place. There are many reasons for this and one of them is the non-axiality of the cable with the female cone, which causes the wires on the inner side of the bend to be stressed much higher.

Load Distribution on Decking

As already explained, they did not have sufficient information regarding the actual behaviour of a prestressed beam grid, in order to clearly predict the distribution pattern. From basic principles and a certain amount of intuition they took the average of the elastic and rigid behaviour of decking to represent the actual. The method followed for the rigid analysis has today come to be recognised as the Courbon approach.

From the test load results of these and other similar bridges, they could confidently conclude that spans with beam spacings of this type, with diaphragm centres upto 4 times the beam depth, behaved almost like rigid decking and it is needless to indulge in the more complicated D.B. 11 method. Further, the deflections showed that although the decking behaved rigidly, their values are such that the bending moment anticipated did not arise in each beam and that it was somewhat less, depending on the grid system, by a constant alpha less than one.

Even so, a comparison of the figures given on page 307 would show that the method of averaging the distribution factor gives a reduced value for the external beams only, by less than 6 per cent than that derived by the Courbon procedure. The actual distribution factor as shown by test loadings being less was not given any importance.

Stress Conditions

It had been remarked that the compressive stresses permitted in the top fibre had not been fully realised and that the minimum compressive stress in the bottom fibre for the 4-beam system was too low.

On spans upto 150 ft, they had often found with the deck systems provided by them, that the compressive stress in the top fibre cannot be fully attained and that a section that fulfils this requirement is not the most economical one. The stress in the

bottom fibre is above zero under the maximum loaded condition with final prestress and this conforms to the Draft Code and also recognised codes abroad. They had not accounted in their design for the loss in cable area before grouting and for the same during working conditions. This had the effect of increasing both the maximum top fibre stress and the minimum bottom fibre stress. As such, the girders would have much more residual compression left in the bottom fibre than shown in the calculations.

Deck System

One of the speakers had queried as to why the 4-beam grid was adopted on Didi and Dimni bridges and the 3-beam grid on Budhara bridge. This had valid justification. They had just completed the construction of the Mahi bridge at Sevalia for the Bombay P.W.D., when they received orders for Didi and Dimni bridges. The spans for these bridges were identical to those of Mahi bridge. They, therefore, decided to utilise the same design, beam section, and available shuttering to expedite the construction of these bridges to their advantage. When the orders were secured for the Budhara bridge much later on, the Didi and Dimni bridges were in progress and the question of reutilisation of shuttering was not feasible. As new shuttering had to be prepared, they investigated the economics more fully and finally decided that for the type of railing, road width, loading, etc., the 3-beam proposal was a more economical proposition.

Pier Design

The use of cellular piers for bridges was not new. He would recommend a reference to the Inverbervie Bridge in the book "R.C. Bridges" by Legat, Dunn and Fairhurst, where such a pier had been shown in detail.

With the continuous R.C.C. bearing used in the stiff pier cap provided over the short piers, one could easily recognise that the load distribution on the outer skin of the cellular pier was not confined to any particular zone. All that was needed vertically in the piers was 0.4 per cent as per present codes for load bearing reinforced concrete walls. However, they took the additional precaution to reinforce the junctions to some extent. It would be noticed from page 304 that the maximum compressive stress in the piers was even less than 400 lb per sq. in. and reinforcing it further would, therefore, be unnecessary.

One of the speakers had asked as to why horizontal diaphragms were not provided in the cellular pier. He would like to point out that such horizontal diaphragms would be necessary in the absence of vertical diaphragms only. They are needed only to prevent

buckling of the outer wall of the pier and this did not arise in this case, since the vertical diaphragms did not permit this to occur.

Scour Depth and Well Design

The design of the foundations was based on the scour depths specified by the Department.

During the construction of the Didi and Dimni bridges, phenomenal early floods occurred in the rivers. The H.F.L.s fixed were exceeded. Some of the wells which had been sunk only 10 to 15 ft below the bed were badly tilted. This incident gave sufficient proof, (despite all the formulae we might conjure), that the scour on these bridges would not exceed about 15 ft at the upstream ends of the wells.

The well design was based on conventional methods accepted then. Moments were carried down to foundation level from the point where the horizontal forces were balanced below scour by the passive earth pressure. He agreed with Shri Shitala Sharan that they had a more refined method of design for wells in sandy and clayey strata these days. Their present designs were based on that method, which accounts for both the active and passive pressures below scour level on the primary assumption that soil resistance varied lineally in proportion to displacement. That method had been advocated by one E. B. Pender of Australia.

Here he wished to draw attention to the formula given by Shri Shitala Sharan. This formula was applicable only to sandy soils whereas on these bridges they met with sand mixed with clay within a few feet from the bed. The results given by it were, therefore, not representative of the actual state of affairs. Even assuming that it could be applied, he did not see any reason as to why it should be necessary to reduce the moments at the base to zero, which is one of the pre-conditions for the application of this formula.

Testing

He had already commented on the rigid behaviour of the decking, which was conclusively proved by the test. The test apparatus consisted of a lever arrangement which gave recorded readings upto $\frac{1}{250}$ in. accuracy and interpolated ones upto $\frac{1}{500}$ in. or less.

One of the speakers had queried the location of the loading for the values given in Table 6. These values represent the loading position at centre of span uniformly distributed over the full width of the roadway. This explained the reason for obtaining equal deflections in all the four beams.

Shri K. K. Nambiar stated that the importance of gravimetric batching had already been stressed by more than one speaker. Specified cube strength at 28 days was 5,000 lb per sq. in. and the permissible compressive stress at transfer was taken at 2,100 p.s.i. This stress appeared to be on the high side. The I.S. Draft Code permits a stress equal to 0.5 times F_c . For F_c to reach 4,200 in a 5,000 psi concrete, it would not be possible to do the prestressing earlier than 20 days after casting of the beams. The criteria for prestressed concrete bridges prepared by the Roads Wing, on the other hand, indicated 1,800 as the permissible temporary stress at transfer for 5,000 psi concrete.

As regards the permissible stresses in steel, they were obviously on the lower side as 66 tons per sq. in. was only 60—66 per cent of the ultimate strength and 82 per cent of proof stress, both of which values were very low and would result in a higher percentage of steel. The final working stress in the steel with 15 per cent losses had also become proportionately lower—70 per cent of 0.1 per cent proof stress.

On the other hand, the frictional loss experienced in some of the cables was said to be as high as 20 per cent and it was obvious that the stress in steel at the jacking end had actually exceeded the 0.1 per cent proof stress of steel. Twenty per cent frictional loss could be considered as rather high and brought out the importance of making up of good quality sheathing for prestressing cables. It had not been indicated how many strands in the prestressing of the cables in any of these bridges were broken during prestressing.

In table 5, serial no. 8, item 4, elongation in inches from the left bank, the actual elongation observed should be 4-9/16 in. instead of 4-3/16 in.

The statement made on page 305, para 5.3.1(i), that equal deflections were recorded in all the four girders during the testing of the Dimni bridge appeared to be too good to be true.

In para 5.3.1(ii), the vibrations created in the bridge by even a small live load were interpreted as the higher degree of resilience in the structure. It would be worthwhile to look into this and find out the degree of vibrations as compared to the size and nature of live load on the structure.

In regard to the method of calculation of side shift factors in the case of 3 and 4-girder systems adopted for the bridges, although Dimni, Didi and Budhara bridges were designed for the same class of loading (Class A) and had more or less identical spans 330 and 127 ft, it was not clear why the design of the Budhara bridge was made a 4-girder construction as compared to Dimni and Didi bridges having 3-girder system while depths of the girders in

both the cases were also almost identical, viz., 6 ft 10 in. and 7 ft 0 in. The Authors' attempt to justify a 3-girder construction as more economical than the 4-girder construction could be said to be justified on the basis of the analysis made by them on two different assumptions, viz., of elastic and firm supports, the method adopted, according to Shri Nambiar, was not very rational in that the mean reaction factors were worked on the basis of an arithmetic average for the above two assumptions. Against this, the Courbon's method of cross distribution of rigid diaphragms with their section moduli more or less identical to those of the girder sections would prove to be more rational. Besides, the minimum economic span of the slab would, in turn, also govern the overall economy of a particular girder system. It would not perhaps be correct to say that the three-girder system would always be cheaper than a four-girder system as mentioned by the Authors, as it would depend upon the width of the carriageway, the distribution of wheel loads, and such other factors.

• With regard to the arrangement indicated on page 315 for testing of wells, measuring the settlement of the well by a lever with a fulcrum fixed on a peg buried in soil quite near the well steining was not likely to give accurate results. The earth around the well also was likely to subside with the settlement of the well. Reading with the theodolite positioned farther away from the well or some other arrangement not likely to be influenced by the movement of the well, should be adopted.

Shri Nambiar added that grouting being a very important item in a work of this nature, the omission to include details of the operation would tend to detract from the value of the Paper.

With regard to some cables having been broken while prestressing, he asked if full cables were broken or only some tendons, and what was done in such cases, had not been stated in the Paper.

As regards the quantities of steel and cement furnished for the R.C.C. design and P.S.C. design indicating the latter's economy in construction, Shri Nambiar stated that the comparison was not proper, as the piers in the two cases were different, one being masonry, and the other R.C.C. If the quantities for superstructure alone were compared, the enormous savings due to the adoption of prestressed concrete construction would be highlighted. He asked the Authors to furnish the figures.

Sarvashri Y. K. Patil and C. Y. Kand (Authors) stated that for purposes of facility, they had grouped the various queries raised during discussion according to different sections of the Paper, instead of replying to the comments of members individually.

Section 2: Hydraulics

The length of the bridges at the three sites was fixed according to the width between the two defined banks of the river and Lacey's width was not taken into consideration for fixing the length. In case of rivers like the Ganges where floods of high intensity pass through for prolonged periods, the river widens to Lacey's width. But in the present case, the duration of maximum flood was only for a very short period and at greater intervals, therefore to fix the length of the bridge equal to Lacey's width for maximum flood, where the defined width of the river was less than Lacey's width, was not practicable.

According to I.R.C. Bridge Code, the depth of scour at the pier works out to $2D$, i.e., $2 \times 24.46 = 48.92$ ft and according to this Code the foundation depth should be $4/3$ of the maximum depth of scour, i.e., $4/3 \times 48.92 = 65.23$ ft. The foundations were, therefore, at safe depth.

Section 4: Specifications and Permissible Stresses

Colerete was better than 1 : 3 : 6 concrete from the viewpoint of the speed of construction. A maximum tensile stress of 20 lb per sq. in., normally permitted in coursed rubble masonry with 1 : 3 cement mortar, was allowed in the colerete wells. Actual tensile stress was about 17 lb per sq. in.

Section 5: Design

5.1. Foundations: The Authors agreed that the strata met with at various depths should have been tested and the bearing capacity fixed from the test results. The facilities for testing soils not being available in the State when the construction was taken up, the foundations of existing bridges in the region were studied for arriving at the bearing capacity of 7 tons as specified and it was checked from the formulae given by Peck, Hanson and Thornburn. Seven tons per sq. ft. was the maximum pressure allowed in the design. The minimum pressure worked out to about 1 ton per sq. ft. Tensile movements on account of cross current were also considered in the design of foundations and piers.

5.1. Well Steining and well cap: The Authors pointed out a misprint on page 303. The live load reaction should be 120 tons in place of 230 tons and stated that there was no special reason other than the one stated in the Paper to increase the diameter of wells under abutments. Maximum foundation pressure at these wells was only 4.6 tons per sq. ft.

5.2. R.C.C. cellular piers: Piers of Didi and Dimni bridges are not provided with weep holes. Due care was taken to design

the piers for one sided water pressure. In case of Budhara bridge, however, 3 in. $\times$ 6 in. staggered weep-holes spaced 3 ft horizontally and 6 ft vertically were provided in order to prevent the pier walls being subjected to one sided water pressure which could be quite high when the water was at H.F.L. Such stresses could be reduced by this simple arrangement.

5.3. Superstructure

5.3.1. Basic assumptions: In regard to the controversial views expressed by a number of speakers on the assumption that the girders and deck slab had been treated as a homogeneous section, the Authors stated that the test on Dimni Bridge with centrally placed load indicated equal deflections which supported the assumption as also the test at Didi bridge with eccentric loading. At Didi bridge, the eccentric load was placed at the centre of span. It was arranged in two equal groups, each group supported on two sleepers 10 in. wide and at 6 ft center to center. This corresponded to IRC Class A train, two lanes. Centre line of first lane was 6 ft-11 in. from the face of kerb while the other lane was 4 ft-4 in. from the other kerb. The load was first put on one of the lanes when all the four girders underwent equal deflections. When, however, the loading on both the lanes was complete, which took ten hours, it was found that the deflections on all the four girders were equal although the modes of deflection curves were different.

5.3.2. Side shift factors: One of the speakers enquired why conventional method had not been used for finding out the reaction factors. By conventional method, probably, he meant the method given in IRC Draft Code Section III, clause 337 to 340. Clause 337 recommends that the reaction on each girder be taken as $S/5$ or $S/6$ of the reaction of one set of wheels. This method was being used in the Bridge Designs Division of the now defunct Bombay P.W.D. when the junior Author was working there. In the design of Koyna Bridge at Helwak, a four girder bridge, the reaction factors on girders were calculated by assuming a continuous deck slab over firm supports for various positions of live loads. There was considerable difference between the reaction factors calculated by two methods. The problem was widely discussed. It was felt that there could be one ideal spacing of girders in each of the three-girder and four-girder systems for 22 ft and 24 ft wide roadways. The ideal spacing would give minimum reaction factors for Class A two lane or Class AA train loadings and hence the design would be economical. Lot of investigations were carried out to determine the ideal spacings and calculate the reaction factors accurately by considering the dispersion of contact area of wheel along the width of slab for various positions of live loads. The Bridge Designs Office of Maharashtra P.W.D. might be able to throw more light on the subject.

The comparative reaction factors by two methods were also calculated in the design of Chhoti Mahanadi bridge in Madhya Pradesh. Following figures indicate the difference between the two results for a 24 ft roadway for a three girder design with girders spaced at 8 ft centre to centre:

	Outer girder	Inner girder
(a) Method suggested in clause 337 of the I.R.C. Code	0.792 W	0.800 W
(b) Alternative method	0.920 W	0.814 W

The problem was referred to the Indian Roads Congress for comments. I.R.C. was of the opinion that clause 337 was mainly intended to apply to girders which were not cast monolithically with the deck slab (for example steel girder bridges carrying R. C. C. decking). The other method proposed was, however, approved by the Indian Roads Congress.

The assumption that the supports of slabs considered in the above alternative method were firm was not quite correct, since the girders deflected and there was a rigid joint between the two. As further refinement reaction factors were calculated by assuming supports for the deck slab to be elastic and the average of the two cases was considered as a more rational reaction factor. Further modification in this method was done by considering the effects of diaphragms which, if spaced at suitable distances, could equalise the deflections and redistribute the reactions on the girders. The ideal spacings quoted in the Paper were worked out with these assumptions.

The Authors felt that a method based on the analysis of grid as suggested by Messrs Apte, Antia and other speakers should be adopted in future. Most of the bridges constructed in this country were either 22 ft or 24 ft wide and designed for I.R.C. standard loadings, the girder system normally being of two, three or four girders. The Authors, therefore, suggested to the Ministry of Transport to investigate various cases in order to work out ideal spacings and corresponding reaction and side shift factors in each case. This standardization would, they felt, be useful for design offices in the State P. W. D.

The Authors did not agree with the comments of Shri Shitala Sharan regarding reaction factors. In the case of three girder system, it was quite correct that maximum reaction on inner or outer girder would occur when there was only one train (assuming firm supports), in which case reactions on other girders would be small. On account of the diaphragms, the deflections would be equalised and there would be redistribution of reactions. Extra reaction on the

inner or outer girder would be transferred to other girders. It was, therefore, quite clear that if it was desired to calculate maximum reactions on all girders, two Class A trains must be considered simultaneously which would give double total reaction on all girders. The ideal spacings worked out by Shri Shitala Sharan were not in accordance with the above assumptions.

The cost of deck slab was raised due to increasing the length of side cantilever arms but since this reduced the length of piers and well foundations, it was obvious that this saving would be much more than the extra cost of decking. Shri Shitala Sharan should consider the overall economy of the bridge.

Section 6: Construction

As desired by a number of speakers the method of sinking wells is given below:

(a) Up to first 5 to 8 feet the excavation was done by hand. Beyond 8 ft, dredging by mechanical grab operated by winch was adopted upto 25 to 30 ft depth from the river bed. Below 30 ft, the excavation under water was done by divers and clearing by mechanical grab. In some cases a chisel was dropped from height which loosened the bed and the loose material was removed by mechanical means. In the first few feet of sinking, kentledge was not required. It was, however, necessary at greater depths. Water from the wells was constantly pumped out. The difference in the head loosened the grip of soil which helped the sinking operation. On occasions, soil blows on account of presence of loose pockets in the neighbourhood of cutting edge were experienced. In one case, a tilt of 6 in. was corrected by eccentric loading.

(b) Shape of wells

Shri Chaugule desired to know why twin wells were adopted. It is well-known that circular shape of wells is more suited to distribute uneven forces uniformly over the circumference during sinking. If a single well had been provided in this case, the diameter would have been too large thereby increasing the cost of foundations. Two independent wells could be provided but in that case sinking might have presented some difficulties if the wells were very close and not resting at the same level.

(c) Wearing coat

The wearing coat over the deck was 3 in. thick cement concrete 1:2:4 mix. Helical rings of 22 in. diameter with 1/4 in. diameter bars were provided in the wearing coat at 6 ft centres in both directions to prevent temperature cracks.

(d) **Thickness of web and concreting :**

The thickness of the web of girders was rather small from practical point of view. It should have been 6 in. in both the types. Since external (side) vibrators and internal rod vibrators were used, there was no difficulty in compacting the concrete.

Section 7: Testing of bridge

The Authors felt that unless some defects were observed during construction, testing of a bridge was not necessary. Tests to verify the validity of design assumptions should, however, be carried out in laboratories since the field deflectometer might not give very accurate results.

In reply to Shri Nambiar's query as to how many cables were broken during prestressing, the Authors stated that actually such an incident was not noticed.

Section 8: Statistics

The Authors explained that cost per square foot of roadway per foot height of Dimni bridge was slightly less than that of Budhara and Didi bridges, the reason being that Dimni bridge was located nearer to rail head. It would, therefore, be more proper to compare the costs of Budhara bridge with that of Didi as the lead for materials was the same in both the cases.

Shri K.K. Nambiar (Chairman) in his concluding remarks stated that the Authors had tried to compress in one Paper the designs and constructional details of three prestressed concrete bridges. Many of the speakers spent quite a large proportion of their time discussing hydraulic particulars and coefficients in discharge formulae. He would have liked the commentators to deal with the superstructure portion at greater length as prestressed concrete construction formed the main attraction of these Papers.

In the end, he congratulated the Authors on the excellent Paper they had produced and also thanked all the speakers for offering useful and instructive comments on the Paper.

Discussion on

**Paper No. 218*—"Crystal Pattern Formula for
Integrated Highway Planning in India"**

By

K.C. MITAL

&

**Paper No. 222†—"Regional Concept for Highway
Planning—The Web and Lattice Pattern"**

By

D.G. BHAGAT

Saturday, 30th January, 1960.

• **Shri S.N. Gupta** (Chairman) called upon the Authors to introduce their Papers.

• **Shri K.C. Mital**, Author of Paper No. 218, stated that the Paper presented by him dealt with the process of determination of road mileage and the pattern of layout of road system with a view to achieve greatest accessibility with the minimum road mileage. The Chief Engineers of all States in their meeting held at Nagpur in December 1943 had evolved the Star and Grid Formula for evaluating the mileage of various categories of roads in the country.

This formula was revised in January 1959, and a new formula was evolved to arrive at higher targets of road mileage, but he could hardly find any other change from the original formula except that the constants and co-efficients had been altered in a manner as to give greater road mileage. He did not agree with any of these formulae. He was of the view that the criterion to determine the targets of road mileage for a road system should be based on some scientific approach to the problem.

As all development was gradual and in stages, the growth of the highway traffic was also gradual and in stages. The pattern of our road system, therefore, needed to be designed in such a manner.

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†Published at pages 629 to 665 of Vol. XXIV—Part 4 of the Journal of the Indian Roads Congress, January 1960.

that it could be built up in stages. While drawing up the general pattern of road development, it could hardly be fair to treat different areas in a different manner. There should, in fact, be no distinction between the developed and undeveloped areas. Development of backward and undeveloped areas should not be handicapped for want of proper means of communications though its development may be gradual.

The theory of adopting the number of towns and villages for evaluating road mileage, did not appeal to his mind as a correct approach. He was of the view that a road when constructed provides immediately an approach to the area surrounding it. This could be termed as "Accessibility". As soon as more than one road appeared in an area, the accessibility to places begins to differ from road to road and the closer the road to a place, the greater the utility of that road to the place. As the road mileage increases in an area the accessibility from places shall reduce. This conception led him to the conclusion that there should be some relation between the accessibility to a road and the road mileage to be laid out in any area for its economic development. He had designed a curve, Plate II of the Paper, to indicate this relation. The question as to how to assess the proposed accessibility is also discussed therein in detail.

He had further suggested a pattern for the layout of the road system. He had developed this idea on the basis of the layout of the roads and tracks in the countryside in the State of U.P. which had been developed by people in the normal course of their lives, and had tried to maintain the same pattern. Slight improvement on these layouts adjustable to our problem should be the right answer to the needs of the country. The pattern suggested by him had the peculiarity of being elastic, i.e., the roads adopted for an accessibility of 10 miles would not be wasted if the accessibility was further reduced to one mile and the road system would develop on the same pattern serving the needs of the country in the same manner.

In the unavoidable absence of Shri D. G. Bhagat, the Author of Paper No. 222, Shri J. M. Trehan read his introductory remarks.

In venturing to write this Paper an attempt had been made to focus the attention of the Highway Engineers to the prime necessity of so integrating the road system of this country as to satisfy the growing aspirations of the nation.

For a healthy and vigorous growth of the country, both the urban and rural sectors have to develop in unison. The cities because of their intrinsic economic set up, do develop instinctively, though the manner of their growth is many times along haphazard lines and proper planning has to be considered in that respect, while

in the rural life an element of cohesion and stability has to be brought about to hold the people together. Both the rural and urban sectors have, therefore, not only to develop simultaneously but also to support each other to their mutual advantage.

This suggests a concept of "Regionalization". Economically and socially self-satisfying regional units, for both urban and rural areas, having inter-regional dependence would seem to be a most feasible set-up and roads could play an efficient part in fostering this partnership. An urban region would comprise the city's or town's active core, its 'satellite' suburban neighbourhoods well served by a radial and concentric road layout, and its "tributary" area with a properly planned road grid for easy accessibility. For rural areas, a bold approach is necessary and for ensuring self-sufficiency here, the most rational method would be to group villages together by means of a circulatory road system. For this purpose a region with about an hour's inter-village-accessibility by foot and covering a population of about 5,000 people would seem to be a minimum base. The regional concept can be further expanded progressively giving eventually a 'zonal' unit extending to an area of about 800 sq. miles and covering a population of about 3 lakhs—roughly corresponding to a district. The various component units in this rural rehabilitation pattern and also the zones among themselves would have to be inter-connected by an integrated road fabric.

An endeavour had been made in the Paper to evolve a suitable pattern to suit the above-mentioned objectives and a "Web and Lattice" system suggested. By this pattern, it was hoped, no place would normally be away from a road by more than $1\frac{1}{2}$ miles.

The categorisation of the various types of roads had also been proposed on a rational basis in keeping with their functional characteristics and not on their crust sufficiencies as was generally done. The pattern had been suggested for adoption only in developed and agricultural areas, but in the other semi-developed and non-developed areas, the intensively habited centres would continue to play a pivotal role in forming the hubs of the entire surrounding rural regions.

In the end, the Author emphasised that the proposed approach was mainly symbolic and it would have to be modified very considerably not only in its presentation but also in its effectiveness depending upon the various factors influencing its application in practice. Patterns could be many and varied and also more efficient.

A broad example of the application of this pattern in Agra District given in the Paper was also of a preliminary character mean

only to emphasise the concept of regionalization suggested. For a scientific planning, it would be necessary to carry out proper detailed economic, physical and engineering surveys.

Shri S. Gangopadhyay requested the Author of Paper No. 218 to consider the following points:

1. As every big village or town had its own zone of influence, it was sure that the intensity of influence of such a nucleus point would vary with some function of the distance from the nucleus point. Hence the mileage of road should also be more near the towns and cities and probably lesser mileage would be required at distant places. The crystal pattern as suggested might be suitable, but the accessibility should probably vary from place to place.

2. The road mileage requirements for a country should not be determined considering the country as a whole, but one should probably plan the N.H. and S.H. taking into consideration the different points of importance to be connected and then other roads might be planned in a manner as described. The total requirements should be the sum total of all the requirements. The road mileage requirements for N.H. and S.H. might be considered on individual merits.

3. In the modified formulae, as in Appendix IV, in the revised 1959 formulae the Author had referred to terms like K, M, N, etc., representing numbers of towns with different population intensities. But a small town might have more than a lakh population whereas a big town (big in area of course) might also have the same population with future scope of expansion, however the formula would give same mileage of road for both. Probably, a better formula might be developed if the constants were expressed in sq. miles with different intensities of population, e.g., K might represent area in sq. miles of populated areas, having an intensity of, say, 500 men per sq. mile, and so on.

Shri D. K. Laroia stated that the Authors of both the Papers had tried to find out the most efficient methods of providing road systems with a view to obtain the best accessibility distance for the places located within the grid for a given road mileage. In the absence of detailed theoretical analysis from the Authors, an analysis had been worked out by him (vide Appendix—p. 929), with square grids, equilateral triangular grids, square grids with diagonal roads as considered by the two Authors and hexagonal grid (something similar to a hexagonal wire netting). It was interesting to note that for an accessibility of 'x' miles, the road mileage required is A/x in each case, where A is the area in square miles and 'x' the accessibility in miles.

It was, therefore, immaterial what type of grid was used for providing the road system and that a grid suiting to the site conditions at each nodal point should be adopted.

An accessibility of 'x' could be obtained for each point in any area by providing only parallel roads $2x$ miles apart and in that case the total mileage required for the area 'A' would be $A/2x$, i.e., half of the figure obtained for various grids. Thus a mileage of $A/2x$ was required for providing necessary accessibility and the remaining length of $A/2x$ was meant for providing inter-connections between these parallel roads.

Shri Bhagat mentioned in his Paper that, barring a circle, a square was the most efficient form for obtaining the least distance between two farthest points. This was no doubt true but if the grid consisted of squares with diagonal roads, then the grid would be quite inefficient in that respect as for an accessibility of 'x', the sides of the triangle became $(2x + \sqrt{2}x)$ and $(2\sqrt{2}x + 2x)$ miles long and the distance between B and N became $(2x + \sqrt{2}x + \sqrt{2}x + x)$ or $3x + 2\sqrt{2}x$, i.e., $5.82x$ miles against $4x$ miles for the square grid. The maximum distance in the case of an equilateral triangular grid would be $1\frac{1}{2} \times 2\sqrt{3}x$ or $5.5x$ miles.

• This showed that there was nothing much to choose between various types of grids on theoretical considerations.

The mileage required for providing any accessibility would generally vary between $A/2x$ and A/x , depending upon the type of pattern adopted.

On pages 353 to 355, **Shri Mital** had given the mileage required for various accessibilities on the crystal pattern. It would be seen that for one mile accessibility road mileage required was 664 miles against 500 to 1,000 miles on the above considerations, and for this accessibility the pattern was quite efficient. For all other accessibilities, the mileage needed was very near the upper figure in each case and, therefore, the pattern was not efficient for those accessibilities.

Shri C. L. N. Iyengar, in referring to para 1.4 of **Shri K. C. Mital's** Paper, wanted to know whether the Author's statement that this country's communication system needed at least four-fold development to cope with the growing requirements was based on any rational assumptions or it was an arbitrary statement. He would also like to know whether the observation in para 2.2.4 (a) about the tendency for direct links for villages with different population groups in plains, semi-hilly and hilly regions, was

applicable to the whole of India or it referred only to the highly populated state of Uttar Pradesh?

Also, in para 3.1, the Author had made a reference that even the bullock carts today needed better roads to raise their economic value and that they had to be co-ordinated with motor vehicles. He requested the Author to explain whether he meant to imply that some restrictions were necessary for the movement of motor vehicles on village roads in order to keep them better maintained for exclusive traffic of the bullock carts.

Coming to Paper No. 222 by Shri Bhagat, the speaker expressed his disagreement with the statement made in para 3.4, viz., that a detailed study was not called for at present because of the country's present inadequate road structure and the under-developed transport system. In a sense, that would defeat the very purpose of planning in that it aimed to avoid errors of judgment by studying on a factual basis whatever might be the stage at which the things had to be developed.

The limitation of this pattern of development of the road network of the country had been fully explained by the Authors. Though this method was useful in fixing the mileage targets, still he felt that it was essential that side by side with this plan of road development, a detailed working plan of road development should be made on the basis of factual needs of the various parts of the country and integrated so that the rate at which it could be justifiably achieved could be worked out on the basis of the available resources and also better system of priorities could be evolved than on distribution of resources purely on regional or political considerations.

Shri R.P. Chanda was of the view that it might be unrealistic or impracticable to consider changes in the alignment of roads in cities and big villages where road alignments for the next 20 or 30 years had already been marked out. It would be different in a large unsettled area where developments might begin from scratch and the planner was free to choose his pattern of road system.

Where lands were in intensive use, even small deviations from existing road alignments were much opposed or even resented, not to speak of long or complete deviations in order to adhere to any particular geometric pattern. The land acquisition was a difficult matter in a settled area. Therefore, the existing roads had to be followed reasonably adhering to prescribed standards in a development programme. However, in case of minor or village roads, feeders and links, scope might exist to consider alternatives. But he felt that the number of new road alignments was likely to be small in a state's 5-year programme in the present stage of development.

Shri J.M. Trehan stated that he was unable to give a reply on behalf of the Author who would give his replies later. The remarks which he had read at the time of introducing the Paper were given to him by the Author.

All that he had to say was that Shri Mital contended that the Authors of the 20-year Plan had only changed the coefficients of the old Grid and Star formula. He had been watching the drafting of this Plan and had also been associated with the discussions in the Chief Engineers' meetings. His own impression was that they obviously realised that there was nothing to choose between the three patterns; they had examined all the three patterns in their various meetings, and they thought that the best thing to do was to increase the coefficients because they wanted to give the country more roads and that was the easiest method.

Shri D. G. Bhagat (Author of Paper No. 222) in his replies stated that he was glad to find the lively interest taken in the subject of Highway Planning under discussion. It was actually time that the Highway Engineer applied his mind to the question of planning of road patterns assiduously.

There seemed to be some mix-up of ideas in regard to the accessibility, mileage formula and layout of road pattern. The Nagpur Report as well as the 1961-81 Report had chiefly dwelt on the mileage aspect of the road system rather than on its layout and for the purpose of working out the mileage, population and areas are obviously the ruling consideration in the conditions obtained at present in our country. The area : accessibility equation would no doubt broadly give directly the overall mileage for the area as has been shown in the Paper; but these two factors have to be judiciously correlated within the accessibility target in order to arrive at an efficient and balanced equilibrium in the mileage of various classes of roads forming the road pattern and for that purpose the Star and Grid formulae provide the simplest approach. No layout pattern had been specifically suggested in the 1961-81 Report, and this has obviously to suit the future developmental mosaic of the country in both its urban and rural sectors.

For a progressive overall development, both the urban and rural sectors have to develop individually and support each other mutually. A unified urban centre in its present activated concept, having satellite settlements on its periphery and a tributary zone around it, presents a composite picture of a self-satisfying "region". In the rural areas, the decentralised community administration or the "panchayat" system is now being adopted in an increasing measure in our country and this system was adopted efficiently during the earlier periods of our long history. This could best be

achieved by developing the rural sector also on "regionalisation" basis and the road is the most efficient bond in fostering and strengthening this process. The Web and Lattice System for a road net work would be one pattern which could do this effectively. The Crystal Pattern, according to Shri Bhagat, focusses the "centralisation" aspect of development, and this would probably be a suitable system where attention has to be concentrated on development of larger towns with road system providing links between them and the outlying rural habitation units rather than integrating the rural centres into composite units. This pattern could be very advantageously adopted in semi-developed and underdeveloped regions.

The "population-density" factor suggested by Shri S. Gangopadhyay for working out milage would, in his opinion, make the formulae more complicated. The range in the population density in every big city varied very heavily and if an average density was taken it would automatically reflect the overall population, and it was, therefore, simpler to take the "population" as the working factor.

He was glad Shri D. K. Laroia had, in regard to accessibility, come to the same conclusion as has been arrived at by him. It was true that the area : milage equation was not truly scientific in its formulation but its result would be correct within very close approximation of that obtained with any other mathematical formula.

Shri C.L.N. Iyengar had emphasised the necessity of carrying out detailed study of the various components listed in para 2.2.4 (a). The importance of this is not at all doubted. What he had suggested was that with the low milage of roads and limited technical personnel available today, it would probably be out of proportion to emphasise the investigational aspect particularly as both the capacity and utility ranges of our roads had not reached their optimum. No road of today having some significance was likely to become infructuous tomorrow. The balance between the capacity of arterial roads and service demands of area commanded would be a subject matter for study when both the components reach a saturation stage.

Any rational road development pattern must obviously take full cognisance of the existing road system as had been suggested by Shri R.P. Chanda. The question of geometrics of a road has, however, to be related to its functionary importance. If a road has inter-regional significance, it will obviously have to be designed to suit that purpose and its alignment need not be cramped only because land for its improvement is not likely to become available.

This approach could, however, be made less rigid in case of roads having purely local importance where traffic conditions were not severe. Each case, has, therefore, by and large to be considered on merits.

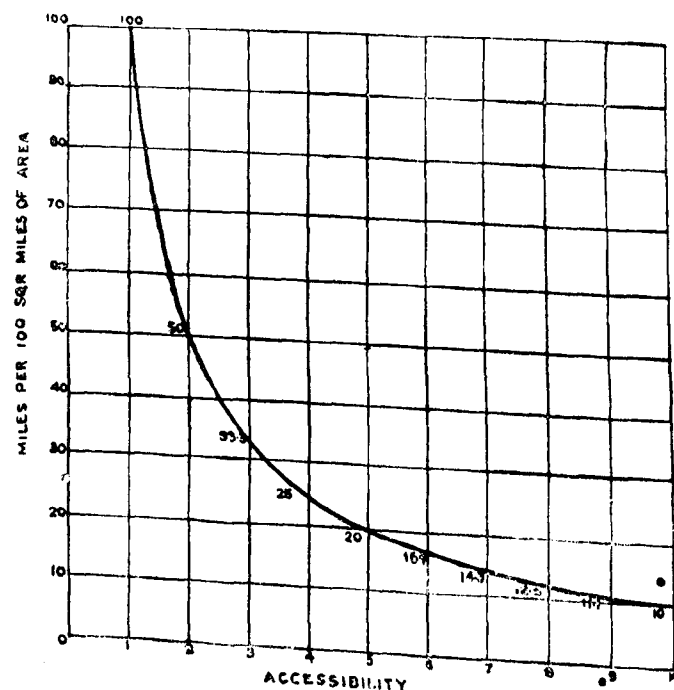
Shri K.C. Mital in his replies stated that the basic concept of the evolution of "Crystal Pattern" formula is on the basis of "Regionalisation". However, Shri D.G. Bhagat, Author of Paper No. 222 on "Regional Concept of Highway Planning", had interpreted it otherwise that it focusses "Centralising" aspect of development. This aspect had been briefly discussed by the Author in para 5.4 of his Paper No. 218.

Shri J.M. Trehan's remark that the Chief Engineers thought it best to increase the values of co-efficients and constants because they wanted to give the country more roads and that it was the easiest method to do so, showed that their approach had not been scientific. The pattern of the layout of road system is of course of primary importance but the process of evaluation of the road milage for different accessibilities had to be indicated on a scientific basis.

Shri Mital did not agree with Shri S. Gangopadhyay that road milage should be more near the towns and lesser at distant places. The traffic near the town is definitely comparatively more but for that it is not the greater length of roads that is required but it is the greater width which is essential. This is true that divergent roads or say convergent roads from and to nucleous centres will be more than at satellites of the towns or small villages. This depends upon the potentiality of the individual places. The accessibilities in different regions can differ in the beginning but when the two regions have developed equally such difference in accessibilities shall vanish. Another point which had been raised by Shri Gangopadhyay is that the road milage requirement for a country should not be determined considering the country as a whole. In this connection his attention was drawn to Chapter 3 of Paper No. 218.

Shri D.K. Laroia had pointed out that the Authors had not indicated any theoretical analysis of their results. He had, therefore, discussed the square grids, equilateral triangle grids, square grids with diagonal roads and hexagonal grids in his comments and had arrived at a conclusion that a road milage required in either case is equivalent to area divided by the accessibility irrespective of the type of grid used to provide the road system. He was of opinion that the milage required for providing any accessibility would generally vary between 500 to 1,000 miles per hundred square miles only of area depending on the type of pattern adopted. His concept is that the relation between the milage and accessibility

would be a straight line. This did not appear to be correct. The curve that draws out the results arrived at by Shri Laroia is given below :



The difference between this curve and the one given by the Author in Paper No. 218, is not much. The considerations ignored by Shri Laroia in his calculations are (1) the direct approach from the nucleus to the sub-centres; (2) the peripheral roads for inter-connections; (3) the consistency in the development of a pattern.

To accommodate these considerations, Shri Laroia might have to consider it necessary to modify his concept and arrive at certain results which might correspond to those of the Author. The curve designed by the Author gives results to satisfy all these considerations. The equation that satisfies this curve had been suggested by Shri H. K. Crowder, Assistant Professor to Dr. S. W. Mc Cuskey, Head of the Department of Mathematics, Case Institute of Technology, University Circle, Cleveland 6, Ohio, as below :

$$Y' = 8 + \frac{729}{8} + \left(\frac{2}{3}\right)^X = 8 + \frac{729}{8} e^{X \log 2/3}$$

Here the logarithm in the last form is to the base 'e' and will yield results that satisfy the curve. Assuming X for accessibility and Y for milage, values work out as below :

X	Y	Rounded figure of Y' worked out by Author
0	99 $\frac{1}{8}$	
1	68 $\frac{3}{4}$	68.7
2	48 $\frac{1}{2}$	48.5
3	35	35.0
4	26	26.0
5	20	20.0
6	16	16.0
7	13 $\frac{1}{3}$	13.0
8	11 $\frac{5}{9}$	11.0
9	10 $\frac{1}{2}$	10.0
10	9 $\frac{4}{8}$	

The extrapolation to 0 is of course meaningless, but the value for X = 10 compares quite favourably with the values worked out by the Author.

He was grateful to Shri Crowder for his assistance and advice. The area of the grid had been assessed by the Author to be enclosed by a side of 42.36 miles and the road system was designed along radial and circumstantial alignments. No place in this pattern would be more distant than the desired accessibility and have as direct approach in all directions as possible within reasonable limits which was self evident.

Shri R. P. Chanda had raised the question of alignment of roads and acquisition of land therefor. This was though beyond the scope of the Paper, it might be usefully said that roads required land for construction and if a minimum of 1 per cent of total area could not be spared for the road system, the movement would become restricted. It was for this reason that more than 8 roads had not been advocated by the Author to spread out from a nucleus centre. It was by providing a peripheral road outside the town that more roads were made to commence from there.

Shri S. N. Gupta (Chairman) while thanking the Authors for their interesting Papers, stated that both of them had suggested the targets of the fixation of road milage in developed, semi-developed and undeveloped areas and proposed different patterns to achieve them.

Certain objections of Shri Mital to the targets of milage adopted in the 2nd 20-year Road Development Plan, had already been replied to by Shri Trehan. It was natural to allot more milage to the industrially developed and populous areas and less milage to rural areas. In introducing his Paper, Shri Mital had said that the pattern should be the same in developed and under-developed areas. It was natural that there should be greater milage of roads in more populous areas and comparatively lesser milage in the thickly populated areas. The pattern would, therefore, vary from area to area. After all the road system is meant to serve the people, and where there are more people, there would be more road milage to cater to their needs and where there is less population, there should be less milage of roads.

APPENDIX

Details of road milage required for a given area 'A' to obtain an accessibility of 'X' miles

In each case an area enclosed by dotted lines as shown in the diagrams was considered. The area had been chosen in such a way that the same area could be added in various directions to obtain the required grid of any dimensions.

1. Square grid:

Consider the area enclosed by dotted lines.

$$AB = 2x \text{ accessibility} = 2x$$

Area enclosed by dotted lines

$$= 4x \times 4x = 16x^2$$

$$\text{Length of roads within this area} = 16x$$

Thus milage required for an area 'A'

$$= \frac{16x}{16x^2} \times A = \frac{A}{X}$$

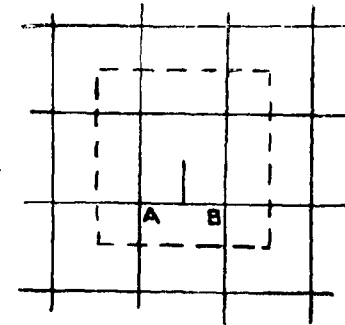


Fig. (i)

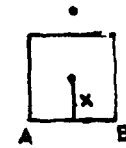


Fig. (ii)

2. Equilateral triangular grid:

Consider the area enclosed by the dotted rhombus.

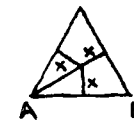


FIG.(ii)

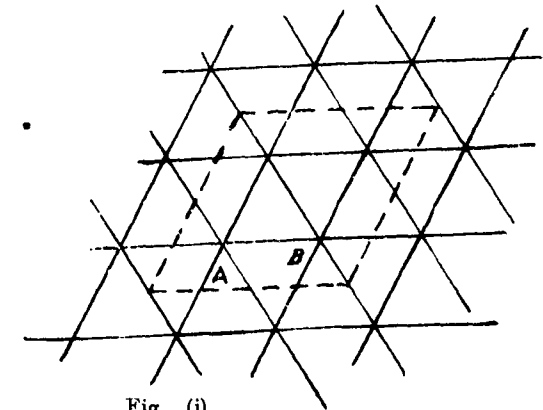


Fig. (i)

For an accessibility 'X' the side of the triangle AB

$$= 2\sqrt{3}x$$

$$\begin{aligned}\text{Area of the dotted rhombus} &= 4\sqrt{3}x \times 4\sqrt{3}x \times \sqrt{\frac{3}{2}} \\ &= 24\sqrt{3}x^2\end{aligned}$$

$$\text{Length of roads in this rhombus} = \frac{24}{2} \times 2\sqrt{3}x = 24\sqrt{3}x$$

$$\text{Length of roads required for an area } A = \frac{24\sqrt{3}x}{24\sqrt{3}x^2} \times A = \frac{A}{X}$$

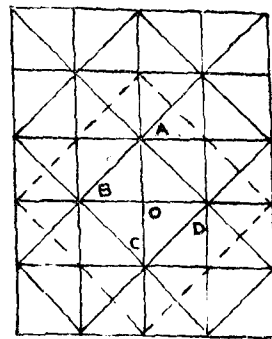


FIG. (i)

3. Grid consisting of diagonal roads added to a square grid:

The grid consists of repetitions of areas enclosed by ABCD. Consider an area enclosed by dotted lines for working out mileage of roads required

$$\begin{aligned}\text{Accessibility} &= PQ = X \\ &= PR = PN\end{aligned}$$

$$OQ = X + X\sqrt{2}$$

$$AB = 2X(1 + \sqrt{2})$$

$$\text{Dotted side in the diagram} = \sqrt{2}(1 + \sqrt{2})x$$

Dotted side in the diagram

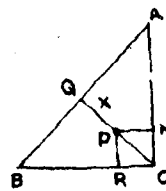


FIG. (ii)

at figure (i).

$$= 2AB = 4x(1 + \sqrt{2})$$

$$\text{Area enclosed by dotted lines} = 16x^2(1 + \sqrt{2})^2$$

$$\text{Length of roads needed for this area} = 8AB + 8BD$$

$$= 16x(1 + \sqrt{2}) \cdot 16\sqrt{2}x(1 + \sqrt{2})$$

$$= 16x(1 + \sqrt{2})(1 + \sqrt{2})$$

Length of roads required for an area A

$$= \frac{16x(1 + \sqrt{2})^2}{16x^2(1 + \sqrt{2})^2} \times A = \frac{A}{X}$$

4. Hexagonal grid resembling a wire netting:

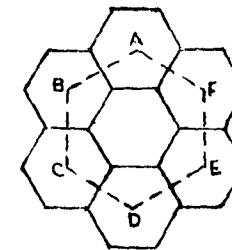


FIG. (i)



FIG. (ii)

Consider the dotted hexagon.

If KP is the side of the hexagon and x the accessibility, then

$$KP = OK = \frac{x^2}{\sqrt{3}}$$

$$\text{Side of dotted hexagon} = 2x$$

$$\begin{aligned}\text{Area enclosed by dotted hexagon} &= 6 \cdot 2x \cdot \sqrt{3}x \cdot \frac{1}{2} \\ &= 6\sqrt{3}x^2\end{aligned}$$

$$\text{Length of roads} = 9KP = 6\sqrt{3}x$$

As such length of roads required for an area A

$$= \frac{6\sqrt{3}x}{6\sqrt{3}x^2} \times A = \frac{A}{X}$$

Discussion on Paper No. 219*

“Scientific Design and Laying of a Bituminous Carpet on a National Highway”

By

S. R. MEHRA, C. G. SWAMINATHAN & V. R. VAISH

Sunday, January 31, 1960.

Shri N. Durrani (Chairman) called upon Shri S. R. Mehra to introduce the Paper for Discussion.

Shri S. R. Mehra (co-Author) in his introductory remarks stated that two main points were kept in mind while designing the project. The first was that before putting down an expensive machine laid carpet, it was necessary that the base should be made so strong that it would not deform under traffic and defeat the object of laying a smooth-surface carpet. This was done by adding the required thickness to the existing base.

Secondly, the intention was to see whether by laboratory designing it was possible to produce a stronger and better carpet than the open graded premix or the crete specification already in use which needed periodical seal coat.

Shri Mehra said, the salient point brought out in the Paper was that it should normally be possible to provide a properly designed carpet at no extra cost than either the pre-coated chips with a certain amount of sand or sanded concrete both of which would require a seal coat at intervals of 2 or 3 years depending on the amount of traffic. A properly designed carpet will not require such a seal coat and, therefore, in the ultimate analysis it might even be cheaper to lay a properly designed carpet than to lay the other types of carpets which have been in vogue so far.

Shri Mehra also stated that traffic at high temperature was likely to permit flow of bitumen into the voids and, therefore, it might be possible to do with a higher percentage of voids under these conditions in this country than was followed in colder countries hoping that under traffic the voids would come down to the required 3 or 4 per cent without much difficulty. The assumption seemed to be supported by whatever little evidence was available.

*Published at pages 475-516 of Volume XXIV—Part 3 of the Journal of the Indian Roads Congress, December 1959.

Shri D. C. Chaturvedi stated that the basis for laying a bituminous carpet of 1 to 1½ in. (with a minimum thickness of 1 in.) had not been mentioned in the Paper. He was, therefore, interested to know whether the thickness had been adopted arbitrarily or on consideration of traffic intensity.

In Asphalt Institute Manual Series No. 1, thickness of asphalt pavement surface has been suggested from 1 in. to 4 in. depending upon the type and intensity of traffic. For heavy traffic, 3 in. thickness of carpet is suggested and minimum thickness recommended is 2 in. for light traffic.

Significance of abrasion test results given in Table 2 might be explained particularly with reference to standard method of test adopted for bituminous mixture for determining the percentage. The results given in the Paper indicate that it was not necessary to adhere strictly to the percentage of voids as specified in Marshalls method. It was, however, possible that due to higher voids, the compaction by traffic might not be uniform and which might give rise to unevenness on the surface and higher values of index by Bump Integrator. It would have been interesting had the index value of Bump Integrator been determined after the premix surface had been under traffic for some time to see if compaction by traffic had resulted in a uniform or uneven surface.

• Table 17 suggested reduction in strength of bitumen mixture due to lower binder content than stipulated amount. It might, however, take sometime before this lower quantity of binder was known as extraction of binder takes time and it might be too late to adjust the binder content in the mixture which had already come out of plant and laid on the void. Measures adopted in such cases might be explained.

On page 509, para 7.7, it is mentioned that where the base is formed by manual labour without accurate controls and when the tolerance in the base is more than 3/8 in., the quantities required for the construction might have to be worked out for a higher thickness.

In U.P., water-bound macadam surface does not involve use of costly materials and if the method of construction is strictly followed it gives a uniform and level surface which does not require extra quantities of premix material.

Shri D. K. Laroia: According to Table 2 on page 478, the void percentage of a crete carpet is given as 9.06 while in para 2.2 it is mentioned to be 15 per cent. Marshall Stability for the crete carpet is mentioned as 9.65 which is perhaps 965. These might be clarified. As the overall costs of the crete and design carpets were approxi-

mately equal, the design carpet was an improvement over the crete carpet.

Para 2.3 on page 478 and Table 3 on page 479, show that the surface of the open graded premix carpet even after applying seal coat was very rough compared to the design carpet. It, however, appears that the open carpet was laid by hand and not by a paver. If the open carpet had also been laid with a paver, its unevenness would have considerably decreased. The seal coat decreases the number of bumps from 250 to 160 and as such an open graded carpet laid with a paver and provided with a seal coat is likely to give a surface that might be smoother than the design carpet.

While working out costs in Appendix II for the design carpet, quantities of aggregate required have been taken as midway between measurements of loose and compacted states. From the market all materials are received stacked loose. Quantities for open graded and crete carpets are taken as such. The difference in quantities works out to 6 per cent. As such, a carpet 6 per cent thinner in the case of design mix would be obtained. The cost for the design carpet—1 in. thick, would, therefore, be 6 per cent higher, i.e., approximately Rs 25.50 per 100 sq. ft. On the other hand, the open graded carpet with the given quantities would be 1.04 in. thick excluding the seal coat assuming that bitumen only filled up voids. The cost of an open graded carpet and a seal coat would be approximately Rs 23 per 100 sq. ft.

Comparing in another way, the quantity of aggregates was 1,300 cu. ft. in open graded carpet against 1,150 cu. ft. for the design mix. As such, the open graded carpet would be much thicker than the design carpet, firstly because of larger quantities of aggregates used and secondly because of the higher percentage of voids.

The cost of an open graded carpet using mixing plant, paver and bulk bitumen being about Rs 23 including a seal coat, against Rs 25.50 for the design carpet, the open graded carpet would, therefore, continue to hold field where traffic was light as the scientific know-how and equipment available could then be utilised for other more pressing demands.

Coming to Table 10, Shri Laroia said that there appeared to be some inconsistency in the results of sieve analysis. At the hot bin the percentage of pieces above $\frac{1}{2}$ in. was 14.1 while their percentage at pugmill was 18.6. Even assuming that there was no breakdown of sizes between these two stages, the percentage can be 18.6 at the pugmill only if $14.1/18.6 \times 100$ or 75.8 per cent of the total material was left and the remaining 24.2 per cent was waste which is very high.

He had come across Sheet Asphalt Carpets in Holland where traffic was not sufficient to keep them in good condition. That

might not, however, apply to this country where climatic conditions were different. The Authors might be able to throw light on the fact whether dense bituminous carpets would also need necessary heavy traffic to keep them in reasonable conditions and if, so, whether the same had been assumed.

Pneumatic traffic has a kneading action while moving over premix carpets. Oils discharged by motor vehicles get absorbed to some extent into the carpets due to this action which keeps the carpets pliable and checks them from getting brittle. If the pneumatic-tyred traffic is low this advantage gets lost, thus making the carpet more liable to brittleness in shorter periods. The grade of bitumen used was 60/70 against the normal 80/100 bitumen and as such the quantities of volatile oils would be small. The carpet might, therefore, not have as long a life as might have been possible with 80/100 bitumen.

Shri A. A. D. O. P. Saparamado (Ceylon): The Authors have assumed that a higher void content of more than 5 per cent might be advantageous, but this could not be justified. Higher voidage might affect the durability of the mix as bitumen might get oxidised due to the circulation of air and it might also deteriorate due to water vapour, with the result that it might not be possible to get a durable carpet, though probably obtaining the necessary stability. The voids of 3 to 5 per cent as given by Marshall's method have been obtained by a series of experiments carried out by the Corps of Engineers, U.S.A., under varying conditions and he was of the opinion that until it was possible to get our own criteria for void content by actual tests carried out, it would be better to keep to the void content of 3 to 5 per cent given in Marshall's method.

On page 497, the Authors had justified the higher percentage of voids by quoting reference to the percentage of voids given by the 'Asphalt Institute' method. He did not agree to this because having used a certain test method, it was not correct to use the criteria from another test method. The difference in void criteria given by the 'Asphalt Institute' method (which he thought refers to the Triaxial test method) and the Marshall test was due to the difference in method of compaction. In Triaxial method, the static compaction was used with a double plunger whereas in the Marshall's system the falling hammer method was used, with the result that the criteria in percentage of voids differed as the tests were correlated with field performance. Moreover, Marshall method uses apparent specific gravity and Triaxial uses bulk specific gravity for determining voids.

On page 480, the Authors had stressed on getting the maximum density in the aggregate mass. To get a suitable mix, the speaker

did not agree that it would be possible to design the mix to the maximum density as in the case of mechanical stabilization of soils.

Referring to Table 12, the Authors in the initial stage have used 80/100 penetration bitumen obtaining a stability value of 1,286. In Marshall's method of design, the criteria for stability is 1,000 lb for heavy traffic. This stability of 1,286 is much higher than the requirements of the Marshall's method, but still the Authors had tried to gain higher stability by using higher penetration grades of bitumen. There is no harm in aiming at higher stability, but still it is not desirable to aim at higher stability at the expense of durability. Further, the Authors have recommended the use of 60/70 penetration bitumen in the field. In a place like Delhi, where temperatures go down very low, the speaker was of the view that 80/100 bitumen would be better in the long run than 60/70.

Shri N. H. Taylor: It is stated in para 1.3, page 477 of the Paper, that since a dense carpet would mean a heavy expenditure, a directive was given to design a mixture which would not be open graded but as dense as possible using the locally available aggregate and keeping in view the limitations of the plant. It must, therefore, be assumed that the mixture to be designed would not be dense but something between a dense mix and an open graded mix. Nevertheless, the specifications quoted and "more or less" followed were those for dense mixtures and the resulting composition was referred to as a "designed mixture".

In Table 2, page 478, the properties of various mixtures are compared and one might gather from the results given that an open graded premix had no stability and that a designed mixture had 133 times the stability of a "stone-sand crete". Again, from Table 3, one might draw the conclusion, that designing a carpet resulted in a more even running surface, although the credit must go to the mechanical paver and finishing machine which could also have laid the "premix" or, with minor modifications, the grouted macadam and the water-bound macadam or even the cement concrete.

He was surprised to learn that a designed mixture, an open graded carpet with seal coat and a crete type mixture, all cost exactly the same when mechanical plant was used. No mention was made of the cost of the mixing and laying equipment and of the tipping lorries required to take the mixed material from the mixing plant to the road but Rs 3 lakhs should cover this. He felt that this outlay must have been ignored when the cost was estimated.

Table 18, page 505, shows this to be a material having voids ranging from 12.0 to 18.0 per cent. He did not think that the limitations of the plant or lack of suitable local materials could be blamed for this failure to produce a mixture complying with foreign specifications.

He felt that the first mistake was in taking graded material from the crushers and then attempting to remix the three grades to give a grading almost identical with that coming from the crushers. The term "crusher run" had mistakenly been applied to the crusher dust. "Crusher run" is the whole material coming from the crusher or, it would appear in this case, from the granulator. This crusher run, if passed through a 7/8 in. screen, could have been combined at the bulk head of the cold material feeder with sand or crusher dust to give a grading satisfying any given specification covering the coarser fine aggregate. The Authors list the shortcomings of the mixing plant and include the fact that there was no fines feeder unit. If there was no fines feeder, it was impossible to prepare a dense asphalt mixture and this project should never have been commenced until a fines feeder had been fitted.

Because of the shortage of filler or material passing 200 mesh, the mixture as designed failed to comply with any known specification in respect of voids. This means that the water absorption must have been extremely high, but no absorption results are quoted. As water is a far more destructive agent than traffic, it is well that this material had been laid in a district where rainfall is low. It is stated that the information in Table 18 was obtained to see whether the mix was compacted or not. At location 3, the density was 2.00 and the voids were 18 per cent while Table 13, page 500, shows that average densities after rolling were even as low as 1.98 which specific gravity would indicate voids of 19 per cent. The Authors have not commented on the field density results obtained and it would be interesting to learn whether the results were accepted as satisfactory.

Shri Satish Prasad: At present with the heavy mixed traffic, he was of the opinion that the strength of the water-bound macadam just $1\frac{1}{2}$ in. below the carpet was not adequate to stand the traffic load which was not likely to reduce very much by the top pavement. Further, he would request the Authors to explain if it was a dense pavement why the water-bound macadam was not constructed accordingly and the plastic materials kept to the minimum.

Regarding the tack coat referred to in para 7.4, Shri Satish Prasad felt that it would have been better to lay either a fluid R.C. prime coat over the relatively dusty water-bound macadam 24 hours in advance or no tack coat should have been given at all. The effect of unevenly applying hot bitumen tack could only introduce a risk of patching up the rough thin carpet.

Shri P. L. De stated that in Appendix II where analysis for designed carpet was given, the rate of bitumen had been taken as Rs 286 per ton whereas in the other two cases (Appendices III and IV) the rate of bitumen was taken as Rs 380 per ton. This discrepancy needs clarification.

In Appendices III and IV, an item, viz., "screening" has been included costing as high as Rs 136 for 10,000 sq. ft. of surface but he did not find this item in the designed carpet. He wondered why screening was not necessary for the designed carpet.

Now coming to another point, viz., the Bump Integrator data as given in Table 3 (page 479), he found the 'Index' for designed carpet less than that for concrete road. He would enquire whether the concrete road on which the measurement was done was also a surface constructed with that much of controlled perfection as the designed carpet surface. The present designed carpet surface was after all laid with extreme care and control and hence the index would naturally be less than that of other road surfaces unless they were also laid with the same care and control.

In Appendices II, III and IV, the speaker found that the total quantity of aggregate for 10,000 sq. ft. of surface for designed carpet was slightly less than that for the other carpets whereas according to Table 2, the void percentage for designed carpet was much less than the others. Now the latter condition, viz., "percentage voids" indicates that more material was present per unit volume of designed carpet. Why, then, in the designed carpet while making the cost analysis, quantities of the aggregates were taken less if the thickness of the carpet was assumed to be the same in all the three cases?

Shri M. B. Jayawant stated that the general gradation of the aggregate from hot-bin analysis given shows that there was no mineral filler present in the mix and a rough gradation would be 60 per cent retained on No. 8 sieve and 40 per cent passing No. 8 sieve. Such a gradation of aggregate was mainly suitable for a base course or a binder course by any method of design. It might be that the Authors had selected the Asphalt Institute's mix types but even according to the Asphalt Institute's classification, this mix was suitable only for a base or the binder course. While designing a dense graded asphaltic concrete one has to keep in view the fundamental objects. One of which is stability. Though this is an important consideration, but it was not necessary to give it the most prominent consideration as in this particular mix. Maximum stability is not always the desirable stability. The mix which is designed for a particular traffic should have a certain minimum Marshall stability of, say, 750 for a very heavy traffic with 75 blows compaction. But to achieve 1,800 or 1,400 stability at the cost of some other properties was not at all desirable.

Another point of importance is to combine aggregates for a dense graded mix and to find out the voids in the mineral aggregates when combining them for a dense graded mix. As long as the voids in the mineral aggregates are too much it is not possible to get 4 to 5 per cent air-voids by any econo-

mical amount of asphalt content in it. Once the specific gravity of the aggregate and the absorption of asphalt by the aggregate and also the specific gravity of the asphalt are known, then if the corrected density of the mix is plotted against the corrected percentage of asphalt content, all the other properties are determined at the same time; such as air-voids in the final mix, voids in the mineral aggregates and the voids filled with asphalt. These three properties are immediately determined by just plotting these particular curves for given specific gravity of aggregates and asphalts. The speaker, by drawing up a sketch, showed that in order to achieve air-voids of 5 per cent in the final mix, very large amount of asphalt was needed, and which would give very low stability in the mix. So, to presume that 5 per cent air-voids would be obtained after compaction by traffic, was not correct. There is no doubt this gradation of the mix is suitable for an asphalt mix design, but a dense graded carpet is not suitable for the wearing surface; it is more suitable for a base or a binder course.

• The second point was about the rolling. He did not know how with three passes a certain density could be obtained and with the increase in the number of passes of roller, the density would drop down. There is a difference of 0.01 in the density with 3 and 4 passes of roller, as given in Table 13. Even one small stone from the aggregate would make the difference of 0.01, that might be the average of various numbers of readings. But the general criteria for checking the adequacy of rolling should be the comparison of field density with the theoretical maximum density. The ideal criterion is to have 92 per cent of theoretical maximum density after rolling, and that is the case when the monsoon is rather away, say, sometime in February or so. But if the carpet is laid near the monsoon, higher density right after compaction should be aimed at. The amount of rolling specified in the Paper gives only 85 per cent density of the theoretical maximum and this was not enough.

It would be necessary also to find out in the laboratory while designing the mix as to how much improvement could be obtained in the mix by adding a little amount of filler and a little amount of sand. These figures are missing from the Paper. The Authors might have found it extremely costly to put additional filler, but at least the advantages that could be achieved by adding it, should have been given for purposes of cost comparison.

This mix brings out the necessity of including the criteria for "voids in mineral aggregates" in the design of dense graded mixes. Normally, peak of density curve is considered maximum of stability curve, air-voids and flow index limits; but in addition the requirement for the minimum percentage of air-voids in mineral aggregates must be considered. Normally, 15 per cent minimum voids in aggregates would give desirable results.

Considering the information furnished by the Authors that, after 6 months of traffic, the voids in the field sample dropped from 14.19 per cent as given in Table 18 to about 5 per cent, it would be necessary to investigate the other properties of the field sample as well; such as asphalt content, stability, grading. The resultant crushing of flaky aggregates, excess asphalt from tack coat or some other factors might have given less voids during the test, but the stability or the presence of broken chips leading to uncoated particles susceptible to ravelling under water needs to be investigated.

Shri R. C. Kalia stated that the Authors had not clarified the moisture conditions of the subgrade at which C.B.R. tests were carried out. Also, whether it was in situ test or laboratory test and what were the average values of C.B.R. obtained—the word bed was also not clear.

He would request the Authors to clarify whether all the 3 mixtures in Table 2 were laid with the help of a paver and mixing plant. The results would be greatly affected if procedure and method of mixing and laying was not the same. Comparison would be correct if the same method was used.

In Table 3, items 6 and 8, the index values of 107 and 119 were given. He felt that the designed carpet gave lower values since it was laid with a paver whereas the concrete was laid manually.

The Authors had tried to justify the high percentage of voids in the carpet (by saying that there is room in the carpet) to get compacted further without distortion. He thought compaction under traffic would make the surface wavy since tendency for the traffic is to move in the centre. The word 'without distortion' is thus not correctly mentioned.

Table 3 did not seem to be correct. It should be Table 6 or 9.

He was of the view that bleeding occurred when percentage voids filled by binder was equal to or less than 100 per cent of voids; otherwise it does not occur and if the voids are kept 5 to 10 per cent, chances of bleeding are very less.

Use of 60-70 penetration bitumen was not possible in winter when the temperature of atmosphere is lower than 250°F and the hot mixture will quickly cool down to the same temperature.

Shri P. D. Shivadasani stated that the void content in the specification adopted by the Authors was very high but he understood that after a few months of the laying of the carpet, the voids had come down to 3½ to 4 per cent. Shri Mehra in his introduction said that when adopting these specifications, Indian conditions including climate which differed from conditions abroad already were taken into account. While climate might be one consideration,

no consideration seemed to have been given to traffic conditions which differ so much from other countries. In western countries, most of the traffic was pneumatic-tyred and most of the action on the road was of one particular type. Traffic on our roads was very much mixed, with steel-tyred bullock carts outnumbering pneumatic-tyred vehicles. Because of this, he felt that the compaction actually resulting on our roads was different from that obtained in western countries where the known laboratory procedures had been correlated with their own traffic conditions. He had mentioned this because according to remarks made by Shri Taylor and Shri Jayawant, this road should not last for long. But he understood that the condition of this road was better—the void content had gone down to 3½ to 4 per cent! He believed that our traffic has a lot to do with it and not so much the climate because similar type of climate was found elsewhere also.

If for the sake of economy or even for the sake of improving on the existing specifications more stretches of roads of this nature was laid, he would suggest that in their next experiments of this nature, the Authors should try to determine the action of our traffic on these roads. He would also suggest segregation of a portion of road only for pneumatic-tyred traffic, a portion for iron-tyred traffic and a portion for mixed traffic to find out what kind of action each type of traffic would have on the design mix.

Shri K. P. Nair stated that in foreign countries where bituminous or asphaltic concrete was laid in huge quantities every year, suitable limits were specified not only for the graded mixture, but also for the constituents, viz., the coarse aggregate, the fine aggregate and the filler, e.g., the specifications of the various Highway organisations of the United States of America. Hence it was possible to give very narrow limits for the mixture gradation and the design also was easier. But, in our country, since only a beginning had been made in this line, there were no specifications for the aggregate materials or the final mixture. As such, he suggested that such specifications depending on the aggregates available and on economy might also be laid in our country for suitable designs of bituminous concrete mixtures which would be made good use of in greater quantities in the years to come.

In this connection, he would like to refer to a new method of approach suggested by him called "the gradation modulus method" and given in I.R.C. Road Research Bulletin No. 6, 1959, for a quicker and economic design of suitable mixtures giving wider limits for the final mixture, at the same time satisfying the requirements of stability, voids, etc.

Again, in order that the engineering staff engaged in the production and laying of bituminous concrete might appreciate the

importance of the quality of materials used, their gradation, design of mixtures and the laboratory tests for the quality control as well as for modern techniques of laying, they should also be given practical training in the subject.

Being in charge of the field laboratory for the quality control of the mixture at the continuous plant whose limitations had been stated in the Paper, he would say that the main difficulty faced by them was in the control of the gradation of the coarse aggregates, the $\frac{1}{2}$ in. and $\frac{3}{8}$ in. materials mixed manually in the proportion of 2 : 3 by volume and fed through one of the two chutes at the cold bucket elevators. But if three separate chutes could be provided to feed the three materials, the $\frac{1}{2}$ in., $\frac{3}{8}$ in. and crusher run grit, in the desired proportions, the control of the gradation of the mixture would have been more easier in the absence of a gradation control unit for the plant.

Considering the importance of bituminous concrete for surfacing of our national highways and roads in and around major cities and industrial townships in the years to come, especially when more bitumen might be available from the new oil finds in the country, it was time that the Central and State P.W.D. tried to collect different types of aggregate materials available uniformly at the crushing plants and to design on a scientific basis suitable mixtures either with the facilities at their disposal or through the Central and State Road Research Laboratories.

But before that, a hot mix plant together with paver, finisher, and tipper set should be acquired. For the mixing plant, a gradation control unit was essential for the proper quality control and there were hot mix plants both of the continuous and batch types each with its own merits and demerits. The Central Road Research Institute could make necessary suggestions in this direction.

Shri I. P. Gupta stated that no details as to how the Authors had arrived at the break up of the total required thickness of crust of 15 in. $\times$ 9 in. of soling and 6 in. of water-bound macadam had been given. It would have also been more useful if the details of the tests on the soils and their results carried out on the subgrade, etc., had been incorporated.

In Table 4, the various methods for design of bituminous paving mixture specify a minimum percentage void of 3 per cent to a maximum of 10 per cent whereas the Authors had recommended voids more than 5 per cent on page 482 so that there might not be any bleeding due to subsequent compaction of the carpet by traffic. He was of the opinion that a more compact carpet was definitely better and efforts should be made to achieve the minimum prescribed percentage of voids. No appreciable bleeding should take place if the quantity of binder used was just sufficient.

In Table 16, the voids in the laid carpet are given as 7.8 per cent against 8.8 per cent obtained in the laboratory and given in Table 11, thereby indicating that the laid carpet was more dense than the designed one but the values given in Marshall's test are low in the former case instead of higher. This discrepancy needed clarification.

Shri R. S. Shukla stated that the gradation control of mixture design is entirely dependent on the gradation of coarse mixture, i.e., $\frac{1}{2}$ in. and $\frac{3}{8}$ in. aggregate material in the proportion of 2 : 3 by volume. During his quality control work at the field laboratory he could see that 2 : 3 mixture especially had too much of fluctuations in the gradation which could have been avoided if there were arrangements to feed the three different materials through separate chutes.

At times there was partial segregation of coarse mixture at the stock piles at the coarse feed and (the coarser materials rolling down the heap) which had to be added at the feed end for the proper control.

Since the mixing plant is a continuous type and the production rate and rate of laying were not properly synchronized due to various reasons already mentioned in the Paper, very often the plant had to be stopped. As a result of this when it was restarted a few cubic feet of mixture coming out of pugmill were not coated properly because the hot aggregates left in the hot bin got partially cooled, bitumen also got cold. There were also occasions when pipe lines were to be heated as they got choked up.

The void content given in Table 18 was about 10-13 per cent while the design void content was only about 7 per cent. An examination of the gradation of the mixture laid on those days showed that they were on the coarser side (due only to the inadequacy of the mixing of $\frac{1}{2}$ in. and $\frac{3}{8}$ in. in the required proportion) and the bitumen content was also on the lower side. The cores taken from the same place after a period of four or five months (consolidation by traffic only) showed that the void content fell down to 2 or 3 per cent, so it was clear that even though void content soon after laying was on the high side than the design, the extra void was just enough to accommodate the expansion of the bitumen.

Usually the continuous mix plants are provided with bin indicators to indicate to the operators to stop the plant when the level goes below a certain fixed up minimum. This arrangement was not provided for the plant used except that it had an indicator at the hot bin to show whether it was full or not.

Shri B. V. Patankar stated that the carpet could be made out of good sand—of course conforming to the usual standards—sand

being the cheapest material available in plenty almost everywhere. Although its qualities vary slightly from place to place, sieved sand would be the best material for the carpet. Also, it was better to conduct some experiments on the suitability of sea sand for the manufacture of the carpet since, its salinity might not have much adverse effect on an inert substance like bitumen. If found suitable, all the coastal towns and villages could be served by excellent carpet-roads made out of bitumen and sea sand.

Vertical tamping would not be satisfactory, since with all care corrugations appear on the carpet even after rolling. Also, when the roller rolls over the carpet, "ripples" or corrugations occur on the carpet. This could be observed on a 'pronounced' scale when the macadam road was being rolled. When a carpet is laid on such a surface, the carpet assumes the profile of these corrugations. Perhaps, the only manner in which the corrugations could be removed, before the carpet is laid, is by means of a horizontal disc machine on the model of a polishing machine.

Shri H. H. Campbell: Various speakers have said that they felt 80/100 penetration bitumen ought to have been specified. He, however, was of the view that in this particular case the selection of 60/70 penetration bitumen was justified, because for such a thin carpet a harder grade is desirable. It might even have been better to come down to 30/40 penetration bitumen as used by Madras Corporation.

Secondly, he did not agree with the idea that the void content had since come down. That he thought, and he was sure Shri Taylor would bear him out in this, was unlikely unless the aggregate had been crushed which would mean the carpet was breaking up and of this there was no evidence. The void content if designed between 5 and 10 could hardly "come down" to $3\frac{1}{2}$ to 4 or near about.

He was fortunate enough to see the work in progress and he felt that there was need for better programming, and greater co-ordination was necessary between the mixing and laying control on this particular section of the road in order to take full advantage of the mechanised methods of road construction.

Shri Fateh Chand*: One important point he would like to stress, in connection with this Paper, was that there were such great variations in climatic and temperature conditions, qualities, and types of coarse and fine aggregates easily and cheaply available, and availability of equipment and labour, in different localities, that an experiment, design or proportion selected for one place, might not be good enough or might even be a failure in another place.

* This comment was received in writing.

As a rule, practice in vogue in each locality, should be the guiding factor, subject to such modifications only as laboratory tests and field work, carried out in such localities, clearly suggested.

As regards precautions in heating bitumen, the range of maximum and minimum temperature, suggested by the manufacturers, should be strictly followed. Also, a proper gradation of materials should be aimed at to give minimum void contents. The aggregates should be measured by volume and bitumen by weight.

Shri S. R. Mehra in his replies stated that there was only one point which he was going briefly to refer to, and that was the objection raised by **Shri N. H. Taylor**.

He felt that a certain amount of misunderstanding had perhaps cropped up as a result of the title of the Paper. As he had explained in his opening remarks, the idea was to make an improvement on the existing practice in two directions: (1) that before a machine laid carpet is put on a flexible pavement, it should be ensured that the flexible pavement has got adequate thickness and that it is not going to wave under traffic loads, thereby defeating the object of a machine laid carpet which is intended to provide a smooth riding surface. (2) The idea was to see whether in the context of availability of materials as they are, it was possible to improve on the engineering properties of carpets as they were being laid already without exceeding very much in cost. The cost question is one which could not be neglected in this country. He remembered a couple of years ago Shri Taylor objected violently to our not using graded stone in water-bound macadam. The answer which he gave then was simple enough, that our stone was broken by hand labour and not by crushers as is done in the western countries, and that was the reason why it was not possible to use graded stone in water-bound macadam and not that there was any ignorance about the superiority of graded stone. In the same way, though it is very desirable to design dense carpets in the conventional method and lay them down, it is too expensive for any wide usage. Ways and means have to be found for simpler and cheaper methods of laying durable carpets which would be better than precoated chips used so far. To that extent, he felt, as results would show, there has probably been some advancement.

With these few words, he would leave it to his co-Authors to reply to any other points of detail that might have arisen.

Shri C. G. Swaminathan: If a carpet was designed just as per practices of the Asphalt Institute there would not have been any necessity of presenting this Paper at all. It was the unconventional approach that prompted the Authors to present this Paper.

The requirements of a bituminous carpet are that it should be strong and durable. There are established gradation limits and stipulations as regards void content and void fill with bitumen, etc., to help in the design of a carpet which would satisfy the final necessities as regards strength and durability. There are number of gradation limits in the U.S.A. itself in the AASHO, ASTM, etc. But all of them are only guides to get a gradation which would finally give as dense a carpet as possible with available materials. Here he quoted one of the pioneers in the field of asphalt technology, Mr. McNaughton who had stated that there is no doubt a good asphalt surface can be obtained with a gradation, meeting the requirements of specifications. But equally good or perhaps better mixtures might be obtained from mixtures which do not meet the grading requirements of the Asphalt Institute or some similar organizations. Secondly, he could show a number of instances in the American Association of Paving Technologists where grading had not been strictly followed to satisfy any particular limits, yet they had been able to get the requisite stability and voids. So, it was not necessary to lay too much emphasis on gradation limits. What is required is to obtain the materials, test them and if satisfied as regards the final properties, lay them.

As regards the void content, quite a number of speakers had said that 3 to 5 per cent should have been the limit. Whereas they had gone overboard, nearer 10, and they had been criticised that this percentage of voids was for the triaxial, method whereas 3 to 5 per cent is related to Marshall's and so on. All these are supposed to be related to the final compaction and the final void content obtained in the field. He could give certain instances and even references where the final requirement had been as high as 10 per cent as regards the void content in the carpet in the field. One of the speakers had stated that we should have expressed in terms of 92 per cent or 93 per cent of the laboratory density and so on. Now, surely one will not use a chemical balance to weigh one ton. It is enough if one says that the final void content in the carpet is such and such. They had taken a number of cores all along the road and it could be proved substantially that in 9 cases out of 10 they got void content of around 5, although the original void content was 10 to 12. The reason is obvious. It is never possible to simulate the compaction as a result of traffic in the field to any sort of compaction in the laboratory. A good deal of work had been done in the various laboratories in the world and it had always been a very controversial subject and nobody had arrived at an exact correlation between the degree of compaction which was obtained in the field as related to the degree of compaction obtained in the laboratory. So, as long as it was possible to get a low void content and adequate stability in the field, he thought it should be considered satisfactory.

Coming to more detailed points raised by various speakers, **Shri D. C. Chaturvedi** had asked as to how the thickness of 1 to 1½ in. was arrived at. It is obvious that a greater thickness will be better. But, from economic considerations and in view of the fact that the need was only for a wearing course and not for any structural element, the thickness of 1 to 1½ in. was adopted.

In Table 2, there is a mistake; actually the value of stability (Marshall) for stone sand crete is 965 and not 9.65. The void percentage of 9.06 obtained for sand stone crete was obtained by the use of crusher run screenings of 1/8 in. and below. On the other hand, if coarse sand was used, which is normally adopted in the crete type of surfaces, voids as high as 15 per cent could be obtained. It was intended to compare the designed mixtures with the ordinary crete type of surface by using the same materials in both of them and that was how 9 per cent was obtained in the case of crete type and it would be 15 per cent if Badarpur sand or any other coarse sand was used. It was intended to note the Bump Index at various intervals to note the reduction in voids. The significance of abrasion test for bituminous mixtures was just for comparison. The abrasion is not a standard test at all. They just wanted to have a comparison between the two and it told them that the stone sand abrades to a greater extent than the designed carpet.

Shri Chaturvedi had also asked about the extraction test and the Authors agreed that the extraction test took a good deal of time. If they had the hot extractor, it would easily have taken about 5 hours, but with the centrifugal extractor in about half an hour the results would be available.

Shri Chaturvedi had stated that U.P. had developed a method of laying the water-bound macadam to a smooth finish. He felt this could be suggested to other States as well.

Passing on to **Shri D. K. Laroia's** comments, **Shri Swaminathan** stated that he had already explained the void percentage of 9.06, and referring to the smoothness of the open graded carpets in Table 3, he stated that it was true that the smoothness of the designed carpet was dependent upon the mechanical laying. On page 478 in para 2.3, it is stated that the bump free surface of the figure of 110 was as a result of mechanical laying. They never claimed that this was as a result of the design of the carpet. As regards the increase of quantities of materials retained on ½ in. as given in Table 10, it should be kept in view that the sieve analysis given was for three different lots and not the sieve analysis of the same material. But it gives the gradation.

Shri Laroia had also referred to the bulk density between loose and compacted material. Most of these designs were worked on

weight-basis and, as such, though only 1,150 cu. ft. was used for dense mix, it would be a tighter mix than the 1,300 cu. ft. as given for the open graded mixture.

Referring to the comments of **Shri Saparamado**, **Shri Swaminathan** remarked that most of the comments have already been answered earlier. As regards Table 4, it is true that the percentage of voids in total mix was stipulated as 10 per cent for the triaxial test and not in Marshall's. But he thought that so long as it was possible to obtain a low void content in the field, it would suffice. It is true, no doubt, that it was attempted to get a mixture so as to have a maximum density similar to the mechanical stabilization of soils. It was attempted by virtue of the fact that additional filler was not to be incorporated. Regarding the use of a softer grade bitumen, **Shri Swaminathan** did not agree with **Shri Saparamado** and he felt that in India, in particular, it is better to go in for a harder grade of bitumen consistent with durability. It is true that although a value of 1,000 lb was obtained by using 80/100, 60/70 bitumen was used not because it gave higher stability but because it was felt that for conditions in Delhi, a harder grade would be better.

Referring to the remarks of **Shri Taylor**, the Author stated that there was a mistake in Table 2. The value of Marshall stability for stone sand crete mixture is 965 and not 9.65. The values were given just to show as to how the various mixtures would behave in similar conditions of testing such as Marshall. **Shri Swaminathan** agreed with **Shri Taylor** that the even-running of surface was mainly due to the use of a mechanical paver and this has been clearly stated in para 2.3.

As regards the cost of the mixing plant, it is covered under the hire charges given as item 5 on page 513. **Shri Swaminathan** agreed that it would have been possible to get a mixture much denser than the one got by them by addition of filler. As regards absorption, the absorption test was conducted and the value of absorption was 0.1 per cent and for a district where rainfall is low such as Delhi, it was felt that this mix would work out very satisfactorily. It is true that the values given for the percentage of voids in Table 18 were taken after rolling, but three months after construction, when specimens were taken out in the same localities, the void per cent had come down to about 5.

Referring to the remarks of **Shri Satish Prasad**, **Shri Swaminathan** stated that the overall thickness of road pavement was arrived at after doing the C.B.R. test and as such it would be adequate. **Shri Swaminathan** himself had referred to the use of primer in section 7.4.

Referring to the remarks of **Shri P. L. De**, in Appendices III and IV, it may be noted that the cost based on bulk bitumen and mixing plant had also been given on pages 515 and 516. The question of screening did not obviously come into the picture as the design was based on the initial sampling and sieving of the materials used. As regards the total quantity of aggregate, it may be noted that though the thickness of all the three carpets may be 1 in., the quantities would vary, depending on the percentage of the void left and the assumed value of bulk density.

Passing on to the remarks of **Shri Jayawant**, **Shri Swaminathan** replied that the gradation limits were taken from the manual of Asphalt Institute in which the gradations given in the Paper were given for use of a surface mixture as well.

Regarding the percentage of voids, **Shri Swaminathan** replied that he had already made them clear earlier. In this connection, he would refer to certain Papers of Norman Mcleod wherein he had quoted instances of well designed mixtures with an initial void content of 4 per cent, showing signs of bleeding as a result of continuous passage of heavy traffic. This clearly shows that it is possible to bring down the percentage of voids as a result of compaction of traffic. It is true that it would have been better if the full compaction had been referred to in terms of ratio between the field density and theoretical density. But it was thought that a simple figure such as density as given in the Paper might be more helpful. It is true that immediately after rolling, this ratio came to only 85, but after three months of traffic, the voids had come down.

Passing on to the remarks of **Shri Kalra**, the C. B. R. test was done after soaking and as regards the use of 60/70 bitumen, some portions of the roads were done during the months of January and February and it was found possible to use the 60/70 bitumen quite easily without the mixture cooling down completely.

Referring to the remarks of **Shri I. P. Gupta**, **Shri Swaminathan** stated that the breakdown of the thickness of the crust of the road was obtained based on C.B.R. values.

Finally, **Shri Swaminathan** thanked the various speakers for evincing keen interest in this Paper.

Shri N. Durrani (Chairman) in winding up the discussion thanked the Authors for a good Paper. He also thanked the various Engineers who took keen interest in the discussion and brought out several other useful points.

Discussion on Paper No. 220*

**"Road Transport Operation Cost on Various
Types of Surfaces"**

By

N. D. DAFTARY & DR. M. K. GANGULI

Sunday, January 31, 1960

Shri Jagdish Prasad (Chairman) called upon **Dr. M. K. Ganguli** to introduce the Paper for discussion.

Dr. M. K. Ganguli stated that he would have liked **Shri N. D. Daftary** (co-Author) to be present here to introduce the Paper.

In 1953, the Council of the Indian Roads Congress appointed, on a recommendation from the Transport Advisory Council, a Committee to study the cost of operation of motor vehicles on different types of road surfaces and the economy of road improvement. The Committee having been satisfied that an experimental approach was unavoidable, decided that two important nationalised undertakings should be approached to carry out an experiment on their behalf. Controlled experiments were thereafter carried out by Bombay and Uttar Pradesh State Transport Undertakings according to design and specifications supplied by the Committee. This Paper gives the details of the actual experiments and their results. The experiments have clearly brought out the amount of reduction in the cost of operation of motor vehicles on different types of surfaces. The observations show that the change of road surface from bad water-bound macadam to good cement concrete reduces the fuel cost per gallon from 22.6 pias to 17.4 pias, which means a saving of fuel consumption to the extent of about 25 per cent. Similarly the data regarding consumption of tyre and spare parts by the vehicles on experimental routes had clearly brought out the amount of reduction in the cost of operation of motor vehicles on different types of surfaces. The variation in the cost of consumption of lubricant oil was, however, not very much marked. The consumption pattern of items like fuel, lubricant, tyre and spare parts had by now more or less stabilized and valid conclusions might, therefore, be made regarding the economy resulting from road improvements with sufficient confidence.

* Published at pages 517 to 540 of Vol. XXIV—Part 3, of I.R.C. Journal, December 1959

The experiments were now being extended to hill roads and, he was sure, that with the availability of sufficient data interesting conclusions could be arrived at on such routes also.

Before concluding, he would like to mention that the Paper discusses in detail the Indian experiments and their results and also reviews the experience of other countries so that an effective comparison could be made.

Shri R. Thillainayagam stated that the economic gain due to reduction in operating time and accident costs, though not easy to evaluate these two important factors an attempt should have been made to take them into consideration in assessing the operating cost on different surfaces. Similar evaluations had been carried out both in U.K. and U.S.A.

As regards categorisation of road surfaces in the Paper, the variation of surface characteristics for the different types might not be much. For instance, in the case of black top surface, the surface characteristics of the different types of pavement were not very pronounced and a bituminous concrete surface could compare very favourably with that of cement concrete surface. Again, the surfaces were classified as good and average, based on the speed at which the vehicle could be operated on them. This classification, in his opinion, did not give an accurate picture of the surface conditions of the pavement as speed was governed more by the traffic intensity, grade, the geometrics of the road and the operator's ability than by the surface condition. Such a classification, he felt, left things more to individual judgment. It should be based more on the surface conditions and other characteristics than on the operating speed alone.

Shri A. C. Sharma remarked that such Papers were necessary for convincing the Legislators about the necessity of good roads. He offered the following further suggestions :

For purposes of experiment black top surface, specially the lengths where premix carpet had been laid or the surface was smooth, should be categorised with cement concrete as per practice in America.

The routes should be taken with equal number of halts as far as possible because larger number of halts resulted in excess consumption of petrol and greater wear of brakes and tyres.

Shri B. V. Patankar stated that it was not clear whether the following observations were also made in these experiments :

1. Speed versus petrol consumption—because greater the speed the higher would be the petrol or diesel consumption.

Uniform weight—some vehicles were overloaded and some under-loaded; and consequently, the data obtained would not be uniform.

Wet surface—the road surface conditions would vary from 'dry' to 'wet'. Hence, some more experiments, if conducted on these lines, might give us better 'data'.

Shri K. K. Nambiar's first point related to oil change, i.e., consumption of oil. In all the foreign countries it has been shown that owing to upgrading of surface there had been a certain amount of saving in the oil consumption, whereas in the experiment conducted by the Authors the oil consumption was shown as the same irrespective whether the road was water-bound macadam, good or bad, bitumen pavement or concrete pavement. This needed to be investigated. Probably, in the matter of oil consumption, the chief factor was the change and not the topping of it. So, he had requested the Authors to correspond with the authorities who had conducted experiments in foreign countries to find out the criteria adopted by them for the change of oil, and whether the oil was changed when it deteriorated to a particular standard. It should certainly show a reduction in the oil consumption if the surface was upgraded.

Secondly, in evaluating the savings or in working out the running costs on bad and good roads, the Authors had not taken into consideration the element of saving in fixed costs that would accrue due to increased number of trips at fast speed ensured by better type of roads. The fixed costs like garage charges, taxation and other charges would remain the same. Therefore, if the element of fixed costs was also incorporated into the running costs for purposes of comparison of bad roads with good roads, it would be possible to get realistic values for savings.

It was mentioned in the Paper that in Great Britain, if the authorities would invest Rs 720 crores on improvement of roads, it would result in an annual saving of Rs 125 crores to the British people. Similarly, if the number of trucks, buses and cars on the roads in India was obtained along with the average mileage done by each of the vehicles, and then evaluate the saving that would accrue to the nation by upgrading the water-bound macadam to black top and black top to concrete and so on, it would be an eye opener to the Members of Parliament that investment on roads was really a very good investment.

Shri Fateh Chand* commented that unlike other countries any improvements made in road surfaces though appreciated by the motorists they would not like to share with the financing authority any portion of the savings accruing to them in the matter of reduced

* This comment was received in writing.

running or repair costs, etc. However, if the Indian Roads Congress could convince the Government fully of the actual expenditure incurred by operators on different types of surfaces, a system could perhaps be evolved so as to apportion the savings accruing from any improvement between the operators and the cost of improvement itself.

As regards the figures quoted for U.S.A. and other countries, these could not serve as a guide for this country as the specifications and condition of earth roads, maintained by machinery in the U.S.A., differed a great deal from those in India. Similarly, condition of road surfaces, nature of vehicles and congestion of traffic differed greatly for metalled roads.

As regards cost per vehicle-mile in Bombay being 17.40 and 19.76 pies respectively for C.C. roads and B.T. roads, **Shri Fateh Chand** stated that his experience in U.P. was that there could not be so much difference in the cost of operation on these two surfaces unless, of course, the black top road selected might be passing through congested areas or there might be heavier gradients, sharper curves, more stoppages or restrictions against higher speed as compared to the cement concrete road selected for the experiment.

Shri Fateh Chand suggested that experiments on larger scale should be made in all States with similar vehicles and conditions on the roads affecting the cost of operation. Then only would it be possible to arrive at some tangible steps to improve road surfaces and to benefit the operators at the same time.

Dr. M. K. Ganguli (Joint Author), referring to the suggestion of **Shri R. Thillainayagam** to also incorporate economic loss due to accidents and savings in time in the experiment, stated that these factors being more or less subjective were not included in the Paper. Here, their effort was to analyse whatever actual observations were supplied to them and which could be quantitatively estimated, so as to focus the attention of the administrative authorities over the necessity of improvement of roads. The saving in time and economic loss due to accidents was likely to be interpreted by different authorities in a different way and they might not be on sure and certain ground so as to say that if these economic benefits would not have been included in that subjective manner, the case could not be proved otherwise.

Regarding the condition of road specifications, etc. obviously, he would have been very happy to put as much control as possible on these experiments so as to put clear cut result before the members, but it will have to be appreciated that the practical limitations of the operators stood in the way of controlled experiment. For instance, one of the speakers said that the number of halting stations

should be made similar, otherwise the vehicles would have to run on low gear thereby causing uncontrolled variation. The suggestion was no doubt quite good but to have similar length of roads, uniform curvature, uniform traffic intensity, and the same number of halts might be impossible to attain in reality. So, these practical difficulties have to be faced before going in for controlled experiments.

Shri K. K. Nambiar had already discussed most of the points with him. As regards his first point about the oil change, Dr. Ganguli stated that he would refer to the Iowa Experimental Station for further details. It was not unlikely that the different Transport Undertakings might be changing the oil after a certain mileage irrespective of the condition of the oil. The condition of the lubricant oil in the vehicles plying on the dusty roads might be relatively worse before a change was affected. It is proposed to sample the oil before change and send it to the proper research organisation for a report about the dustiness of the oil, which might confirm the above conclusion.

So far as his second point was concerned, about calculating the national loss, they were certainly interested in it, but the only thing was that the results available till now related mainly to plain roads and they were awaiting the results of hill roads from the Himachal Pradesh Government as well as from other States. Only receipt of these details a comprehensive estimate for India as a whole could be made.

Shri Jagdish Prasad (Chairman) concluding the discussion, thanked the Authors for the valuable Paper that they had presented to the Congress. The subject of the cost of operation of motor vehicles on various types of roads had perhaps come up before the I.R.C. Session for the first time and members would agree that it deserved further study and investigation. It is of interest to engineers because it was very difficult nowadays with increased cost of construction of roads to get adequate funds for improvement and maintenance of roads. Unless it could be proved to the Legislatures and the Government that money could be saved by improving the surface of roads, it would be difficult to get adequate funds for improving the roads as well as for maintaining them properly.

This problem of determining the cost of operation of vehicles on different types of surfaces was entrusted to the I.R.C. by the Transport Advisory Council. The IRC was rather in a difficult position because it could not directly conduct the experiments which had to be carried out by large Transport Undertakings. Private motor operators generally being not so well organized the data required for these experiments could not be obtained from them. It was, therefore, thought that the two well organized road

Transport Undertakings, i.e., the Bombay State Road Transport and the U.P. Government Roadways, be requested to carry out these experiments on behalf of the I.R.C., but it seems that the Committee entrusted with this work would probably have to discuss the matters with the authorities of the State Transport Undertakings in greater detail so that, as desired by Members, further investigations might be carried out and greater details obtained. At present the matters were being dealt with by correspondence, and unless there were personal discussion between the Committee and the Management of these Transport Undertakings, probably they would not be able to understand the requirements and points of view. He therefore suggested that the Committee should meet the Transport Undertakings, and see for themselves where the experiments were being conducted and what further data and details had to be supplied by the Transport Undertakings, in order that the variables might be reduced as far as possible and definite conclusions drawn from the experiments carried out.

Discussion on Paper No. 221*

"Origin and Destination Study of Traffic of Greater Delhi"

By

T. S. KHANNA & T. R. SEHGAL

Sunday, January 31, 1960.

Shri Jagdish Prasad (Chairman) called upon Shri T. S. Khanna (one of the Authors) to introduce the Paper for discussion.

Shri T. S. Khanna (Author), while introducing his Paper for discussion, drew attention of the members to the historical background of the city dating back to 1400 B.C. to 1912, when New Delhi came into being as the seat of the then Government. Since then the two adjacent cities of Delhi and New Delhi have developed separately instead of growing into one unit which was mainly due to lack of integrated planning. He added that, in 1947, when partition of the country took place, more than half a million refugees moved into Delhi creating numerous problems. The sudden and haphazard growth of the city was responsible for a number of present day traffic and transport problems. Even now about 70,000 people come to settle in Delhi from surrounding areas every year.

Shri Khanna enumerated several factors which had given rise to Delhi's traffic problem, viz., (i) sudden rise in the population soon after the partition, (ii) unplanned expansion of Delhi urban areas to settle the refugee population causing ribbon development, (iii) rising demand of transport as the refugees settled down and found jobs, (iv) general rise in per capita income in Delhi, (v) all types of vehicles coming on to road to meet this transport demand creating serious traffic complexities, (vi) functional obsolescence of roads built for light and slow traffic of the past, (vii) concentration of Government offices in particular areas, (viii) lack of road sense on the part of road users, (ix) lack of any particular organization dealing with the problem, and (x) more people settling in Delhi further aggravating the problem.

Efforts in the past to solve the traffic problem, he said, had not shown impressive results. This was mainly due to the fact that (i)

action to provide roads, parking and transport services had been taken independently without any definite overall concept, (ii) supply of finances had not been able to meet the extraordinary requirements of the essential improvements, (iii) responsibilities of the traffic problem were divided into a number of organisations and (iv) trained men for the job were not made use of.

Shri Khanna observed that there were at least 13 different types of vehicles on Delhi roads which created accidents and congestion problem due to great variety in their behaviour and road requirements.

There were about 8,000 motor cycles, 12,600 private cars, 1,700 auto-rickshaws, 1,550 taxis, 2,900 trucks, 500 private buses, 550 D.T.U. buses, 4,500 tongas and rehras, about 300,000 cycles, 800 cycle-rickshaws, 2,650 hand-carts, 3,500 bullock carts and innumerable pedestrians.

A glance at Delhi road accident records would reveal some important facts. During the two years 1958 and 1959 there had been 6,561 accidents on Delhi roads, 2,642 persons being injured and 293 persons killed during the same period. For every 23 accidents there was one fatal accident and in every 3 accidents at least 1 person was injured. Death-rate was increasing as one person was killed every two days during the year 1959 compared to 1 killed every 3 days in 1958. Ten to 11 accidents occurred every day compared to 8 accidents per day about a year ago.

Exact economic loss due to accidents had not been calculated but a rough and modest estimate showed that about Rs 15,000 loss per day was being incurred in Delhi road accidents.

As far as total fatal accidents were concerned, the most lethal vehicles on Delhi roads were trucks and the Delhi Transport (D.T.U.) buses. Yet the safest vehicle to travel in was a D.T.U. bus. It was paradoxical that a vehicle which had the highest chances of being involved in an accident should be the safest vehicle to travel in. Pedestrians and cyclists were the worst hit in fatal accidents.

A recent study showed that Delhi Transport Undertaking (D.T.U.) buses were involved in 18.7 per cent of 1958 accidents whereas their daily run was only 1.3 per cent of the total vehicle-miles travelled everyday. Auto-rickshaws and trucks were involved in 15 per cent and 21 per cent accidents respectively whereas their daily mileage constituted only 4 per cent and 7.8 per cent of the total daily vehicle-miles. Animal drawn vehicles constituting 7 per cent of the total vehicle-miles travelled everyday were involved in 17 per cent of the total accidents in 1958. Taxis were involved in

* Published at pages 579 to 627, Vol. XXIV—Part 4 of the Journal of the Indian Roads Congress, January 1960.

11 per cent of accidents whereas daily taxi-miles were only 2.8 per cent of the total vehicle-miles travelled everyday. Judging from these figures one could see that the D.T.U. bus drivers, taxi drivers, truck drivers and auto-rickshaw drivers needed a special attention in driver-improvement programme.

As regards accident prone areas, Shri Khanna suggested that Rohtak road, Najafgarh road and Elgin road needed first attention for improving them from fatal accidents point of view; Gurgaon road and G.T. road demanded the next priority. Ring road, Pusa road, Bela road, Sadar Bazar, Chandni Chowk, Subzimandi, Gandhi Nagar were next in line to take measures for eliminating fatal accidents.

As far as the number of accidents per mile was concerned, Faiz Bazar topped the list with 280 accidents per mile. Next in line were Connaught Circus, Dufferin Bridge, Elgin road, Pull Mathai, ranging from 122 to 90 accidents per mile. Minto road, Janpath, Parliament Street, Jamuna Bridge had about 60 accidents per mile. Connaught Place, Panchkuin road, Chelmsford road, Rohtak road followed with about 40 accidents per mile.

Shri Khanna stated that in very congested areas there were fewer severe accidents due to slowed down speeds. But these areas have a subtle effect on accident severity. The drivers tried to make up for the lost time by speeding up or driving rashly in open areas, thus becoming more accident prone.

Shri Khanna remarked that though maximum motor-vehicle speed attained over a single measured mile, with a running start increased from about 40 miles per hour in 1898 to 400 miles per hour in 1948. But travel speeds in city areas had been slowing down due to congestion on certain routes. Travel speed on the main route between Delhi and New Delhi, i.e., Delhi Gate to Kashmere Gate, was about 16 miles per hour. Average travel speed of the D.T.U. buses was only 12 miles per hour. Travel speed in Chandni Chowk, Jama Masjid, Naya Bazar, Lal Kuan, Fetei Puri, Khari Baoli, Hauz Qazy, etc., ranged from only 4 to 6 miles per hour. 1.83 million cycle-miles were travelled everyday on Delhi roads between the speeds 7 to 9 miles per hour.

A study indicated that about Rs 725,000 was spent everyday on transport operations in Delhi. This included expenditure on all types of vehicles. Annual expenditure came to about Rs 260 million.

If the average travel speed of D.T.U. buses could be increased only by two miles per hour, i.e., from 12 m/hr. to 14 m/hr. a saving of about 600 operation hours per day could be effected; this would mean that 10 per cent less buses could do the same service.

Delhi was likely to continue growing for a number of years yet. The Master Plan of Delhi recommended the development of 5 major industrial areas covering more than 5,600 acres land to provide employment to 170,000 persons. Future expansion of Delhi would naturally give rise to further traffic problems. In old times cities were developed around a core area and the development was governed by distance-radius. But in modern times, expansion of cities seemed to be governed by travel-time-radius. In other words, instead of the distance being measured as miles away it was being measured as minutes away provided the transport cost was within a certain limit of about 5 per cent to 7 per cent of one's income.

Traffic and transport could be planned for cities of limited size but not for unlimited size. The situation becomes still worse when cities keep expanding and start bursting into each other as it has already started happening in the U.S.A. where it is being believed that before the turn of this century the entire Eastern sea-board of the U.S.A. will turn into one city 640 miles long with variable width. According to the Delhi Planners, population of Delhi would be 5 million by 1980. It is high time that optimum size for Delhi was fixed and no more growth permitted thereafter.

Concluding, Shri Khanna felt convinced that professional training to those engaged in traffic and transport problems was absolutely essential. Speaking particularly of Delhi and other big cities of India in general, the responsibility of traffic and transport problem should be entrusted to a body of trained men who would make traffic and transport as their career. By professional training he did not mean only technical training as these men could not work in 'technological corral' and function only within technological professional walls. They must be equipped to cope with administrative, social, economic and planning problems and several other fields through which traffic cuts across. Besides the necessary technical training of these men, their training programme could usefully include techniques in public administration, public psychology and sociology, public finance and economics, principles of planning and of legislation, enforcement planning and techniques and public education.

He hoped that as the needs of the country became greater, the attitudes and actions of the Government would become adjusted to the real needs of the people. And these attitudes and actions would be translated into the policies of the Government. These policies, in turn, must be applied to such concrete acts as creating increasingly effective measures for improving traffic and transport conditions.

G. B. Shaw once said: "Unless you take care to have the things you like you will be forced to like the things you have". As

revealed by the traffic studies of Delhi now, it was high time to take care to have the things they liked in traffic.

Shri C. L. N. Iyengar observed that the O and D survey, described in the Paper unlike some other O and D surveys reported earlier to this Congress, was the first of its kind, with a comprehensive analysis of the O and D facts in the manner adopted in various U.S. cities, and he complimented the C.R.R.I. for having taken great trouble in carrying out a routine job of almost a city Government.

Many recommendations made as an outcome of this study, Shri Iyengar remarked, were more or less qualitative, though to a certain extent Shri Khanna had elaborated quantitatively the problems during his introduction. Therefore, it made readers and possibly even some of the engineers familiar with Delhi, feel as to whether the conclusions could not have been made just as an outcome of their own experience. In that context, it would have been better if things had been put down qualitatively. By that he meant that they had established by careful studies as to what were the actual traffic volumes going along the various roads. By a proper correlation of the traffic figures with the geometrics of the roads they could try and find out as to whether capacity of the road was adequate for carrying the type of traffic going along it, or whether by enforcing some orderly movement or by a segregation of traffic, improvement in speed and other functional characteristics of the road could have been made by these measures. Similarly, there was a reference on page 600 about a very novel method of locating highway crossings like bridges, etc., by moment area method obtained by the O and D facts. Now, having found from the present data that another bridge site over the Jamuna should be located close to the existing bridge, a random shift, without having adequate traffic predictions of the development of the area in the near future near Nizamuddin or some other place, left the application of these facts still incomplete. Most of the traffic facts, regarding peak hour, Shri Iyengar stated, were taken on a $1\frac{1}{4}$ hour basis with the break-up of 15 minutes intervals without giving the classification of the traffic by the individual trips for the 15 minutes, to find out the intensity of traffic of short periods. This was not easily analysed by the facts presented.

There was a suggestion made in the Paper for staggering of office hours as a solution to relieve traffic congestion. Shri Iyengar was not sure to what extent they could stagger the office hours practically to resolve this congestion if peak traffic continued for $1\frac{1}{4}$ hours. If the peak traffic was concentrated for a short period of half an hour, then it was possible to stagger the office hours for 2 hours or so and it might be possible to help in this regard, but if the peak traffic assumption remained uniform for 7 or 8 quarter

hours, then it was impractical to achieve relief by staggering office hours.

Shri Iyengar added that a 10 per cent sample had been taken for analysis. For certain things, this 10 per cent sample was adequate, but for analysing all the variables it was not adequate. For example, the fallacy of this analysis was proved by the figures given in Table 10 on page 598 of the Paper where it was shown that people with income group of Rs 1,500 or above used less of their cars than the people in the income group below Rs 1,500, i.e., of the people in income group of Rs 1,500 or more only 74.92 per cent used their own cars whereas in the income group of Rs 100 to 1,500 about 86.76 per cent used their cars. He thought this error was only on account of the smallness of the sample.

Most of the engineers, Shri Iyengar thought, would be scared of undertaking a survey of this nature unless they had some idea of the cost of such survey and whatever might be the type of the problem, the factual basis was definitely better than having a basis using pure judgment. If the cost of the survey along with an idea of manpower required had been included, it would have substantially added to the value of the contribution.

Shri R. Thillainayagam stated that before O and D surveys in United States of America and other countries were done, people were under the impression that they could avoid the major part of the traffic coming to the city by putting a bypass. But when they took a detailed survey and analysed the data, they found that almost more than 90 per cent of the traffic coming to the city was going into the heart. Instead of a bye-pass they started improving the road by constructing overbridges and flyovers and other things. Here, also, the analysis had shown that except for 19.23 per cent of the total traffic, all the other traffic was bound to the heart of New Delhi. He was not sure whether the figure of 19.23 per cent might be a high figure, for the reason that many of the commercial concerns might be located between the outer cordon and the inner cordon.

The O and D survey should be taken only as an indication of the present state of affairs of the traffic conditions in New Delhi and it should not be used in planning the future locations of bridges and other important road and transport facilities. In America and other western countries, the cities were growing rapidly and they were not in a position to correctly judge the exact future traffic pattern in a city. So the city planners were now evolving a new method by which they could assess the traffic generating capacity of a particular area. This helped assess the traffic facility to be provided for the future needs. For instance, they had a high class residential area, a middle class residential area, a factory area, etc.; by grouping the area in zones they exactly knew that in a high class area one could

expect the number of cars greater, whereas in the low income group the conveyance generally used would be of a cheaper type such as cycles, etc. He would, therefore, suggest, that instead of being carried away blindly by the present O and D traffic surveys, the Author should group the future land development envisaged in and around Delhi into various zones and from that assess the future origin of traffic in and around Delhi. The traffic thus assessed should also be taken into consideration while fixing the traffic facilities.

As Shri C. L. N. Iyengar had already pointed out, they could not adopt in India, where fast moving traffic was low when compared to other countries, the limited sample of 1 in 20 or 1 in 10 which should be alright where the motor traffic was of the order of hundred thousands. But in a city like Delhi, Madras or Bombay, where the motor traffic was of the order of thousands, the random sampling factor should be comparatively low. He, therefore, suggested that the Author should investigate by taking a full scale survey and find out the error introduced by taking 1 in 10 and 1 in 20 samples. On the basis of the study the future sampling of traffic should be done.

Delhi being the capital city, he thought, there should be large fluctuations of the traffic patterns according to the season and important events in the city. Traffic routing and facilities will also have to be planned for such seasonal traffic and events.

Dr. M. K. Ganguli stated the first point he would like to stress was that the origin and destination of the traffic was necessarily the same as the origin and destination of the vehicle. In the Paper, he felt, the origin and destination of the traffic had been somewhat overlooked and the D.T.U. buses and the economic characteristics of their users altogether omitted. Since the approach was by stopping the vehicle, one could appreciate the difficulty for the investigator to stop the bus and then enquire about the origin and destination of all the passengers, their purpose of visit, etc. But unless they knew the route that a person going from A to C or desiring to go from A to C had been compelled to take, it might not be possible to tackle the traffic problem properly. The same applied to the goods traffic also.

Apart from the trips made by bullock-carts, thelas, tongas, etc., in a place like Delhi foot trips were also extremely important. In a similar survey conducted by the Ministry of Transport as early as 1954, it was found that 38 per cent of the trips were made on foot in Delhi. Such a high percentage of foot trips only indicated the lack of proper conveyance facilities in the different routes or else the economic conditions of the people. Since the present survey was conducted after 3 years, he would very much like if the Authors

could throw some light on the present position and whether there had been some improvement.

Regarding congestion and various other problems arising in a modern city, Dr. Ganguli stated that sometimes, however, in a city like Delhi they got the reverse conditions, that is to say, no conveyance was available for hours together. In the 1954 survey, it was found out if the travelling time of a person was one hour in a D.T.U. bus or some such conveyance, his waiting time was about another one hour. It was quite likely that the position had improved in many directions, particularly due to the increase in the number of vehicles. It would be of interest to know the change of trend since then if the Authors could throw some light.

Dr. R. K. N. Iyengar observed that the study provided a very good example of what could be achieved by the co-ordinated efforts of the traffic authorities, research organisations, town-planning departments, police departments, and all others concerned with traffic, by carrying out such investigations for getting at the amount of traffic volume and intensity flowing from one area of the city to the other, which in turn would greatly help in the planning, design and location of roads to cater to the ever increasing traffic.

In the Paper, the random sampling techniques adopted were found to be very expeditious and time saving and also money saving. He thought that with suitable modifications, it could be recommended for adoption in other cities where traffic O and D surveys were to be carried out.

Generally speaking, there was a tendency of random development of roads in many of the major cities which are expanding at a very fast rate. A properly planned O and D survey, as carried out in the capital city of Delhi, could be useful for design of suitable routes in other cities to cater to the ever increasing traffic, and it would also decrease the traffic hazards which were a common feature in most of the fast developing cities. It would be most useful if the concerned authorities in Delhi would accept and adopt the recommendations made in the Paper.

Shri R. P. Chanda stated that Shri Khanna had brought up a very interesting subject which was highly topical and very very urgent, i.e., the road and the transport problems in urban areas. The cities may be ancient ones like Delhi, not so ancient, or modern, but nevertheless the problems were or would be the same and might get worse.

Shri Chanda stated that 'planning' is a tool for what was needed. How to utilize or implement the results of planning surveys? Every city in existence had various authorities dealing

with the same problem. From traffic point of view, he could not think of anything worse. Take, for example, the city of Calcutta, they had the Port authorities who looked after roads serving the ports; then there was the Municipal Corporation, the Improvement Trust the canals and the irrigation department in addition to the railway organizations with its headquarters, warehouses, sidings, etc., and they required approach roads: the State Government had its road department with some of the National Highways going in and around the city. Thus a host of people were in charge of roads. Unless co-ordination was done, the road planning would not succeed. For this purpose, there was the necessity of an authoritative body to coordinate and control both planning and implementation of the decisions arrived at. Shri Chanda requested the Author to consider the problem of organization in a body in different cities, which would be able to control and work out the details of planning as well as means and measures for implementation. He hoped the Indian Roads Congress would also take this matter up, prepare standards, and make recommendations to the State governments so that they could have a City Road Board like Metropolitan Water Board, Sewage Board.

Shri B. V. Patankar wanted to ask the Authors whether the word 'traffic' did not include the pedestrians. Pedestrian survey would, of course, be difficult, but at the same time it might throw some light on the O and D studies and also prevent accidents because, in all accidents there were two parties and generally the pedestrian was a greater sufferer. Unfortunately, the study of accidents was not given. But he had read in some other Papers that at least more than 35 per cent of the accidents were due to the "jay" walking tendencies of the pedestrians.

Shri R. Krishnamachari* stated that the Authors had suggested separate cycle tracks as well as expressways in certain areas. In a city which had already developed, it might be very difficult to clear the road side and provide cycle tracks. The whole question of providing covered and separate cycle expressways might cost the exchequer quite a lot of money. Instead of spending on this item, it would be better if the money was spent on increasing the number of buses in the capital. In Bombay, one would see the gradual disappearance of cycles from the road in the last few years. This was because of the increased facility of public transportation. As such, the step in the right direction would be to better the public transport services, and to spend the money on such items rather than on building new cycle expressways. These expressways, in future, might not be used when better transport facilities came into existence.

* This Comment was received in writing.

Since the Subzimandi area of Delhi was already crowded, it might be worth while to study the possibility of shifting the market to another area so that the slow moving traffic could be minimized.

Shri T. S. Khanna replying to **Shri C. L. N. Iyengar** stated that it was really not a routine job because if Shri Iyengar had looked through the questionnaire he would find that the questions asked were not routine ones. The mode of transport was analysed with the income group. It was not a routine job, but a research job for the planners. There were 4 or 5 other questions with which we tried to relate the type of areas with the type of traffic that they were likely to generate so that they could do some future planning and provide the facility accordingly.

Regarding the objection raised by Shri Iyengar about the location of the new bridge across Jamuna, Shri Khanna stated that though the technical aspects warranted that the bridge should be developed along with the existing bridge, but it would not be feasible as certain other areas have to be developed and the facility to crossing of Jamuna to be given to other areas also. That is why in spite of the fact that moment area method was pointing the location of another bridge near the existing Jamuna bridge it had still not been recommended.

Regarding Shri Iyengar's comment about fifteen-minute counts, Shri Khanna replied that the main idea was to find out during peak hours the traffic volumes on various roads and the warranted improvements and all that had been very clearly stated in the Paper and even in the travel lines the desire lines covered all the 24 hours as well as during peak hours. The thick black line within the travel lines was the peak hour demand.

Regarding staggering of office hours, to which Shri Iyengar had drawn attention, Shri Khanna explained that the peak demand where there were government offices was always more than half an hour, but it generally varied from half an hour to 45 minutes. It was really not a 15-minute demand because everybody could not get on the road and get started from the house at the same time. So, not only this study but another study also indicated that staggering of hours would be a very useful idea if it could be implemented.

Sample was too small according to Shri Iyengar, but Shri Khanna was of the opinion that a via media had to be fixed somewhere in order to choose some kind of sample which would be closest to true representative. It was not claimed that there was error within 0.1 per cent or something; the error may be about 5 per cent or even 7 per cent. But it was to be seen up to what limit we could spend money and get results. Was it necessary really to draw full 100

per cent results by paying so much extra? Would that be essential at all? This sample size was not his decision alone, but also the decision of a few statisticians who were consulted. They were first fully made acquainted with the locality, the types of area, for instance, industrial area, the residential area, and then the geographical boundaries as well. These consultations were done not only in India but they were also done in the United States. Mr. Walter P. Heddon who came to India specially to get acquainted with the Delhi conditions opined that 10 per cent sample for fast and slow moving vehicles and smaller samples for cycles would be sufficient.

The cost of survey, as asked by Shri Iyengar, was fairly high. The total cost was somewhere close to Rs 16,000 to 17,000. The number of people employed were not regular; they were employed for this particular job on daily wages, and the people employed during the days of traffic survey was close to 90. Survey was carried out night and day with different shifts and people were trained and given shifts. Then the analysis also cost very high, somewhere close to Rs 6,000. There were 33,000 interviews. Each interview represented at least ten vehicles and the variety of vehicles was mentioned by him in his introduction.

Referring to Shri Thillainayagam's comments that the survey couldn't be a guide for future because it was representative of New Delhi traffic, Shri Khanna pointed out that the traffic surveys were for Greater Delhi and not for New Delhi only. It is a guide inasmuch as whenever a survey was made it related to existing time and how the future requirements were judged depended on the number of factors that have worked in the past and are working and have a tendency to work in the future.

Regarding his comment on generation of traffic according to areas, Shri Khanna replied that, as already explained by him, the various classifications, viz., according to income group, according to industrial area, according to residential area indicated how much traffic would come from what type of area, and from what income group of people and what profession of people and how frequently would they be travelling. All these things were included in the Paper.

Regarding Shri Thillainayagam's suggestion to take the dignitaries into consideration while deciding the traffic pattern, Shri Khanna observed that the route of dignitaries was not fixed; they would perhaps like to go to any part of the city and for 2 or 3 or 7 days in a year to plan the roads to suit those 7 days, it would not be economical.

Dr. M. K. Ganguli had pointed out that O and D of passengers had not been cared for and the survey related only to vehicles.

Shri Khanna contended that the vehicles did not move without passengers and both the vehicle and the passengers had the same destination. Further, in trying to plan for roads they were planning for the vehicles that have to be accommodated there. Passengers were thus automatically being taken care of. D.T.U. buses were excluded intentionally as there was no need of stopping the D.T.U. buses and asking the passengers the questions of origin and destination, because the D.T.U. time table was always available. The number of passengers carried by each bus was also known and from which point to which point. All these statistics were available, and also what time how many buses run and from which station to which station. It was an additional study supplementing the one in hand. In all O and D studies he would recommend not to interview all those vehicles which were on regular service and controlled by a department. It would mean only adding to the cost and not gaining anything out of it.

Further, in reply to Dr. Ganguli, Shri Khanna stated that if pedestrians were also to be included it would be too laborious to carry out O and D studies. Pedestrian study should be taken for particular areas and not for Delhi as a whole, and those areas might be improved as indicated by the study. Shri Khanna then added that an additional study called a Public Transport Study, had been carried out, in which D.T.U. buses, cycles and pedestrians were studied. The questionnaire was passed on to 40,000 employees in office concentration areas of New Delhi to answer by what mode of transport they were coming and it had already been published.

Shri Khanna agreed with Shri R. P. Chanda that there should be some special body dealing with the problem as the variety of organisations required to handle it was nobody's business, and the papers were passed from one body to another without any decisions thereon. He assured the house that they could draw many more benefits from what they were spending now than what they were getting from the expenditure being incurred on traffic problem not only in Delhi but in Calcutta, and possibly in Bombay too. He urged that they should not be content with false beliefs that merely carrying out of some technical studies would help improve the traffic conditions. The implementation of that study could only be done by those who understood the problem. He, therefore, recommended that a body of specialists who made traffic and transport their career should be established and whose sole responsibility should be to look after the traffic conditions and transport improvements.

Shri B. V. Patankar's point whether pedestrians were included in this study or not had already been answered.

Shri Jagdish Prasad (Chairman) in his closing remarks thanked **Shri Khanna** and his co-Author for a very interesting and thought provoking Paper presented before the Congress and the members for having offered very valuable comments.

All would no doubt agree that traffic problem in Delhi as well as in other big cities was a formidable one and should be tackled by properly trained persons. The City of Delhi has considerably increased in size and is still increasing further. It appeared that all those who were interested or were competent in traffic problems were either not consulted or probably did not have any voice in the planning of new areas in Delhi. For example, probably the Traffic Engineers were not consulted in regard to the siting of the new multiple-storied Secretariat buildings which have been constructed very near the Secretariat in New Delhi. They might have suggested that the new buildings should be constructed somewhere else, probably near the ring road, so that the present peak hour traffic problem and congestion produced by all the traffic going towards the Secretariat at about 10 o' clock in the morning could have been avoided. **Shri Khanna** had rightly pointed out that persons who have made a special study of traffic problems should be associated with planning of cities. Also, there was a limit to which the existing roads could be improved. Therefore, it was very necessary that while on the one hand improvement of roads should be carried out, on the other hand, adequate stress should be laid on the training of public service vehicle drivers as well as on the training of the general public in Traffic Rules and Regulations.

"General Report on Road Research in India, 1958-59"

Sunday, 31st January and Monday, 1st February, 1960

Shri U. J. Bhatt (Chairman) opening the discussion on General Report on Road Research, stated that this is one of the most important features of the Annual Sessions and the current report was the fourth one presented on the road research work done in India. It was based on reports received from seven laboratories including the Central Road Research Institute. He added that if there were any omissions or if any laboratory's work might not have reached the Director, Central Road Research Institute, they should kindly bring it up now.

Shri Bhatt then called upon **Dr. M. L. Puri** to introduce the first section of the report dealing with Rigid Pavements.

RIGID PAVEMENTS

Dr. M. L. Puri stated that some preliminary laboratory work on the use of air entrainment in concrete was carried out in the Central Road Research Institute. A Paper on this subject has also been published in the I.R.C. Road Research Bulletin No. 6.

A study of the existing literature on the subject shows a great confusion on the effect of entrainment of air on the strength of concrete. Many workers have carried out research in this particular line and there has been great divergence of opinion on how to offset the reduction in strength of air entrained concrete by redesigning the concrete mix. The data of various researches show that complete advantage of extra workability of air-entrained concrete along with possible reduction in sand content has not been taken. Their study had revealed that if water-cement ratio and sand-aggregate ratio are considerably reduced as a result of a judicious redesign of the air-entrained concrete mixes, not only the loss can be offset in strength due to the entrainment of air, but certain types of concrete mixes as are generally used for pavement construction in India, can also attain even increased strength.

The study in the C.R.R.I., **Dr. Puri** continued, had also revealed that if 4.5 per cent air is entrained in the concrete by the use of a suitable air entraining agent and the sand-aggregate ratio reduced by 1.1 per cent for every one per cent of air entrained in concrete, about

* Published at pages 681-705 of Vol. XXIV—Part 4, of the Journal of the Indian Roads Congress, January 1960.

half a bag of cement per cubic yard of concrete can be saved without any loss in strength provided the w/c ratio is also reduced so as to take full advantage of increased workability of the mix due to entrainment of air. In addition to this, some work carried out to find out the resistance of air-entrained concrete to sulphate attack had shown encouraging results. But the greatest advantage and economy lies in the increased durability of concrete as a result of air entrainment. A lot of work had been carried out in other countries, especially in U.S.A., on the durability of air entrained concrete to freezing and thawing. As these conditions were not generally prevalent in India, the C.R.R.I. had carried out durability tests with respect to weathering of concrete. Each cycle of weathering consisted of heating the concrete to 140 deg. F and cooling the same to 50 deg. F. It was found that the air-entrained concrete had 1½ times the life as compared to that of the plain concrete.

Regarding the economic aspect, by a judicious redesign of air-entrained concrete mix, there could be saving in the use of cement in addition to the economy due to its increased workability.

Dr. Puri explained that the air-entraining agent used in this study was Vinsol Resin, a very well tried air-entraining agent manufactured in the U.S.A. Now some air-entraining agents are being manufactured in this country, but before using these for large scale construction, it is absolutely essential to determine the effect of such air-entraining agents on the properties of concrete, like compressive strength, flexural strength, workability, etc., in addition to the durability aspect.

Shri K. K. Nambiar referred to vibration compaction and recommended the same on the ground that it would eliminate the personal factor and stated that even in the case of vibrators, variations could occur due to the type of the vibrators used, the frequency, the amplitude, the size of vibrator compared to the size of the sample being vibrated, etc. Therefore, for strictly comparable results, the nature of the vibrator, its size, its amplitude, weight, frequency, etc., should be specified.

Regarding air-entraining agents, Shri Nambiar stated that most of them are imported ones and expressed the view that if greater details of the Rihand A.E.A. manufactured in India and used on the Hirakud Project in Orissa or some others manufactured by the I.C.I. in India were made available, it would be more useful and foreign exchange requirements could then be eliminated.

Regarding membrane curing of concrete, Shri Nambiar explained that Ceremul was also used some years back in Madras and was found quite satisfactory.

With regard to replacement of cement up to a certain percentage of cement by pozzolanas, Shri Nambiar felt that as surkhi could be made at various places with different kinds of clays at various temperatures of burning and with different amounts of grinding, it was difficult generally to get standard surkhi or pozzolana for admixtures.

Regarding the joint sealing compounds mentioned in para 1.3.7, Shri Nambiar described his experience of recently seeing a joint sealing work in the U.K. using a stuff known as "Cedspan" joint sealing material stuck together by some kind of glue. He and Shri T. R. S. Kynnersely tested the strength of the sealed joint by pulling the two blocks apart, but could not break the joint. Such is the strength of this glue and jointing material used.

With regard to the items of research work being done on prestressed concrete slabs in the Madras Research Station and the C.R.R.I., he suggested research be made on the design of composite construction. In the U.K., composite beams such as the inverted 'T' type beams and other beams were being used on a very large scale by the Railways and the Highway authority for culverts and bridges. They make these inverted T-shape prestress concrete beams, span the gaps without a centring and then put in-situ concrete with some transverse rods to keep the continuity; this system has been found to be very economical and very quick in making bridges and culverts.

Referring to item 5 under salient points regarding the reinforcement in slabs, Shri Nambiar stated that he had not been able to find any reference in the text of the report to what experiments had been carried out in this connection and as to what exactly were the points to be discussed.

Dr. Bh. Subbaraju replying to the last comment of Shri K. K. Nambiar, stated that last year a question was raised during the discussion of a Paper on the use of reinforcement in concrete pavements, whether it was to be structurally reinforced or only for counteracting thermal stresses, etc. This item was, therefore, included just to invite suggestions based on experience on the use of reinforcement, whether the reinforcement was to be only for thermal stresses and for load transfer devices at joints or for strengthening the slabs structurally also.

Shri R. P. Chanda stated that relation between water-cement ratio and the compressive strength of concrete raised the major problem of design of mixes and wondered whether a series of experiments could be made to establish rough and ready relationship between the voids of coarse aggregates and the strength of concrete for a certain water-cement ratio to act as a guide for future.

Shri D. C. Chaturvedi observed that as already suggested by him in the Research Organization meeting, the C.R.R.I. as well as other laboratories should carry out some tests, including compression and durability tests, using the Rihand A.E.A. to find out the usefulness of this indigenous product which is available in large quantities, being produced by the Turpentine Oil Factory at Bareilly under the guidance of the Rihand Dam authorities.

Regarding the use of surkhi as pozzolana, he wanted to know whether all surkhis produced ordinarily did not give high resistance to sulphate attack or whether it was necessary to burn them at a particular temperature to make them effective. He requested Dr. Puri to throw some light on this point.

Shri Chaturvedi also added that some experiments at Lucknow were made on the use of burnt shale to overcome the shortage of cement in hilly regions. It was found that shale burnt at a particular temperature developed good pozzolanic activity. But the difficulty was how to burn this shale locally in hilly regions. He wanted to know if shale could be conveniently burnt at a specified temperature in a local kiln. Shri Chaturvedi felt that if it could be possible to use this pozzolana (burnt shale) in lime mortar, it might be possible to get better results and obtain sufficient strength in big masonry structures like retaining walls where the setting of lime mortar was a problem.

Regarding vibration method of testing, he asked if the present work was in continuation of that already published by the C.R.R.I. in the I.S.I. Bulletin. He also wanted to know whether in the vibration method, the equipment was the same as that used for preparing cement cubes for compressive strength tests.

Regarding membrane curing, Shri Chaturvedi stated that the product "Ceremul" was not available in India nor could it be supplied by the Standard Vacuum Oil Co. Alkathene film had also been tried by them and proved equally effective for curing.

Shri C. L. N. Iyengar remarked that many of the items reported were a carryover from the last year's note on road research and since some points already mentioned by him had not still come within the scope of investigation, he wanted to bring them up again.

Regarding the construction of a 12-in. thick concrete pavement for Heavy Electrical Factory at Bhopal, he wanted to know whether any observations were being made about the compaction at various depths and note taken of improvement achieved through the use of internal vibrators. At the Road Research Laboratory, Harmondsworth, it had been proved that the intensity of compaction goes on

reducing considerably after about 4 in. depth if hand-operated vibrating screeds were employed. Some improvisations had been suggested by them, such as provision of some leading edges and arresting free travel in the first pass of the vibrator. Possibly, before recommending the use of internal vibration in the marginal depth of the pavement such as 6 to 7 in., it would be necessary to investigate the compaction achieved by using those devices.

Regarding the observation made in para 1. 2. 2., that 1:2:4 concrete having a strength of 2,500 lb per sq. in. gets abraded much faster than the concrete having higher strength, he thought that in pavement concrete, even with the normal mix of 1:2:4, invariably much higher average strengths had been seen in the field and, as such, in the laboratory this figure should be definitely higher. Further, it is obvious that higher wearing strength than the coarse aggregate cannot be had unless the mortar matrix is made stronger than the stone. This is rather difficult to obtain within the range of economical mixes. Of course, it has been shown by the Road Research Laboratory, U.K., that for concrete strengths averaging over 7000 psi., it was not the aggregate strength that was more important, but actually it is the mortar cover that developed a higher wearing strength than the aggregate itself because the aggregate did not get exposed. Unless that range of strength was reached, it would not be possible to improve upon the wearing quality of concrete for those adverse conditions of tracked vehicles. Besides, if abrasion is accounted for the dislodgment of particles either by impact or by the breakdown of particles by impact to smaller particles and subsequent dislodgment, in either case if there is some method by which it will be possible to confine these particles by certain precompression in the mass of material, there is a possibility that the wearing resistance might be considerably improved, which possibility was suggested by prestressed concrete. He cited the case of Cable Company floors where they had found very high wearing resistance by using prestressed concrete. He would, therefore, strongly recommended that some experiments be made by using prestressed concrete to obtain such high wearing resistances.

Reverting to vibration in compaction of floors, Shri Iyengar observed that the vibrating hand screeds could be a very dangerous tool without proper supervision of labour.

Regarding reinforcement in slabs, Shri Iyengar stated that one of the greatest factors against difficulties in the use of reinforcement was the cost.

Dr. Bh. Subbaraju replying to Shri C. L. N. Iyengar's question whether any tests were carried out at the Heavy Electricals, Bhopal, to find the effectiveness of internal vibration, stated that it was considered in the beginning, but for want of equipment it could

not be done. However, in one case by the side of the formwork, 12 in. thick concrete was compacted using internal vibration as well as surface vibrator, and in the other case only surface vibrator. Honeycombing was noticed more by the side of the formwork where internal vibration was not used. That was the only test done on a limited scale for want of equipment.

Shri G. C. Khanna remarked that by surkhi it was normally understood the powder obtained by grinding well-burnt or over-burnt bricks. As this type of surkhi had large contents of sand, its use in concrete would definitely lower the strength of concrete considerably. It was, therefore, essential that proper specifications for surkhi should be given. In his opinion, it would be advantageous if a new name was used for this material instead of 'surkhi' as this nomenclature was rather misleading.

He doubted if 25 per cent surkhi could be used in concrete. Even at Bhakra, where surkhi was manufactured under controlled conditions, and specifications and grading were rigidly enforced, the percentage of surkhi used in concrete was upto 10 per cent. Before making recommendations, he suggested, larger number of experiments on field scale should be carried out after successful laboratory experiments. He would, therefore, for the present, suggest caution in the use of surkhi over 10 per cent.

In regard to the work done relating to water-cement ratio and compressive strength of concrete, he wanted to know whether any original work had been done on this subject and whether any new theory evolved. He also desired to know the type of research work that had been done in the laboratory which was not given in text books.

Dr. M. L. Puri offered to answer some of the points raised by various speakers so far.

Regarding comments by M/s. C. L. N. Iyengar, K. K. Nambiar and D. C. Chaturvedi on vibration compaction of concrete, he stated that it was a new study and the results were still unpublished. The compaction apparatus used for casting the cubes for compressive strength was used in this study with the only difference that briquette-shaped metallic weight, weighing about 500 lb, was superimposed on the ordinary briquette mould. The results being highly encouraging, a Paper was proposed to be published shortly on this subject.

Regarding the point of Shri Chanda on the water-cement ratio and strength relationship, Dr. Puri replied that they were using Kennedy's method for concrete mix design in this investigation, which automatically took into consideration the void content in the aggregate.

Shri Chaturvedi had raised the point regarding Rihand air entraining agent. It would certainly be tried. Regarding Shri Chaturvedi's mention about shale, Dr. Puri wanted to know at what temperature of calcination he got the maximum benefit.

Dr. Puri informed Shri Khanna that at Bhakra 20 per cent and not 10 per cent of surkhi was being used in concrete. Further, the reactivity of the surkhi was evaluated by a well-known test known as lime reactivity test and, in fact, the Indian Standards Institution was laying specifications for pozzolanas in general and the C.R.R.I. were working to lay down definite specifications for surkhis in particular. So far as the work carried out in the C.R.R.I. on four different types of surkhis was concerned, it had shown that 20 to 25 per cent of cement could be replaced by reactive surkhi. The kaolinitic type of surkhi as well as montmorillonitic type had given excellent results. He suggested to Shri Khanna to read the Paper on this subject published in I.R.C. Road Research Bulletin No. 6.

• **Shri N. H. Taylor** replying to Shri Khanna who had asked if any work had been done on the subject of water-cement ratio, stated that for many years he had been suggesting that in research organizations there should be very close collaboration between the soils department, the concrete department and the asphalt department. The basic principles of design of the three materials seemed to be almost exactly the same but the three departments presented their research in entirely different manner.

It was well-known that when increasing quantities of bitumen were added to aggregate or water to soil, there is at first a reduction in voids in the mineral matter as the fluid lubricates the mass and later on an increase in voids in the aggregate as the particles are moved apart by the surplus water or bitumen. In the case of soils, the amount of water giving the lowest voids in the compacted soil is referred to as the optimum moisture content. In the case of asphalt paving mixtures, the optimum bitumen content is always more than that required to give the most compact aggregate as the air voids in the compacted mass is the important factor.

If increasing quantities of mortar of a given water-cement ratio were added to an aggregate, there was an optimum quantity of mortar applicable to any given method of compaction and any further increase of mortar will increase the workability or slump but will reduce the strength of the concrete. When people talk vaguely about water-cement ratio, they do not always realise that by increasing the water-cement ratio they were not only weakening the matrix in the concrete but by increasing the volume of the mortar they were reducing the quantity of mortar that could be effectively used.

When the grading of an aggregate was being designed according to, say, Fuller's curve, the object is to reduce the voids and thus the volume of mortar required to fill the voids. If the volume of mortar necessary to give a required consistency is reduced by reducing the voids in the aggregate and the cement is kept constant, the water-cement ratio is reduced and the strength of the concrete is increased.

The compressive strength of concrete has two contributing factors: firstly, the strength of the mortar which will be related to the water-cement ratio, and, secondly, the friction in the aggregate itself. If the volume of mortar having a given water-cement ratio was increased so that the concrete had a high slump, the contribution of the aggregate friction must be ignored and the strength of the concrete will be the same as that of the mortar. To sum up, the water-cement ratio determines the strength of the mortar and the strength of the mortar determines the strength of the concrete always, provided that sufficient mortar is present to fill the voids in the aggregate.

Shri K. S. Sankaran offered to supplement information about vibration compaction which was referred to by various speakers.

To test the tensile strength of cement, the I.S.I. specification followed the British Standard Specification specifying the spatula method. In his opinion, with the help of this method, any cement could be made to pass this specification. In the C.R.R.I., about 4 years back, they wanted to eliminate the personal bias involved in the test. While doing compaction they tried to eliminate these variations and it proved to be a little better than the spatula method. Later on, they thought of using the existing compacting machine as it was a standardized one. It was found that the results were very encouraging and it was to be suggested to the I.S.I. to adopt this method for specifying the tensile strength of the concrete.

Shri Chanda and Shri Khanna talked about the design of the mix. Shri Sankaran wanted to impress on all the engineers that the ultimate purpose of the mix design was only to start the trial mixes, as there was no mathematical rule by which to design a mix. In the C.R.R.I., they were not using the good old methods but were trying to evolve new method of mix design. As a result, they had modified Kennedy's formula. They had tried 3 or 4 types of cements till now and hoped to complete another series of tests and present the results before this body.

Shri Sankaran did not agree with Shri Taylor in regard to the comparison between a bituminous concrete and a Portland cement concrete. The concept of the design of the dense graded asphalt

was to use as much asphalt as possible so long as the stability requirements were satisfied. There was no optimum about asphalt content. But in the case of Portland cement concrete, the lower the water-cement ratio the higher the strength. Secondly, Shri Taylor gave a new concept of mortar plus aggregate. Shri Sankaran did not agree with Shri Taylor because even for ordinary pavement concrete, the water-cement ratio controlled the strength. He agreed that, in the case of high strength concrete, the aggregate had got an important part to play for the strength properties, otherwise it did not affect the strength of the concrete.

Shri H. H. Campbell referring to the question of rigid and flexible overlays, stated that he had not read all the Papers in as great detail as he would have liked but he had not seen any mention of actual results which had been recorded. There were two or three established materials for road construction, one of which is concrete and another is asphalt. The two do not combine. In the past, it was thought perhaps they would, but experience had shown that they do not. If cracks appear in concrete surface and asphalt is put in over the top, no matter how thick within the reach of economy, the cracks will eventually be transmitted through to the asphalt layer. He would be interested to know the results of any experiments made so far in this field. But his recommendation was—and this possibility has been suggested before—to break up any cracked concrete in situ to provide the base and then lay the asphalt on top.

Shri K. S. Sankaran replying to Shri Campbell's comment, stated that flexible pavement was amenable to stage construction. Now a new study was in hand to see whether rigid pavement was also amenable to stage construction or not. For example, the concrete roads in the country, generally speaking, were 4 in. thick and like some other roads, if the traffic was less, they could stand it. But heavy traffic was now expected in the next few years and the question was whether the existing 4 in. thick concrete pavement could be strengthened by an overlay of concrete? Experiments were already in hand, the preliminary results were encouraging and showed that when an overlay of the same thickness as the existing pavement was bonded, the flexural strength was of the same order as that of the total increased thickness. Shri Sankaran felt that there was a possibility of stage construction of the rigid pavement if it had not cracked. This will be particularly significant in the case of those pavements which were now in a good condition and where heavy traffic was expected after sometime.

Portland Cement Association of U.S.A. have shown how to bond the two slabs and what type of insulation layer should be used. Various permutations and combinations were being tried in the C.R.R.I. to see how far it was feasible.

Shri K. K. Nambiar did not agree with Shri Campbell that when an overlay was to be laid, the rigid and the flexible pavements could not act together. This assumption must have been of recent origin because both types of pavement had been getting on very well. In certain States in U.S.A., it was a standard policy to construct concrete pavement to start with and after some years of life, on the concrete road showing signs of wear, a layer of asphaltic concrete was superimposed.

Even in the City of Bombay, same policy had been followed all these years, to lay a concrete base and then to put a thick asphalt overlay on it.

Shri S. R. Mehra referring to the question of overlays on concrete roads, stated that the problem was much more serious than it appeared on the surface. There were hundreds of miles of concrete roads which were not able to stand the type of traffic coming on them and the problem was how to prevent them from going to rack and ruin. In the present concept of concrete roads, it was going to be extremely difficult to convince anybody that he should put a 6½-in. thick overlay on a concrete road 3 or 4 in. thick. The other alternative, where it was possible both within the scope of economy and practice, was to put reasonably thick flexible overlays on rigid bases, treating the existing uncracked roads as bases, and produce roads which are likely to tide over for even 10 or 12 years. Personally, he believed that there was a possibility of getting something out of the idea of putting flexible overlays over existing concrete roads in reasonable condition. The calculations showed that even 5 or 6 in. thick flexible overlay might tide them over for quite a few years. The C.R.R.I. were going the whole hog in trying out the idea.

Shri C. L. N. Iyengar was more or less in agreement with Shri Taylor, because what he said might not be totally untrue. Up to now, the general concept of the maximum size of the coarse aggregate in concrete was that the coarse aggregate should not be more than 1/3rd the least lateral dimension fixing the aggregate size for a 6-in. thick slab as 2 in. and possibly for a thicker section a much larger figure. This was the basis to get an economical yield of concrete by increasing the aggregate size, and as the surface area of the aggregate was reduced by increase in size, lesser mortar quantities could give the required workability. In 1959 proceedings of the Highway Research Board, there is an article suggesting that there was an optimum maximum size of aggregate which gave the maximum strength of concrete. Of course, there was no denying the fact that water-cement ratio was the most important consideration as far as the strength of concrete was concerned.

As for overlays, Shri Mehra mentioned the minimum thickness of overlays being about 6 in. Shri Iyengar did not know how the

thickness had been arrived at. They had occasion to examine the design thickness of overlays for a badly cracked portion as well as medium cracked portions on certain sections of the National Highways with 5 in. thick concrete pavement. For intensely cracked sections, on the basis of experience, they calculated a 4½-in. thickness of additional concrete, whereas for the intermediate cracked sections, the thickness was of the order of 3½ in. for an equivalent depth of 6 in. of concrete. Of course, it should be borne in mind that it was not merely the cracking that was responsible for the damage that works into the bituminous overlays or the concrete overlays when laid on the existing slabs. Rather, if the overlay, whether of bitumen or concrete, was laid, without taking care of the subgrade failure, there was going to be a lot of trouble.

Shri M. B. Jayawant clarified that out of the two grades of Ceremuls marketed, one grade "S/V Ceremul C" was readily available. The other grade "S/V Ceremul M" could also be supplied; but due to the restrictions on imports of its ingredients, an actual user's import licence was necessary.

Shri Sujan Singh was surprised that none of the speakers had touched on the important subject of joint sealing compounds. In Bombay, while driving on the Marine Drive one bumps all the way, because the joints between slabs were bad. He referred to page 688 where it was reported that some work had been done which was good at certain temperatures but when tried at low temperatures did not behave satisfactorily. He felt it was high time that research workers and the manufacturers tried to produce a solution and concentrate on one type suitable both for roads and air-fields and for all purposes. For airfields, certainly something special was needed particularly with the jet airplane coming in. For roads, certainly, it should not be difficult to design a suitable joint sealing compound because after all the driving comfort did not depend only on the cement slab but also on the joints. He knew that lot of work had been done, but unfortunately the progress of the works was at such a stage that results could not be implemented.

Dr. Bh. Subbaraju referred to Shri C. L. N. Iyengar's remark stating that he calculated the thickness of overlay on some National Highways as 3½ in., while Shri Mehra suggested a thickness of 6 to 6½ in. According to Dr. Raju, both of them might have used the same formula, but they might have taken different wheel loads for the design purpose and hence the difference.

Shri H. H. Campbell wanted to clarify two points which, he felt, he possibly did not make clear earlier.

In connection with overlays, as Shri Mehra pointed out, where slabs had not suffered, the matter had to be considered on different

basis. But he had been thinking of cases where the concrete bases had cracked considerably. In such cases, he could only recommend that the concrete should be broken in situ first and then a flexible overlay put on top. In cities, they have to consider the problem of service mains underneath.

Also, if there was any crack underneath, it would eventually show itself through. It must be remembered that a bitumen or asphalt carpet has no strength in tension. Therefore, some form of slip-sheet or isolating membrane over the crack should be placed over the crack first. The idea of placing that there before laying the asphalt carpet on top was to distribute the load more evenly.

Regarding Shri Sujan Singh's point about bump over the joints, he felt these were caused by the subsidence or settlement underneath and he felt that something more than just jointing was needed. A process had been devised for "jacking" the corners, using either mud, a concrete mix or hot asphalt. The great advantage of hot asphalt is that it solidifies immediately and if water is present under the slab there is no chance of retarding the setting. He had seen asphalt jacking work carried out in Belgium to great satisfaction, using a blown grade injected by an ordinary bitumen sprayer at the rate of 14 lb per sq. in. max. @ 200°C.

Finally, this problem of cracked or spalled concrete is not unique to India. In Germany, the Reich Autobahns which served so well during the war were cracking up now. The problem was being met by breaking up the concrete either in situ or in crushers, and using it as the base for subsequent flexible pavements.

FLEXIBLE PAVEMENTS

Shri C. G. Swaminathan, introducing the section "Flexible Pavements", stated that the criteria for the design of dense mixture had been discussed at length and he did not propose to raise further points as to what should be the exact criteria for Indian conditions. The second salient point dealt with a well-known factor that as a result of mechanisation there would not only be rapid progress with improved methods of construction but also it would yield a good surface as has also been shown in his Paper, by the comparison of bump integrator data on mechanically laid and manually laid surfaces. Regarding the third point, he stated that tar and bitumen could be mixed only in a proportion of 75 to 25 or 25 to 75. Some work was done in the C.R.R.I. using low temperature tar and bitumen and in many cases satisfactory mixtures were obtained with 50 : 50 of each. Lastly, as regards the use of emulsions, in Europe, emulsion was used extensively and new types of emulsions such as cationic ones were in vogue. The only deterrent factor for use in India was that the emulsion costs were more or less the same

as bitumen and, as such, straight bitumen was obviously preferred. However, he liked the manufacturers of emulsions to come forward and give their opinion on this matter.

Shri N. H. Taylor stated that references to the design of flexible pavements tended to over-simplify the problem when relating pavement thickness to the C.B.R. of the subgrade. For the benefit of young or inexperienced designers, it should be stressed that, throughout the thickness of the pavement, the strength or C.B.R. of the material used must increase from the bottom to the top of the pavement. If this necessity was always appreciated they would not find materials with a low C.B.R., such as plastic soil being used above brick or rubble soling.

Shri K. P. Nair, referring to the comments made by Shri N. H. Taylor about the test devised at the C.R.R.I. for absorption and swell of bituminous concrete, stated that the C.R.R.I. test was preferable to the swell test suggested by Shri Taylor, because in his method the compacted specimen to be tested was put in a chamber, evacuated, water added to immerse the specimen at normal temperature and then subjected to air pressure, while in the C.R.R.I. test all the three operations were covered by a single operation, viz., immersing the specimen in water and evacuating the chamber to the desired extent. It had an added advantage that the temperature of the water was also maintained at 140°F during the test, the temperature corresponding to the stability test temperature, and it is well-known that swelling took place as a result of stripping or absorption.

Further work to finalise the test conditions, he added, was in progress.

Shri K. Ramaswamy Reddy stated that in one of the experimental works in Madras State, i.e., in Rattambedu village road, surface dressing was done over the mechanically stabilized sand gravel base. The primer used in that road was Road Tar No. 3. The entire section failed completely in a short time mainly due to the inadequate design. For the mechanically stabilized sand clay or sand gravel mixes, the maximum C.B.R. value was found to be only 35 per cent and such a base course would not function successfully immediately below the 3/4 in. wearing course. His experience was that for the successful behaviour of the flexible pavement, the base course immediately below the wearing course should have a C.B.R. value of not less than 80 per cent.

Shri G. C. Khanna stated that in the recommendations made on the subject of 'Flexible Pavements', the Road Research authorities had suggested the use of bitumen upto 110 to 115 lb and in some cases upto 150 lb. The Government had asked the engineers to devise cheap specifications for our roads while the specifica-

tion proposed was extremely expensive involving large quantities of bitumen. The Road Research authorities should, therefore, focus their attention on evolving cheap specifications.

Even if 3 in. thick pre-mix carpet was used, the quantity of bitumen used would vary from 75 to 90 lb depending on the grading of the aggregate. He would, therefore, like to know the advantages of adopting 'Grout specification' involving greater quantity of bitumen.

Shri R. P. Chanda suggested that the producers should undertake researches towards improving the durability of tar and bitumen under water. Many roads in Bengal were over-topped during floods and remained submerged for several days or even weeks. Naturally, damages to the asphalt binders were severe. If resistance to water could be improved in the production stage, it would cut down considerably the maintenance cost of the roadways.

Shri D. C. Chaturvedi felt that there appeared to be some mistake in para 2.1.2, regarding simultaneous painting with tar and bitumen. Their experience was that simultaneous coat of tar and bitumen was better than one coat painting with tar alone and not two coat painting as mentioned, the quantity of binder in simultaneous coat being only slightly more than one coat painting with tar.

For open graded premix carpets, use of pre-coated chipping had got definite advantage over usual surface dressing. However, the last sentence "and even better than a two coat surface dressing" should be deleted, as no comparison had been made in their study on this aspect.

Shri C. G. Swaminathan, replying to the two points raised by Shri Khanna in regard to the amount of bitumen required for $\frac{1}{4}$ in. size aggregate, stated that four per cent bitumen by weight of aggregate was required which would roughly work out to about $3\frac{1}{2}$ lb per cu. ft. of aggregate. As regards the optimum quantity of binder required for bituminous penetration macadam, they tried an empirical type of test and not a rigorous test, to obtain the maximum quantity that would be necessary. They found that 110 and 150 lb for 2 in. and 3 in. macadam respectively tallied more or less with the accepted practices of many States and marketing firms.

Dr. Bh. Subbaraju took up the same point raised by Shri Khanna and replied by Shri Swaminathan. In his view, the question posed by Shri Khanna was if he was able to get away with $3\frac{1}{2}$ lb bitumen in surface dressing, why use such costly penetration macadam of 150 lb? What was the additional advantage? But he requested Shri Khanna to remember that he could not get on with

surface dressing for ever as when the wheel loads increase tremendously, the $\frac{3}{4}$ in. premix or surface dressing would not do. It was only as an insulation layer to partly prevent the moisture movement from top to bottom. Penetration macadam was intended for improved constructions giving additional structural stability wherever necessary.

Shri Sujan Singh expressed his doubts about what had been said about 3 in. full grout done in Northern India his own experience was not a happy one. The climatic conditions in the North being extreme, if 3 in. grout with 150 or 110 lb was used as mentioned in the note, it would simply give way under the bullock-cart traffic around Delhi and right up to the North of Punjab. That is why this specification of full grout was never popular in the Northern India, and it was very popular in Bombay, and Calcutta where rains were heavy.

Shri J. M. Trehan, referring to an experiment on a road near Madras, viz., Rattambedu village road, stated that Shri Reddy gave the details about the road, and Shri Nambiar explained that the failure was probably due to the particular type of traffic and not due to any shortcoming in the specification itself.

This particular specification, Shri Trehan added, was meant for trial on a village road where nothing but iron-tyred traffic could be expected. The specification was also tried on the Road Test Track at Calcutta. There also it failed under the iron tyred traffic, and the failure on the Rattambedu road was exactly similar to the one on the Test Track, i.e., the stabilized-soil seemed to have softened to some extent and had heaved on both sides of the wheel tracks. This experiment was part of the field research which was to be carried out in two States, viz., in the Punjab and Madras. Madras carried out the experiment exactly as laid down by the Soil Research Committee, but the Punjab having foreseen the failure, covered the stabilised soil with some stone metal as suggested by Shri Mehra's latest specification (about 7 cu. ft. of stone metal per 100 sq. ft.). On that particular road, which is in Bighan village near Sonapat, the results had been better than those obtained in Madras.

WATER-BOUND MACADAM AND BRICK PAVEMENTS

Shri D. C. Chaturvedi explained that the experiments done on brick pavements had already been discussed during the last Session at Hyderabad and the present observations were based on the further study of the behaviour of these surfaces.

He stated that the current practice in the construction of water-bound macadam, was that the stone metal was consolidated during rainy season and the surface painting carried out some time in

October or November. During consolidation, mud slurry was added to fill up the voids. During this period when the surface remained unpainted, it had to be blinded constantly. Otherwise, metal was likely to come out and make the surface very rough. It was decided to carry out this experiment in a small stretch using emulsion in the mud slurry to stabilize it to some extent. It was observed that painting could be postponed for about six months and no blinding was required during this period. A Paper on the subject has been submitted to the Indian Roads Congress and when published the matter could be discussed in detail.

Dr. A. S. Adke reported that no experiments on brick pavements had been carried out in his State because they had ample quantity of stone available. He described an experiment performed with stone cubes similar to bricks in the Kolhapur district of Bombay. That road had stood very well for the last 6 or 7 years. He, therefore, recommended that in areas where stone cubes were available in plenty, stone cubes with the cushioning of sand and with emulsion of bitumen with sand to fill the joints should be adopted and that would give very good riding surface, of course, on macadam base.

SOIL ROADS AND STABILIZATION

Shri K. Ramaswamy Reddy, introducing the subject for discussion, stated that the only work done by them in black cotton soil was on the Rattambedu road near Madras, which had failed; there they had mixed sand with black cotton soil to reduce plasticity.

Soil cement stabilization had been done for the base course for a length of about 22 miles on Ramnad-Mandapam road over which asphaltic concrete $1\frac{1}{2}$ in. thick was laid for the wearing surface. The road behaved alright for a short period, but after some time, some stretches failed. On examination, it was found that reaches with unconfined compressive strength of the soil cement of less than 400 p.s.i., had failed under the inundation condition. But reaches even with design value of 250 lb per sq. in. compressive strength in areas not submerged under water stood very well. From experience on this road, it was found that a design criteria of a minimum strength of 250 lb per sq. in. for 7 days moist curing was not at all adequate for places with heavy concentrations of rainfall and frequent submersions. The laboratory investigations taken up in the Highways Research Station, Madras, also confirmed the above fact and a detailed report regarding this was being sent to the I.R.C.

Regarding lime stabilization, in one of the experimental works, addition of small percentage of lime was tried for increasing the strength characteristics of a particular gravel. But from the various test values, it was found that though the plasticity characteristics of the gravel were reduced considerably by the addition of

sand, the strength characteristics of same did not increase appreciably to the required standard.

Dr. H. L. Uppal, initiating the discussion on soil stabilization, stated that research work had been going on in different parts of India on the use of local materials with the object of economising in the cost of road construction. The various lines on which work has been carried out consist either in improving the local soil as such and by mechanical gradation or by stabilization with lime, chemicals or binders like molasses or bitumen, depending upon the type of soil or cost of material.

(i) **Mechanical stabilization with soft aggregates:** One mile length of road was being constructed in every state to see how far mechanical stabilization could cut down the cost of road construction. Even in predominantly black cotton soil areas, there were some stretches where this technique could also be justified. (ii) The other line of attack had been to improve the soils by lime treatment. There were two particular types of soils met with in the country. Alluvial soils to which even if a small quantity of lime was added, the reaction was very favourable resulting in improved C.B.R. With further addition of lime the C.B.R. will even go as high as nearly 80 per cent. That meant, that these soils when properly graded and treated with lime, would hardly need 2 to 3 in. of stone met above it. The other use of lime was for the improvement of clayey soils. Field experiments had been carried out on some small lengths with concentration of lime varying between 4 to 5 per cent.

Normally, the economics of treatment of black cotton soil with lime would depend upon the cost of stone boulders available at site. Even if the cost of the lime treated soil base is the same as that of the stone boulder base, it is justifiable because it prevents the stone from sinking into the subgrade, and thus effects saving in the maintenance if not in the initial cost.

Research work carried out on the chemical stabilization of black cotton soil had shown that addition of small concentration of alum can considerably reduce the swelling characteristics and thereby increasing the C.B.R.

The other experiments carried out were on the use of lime mixed with molasses. About two years ago, this subject was discussed on the platform of the I.R.C. It was stated that since molasses were not available in plenty for such purposes, the technique could not be pursued. All the molasses that a factory produced could not be removed for power alcohol and, therefore, the areas near about the factories had still a case for the use of molasses. The molasses would also work well in increasing the binding property of the sandy

soils, but with addition of 2 per cent of lime and double the quantity of molasses, the crust improves considerably in strength as well as in its resistance to abrasion.

Cement stabilization is one line which was showing promising results, specially for its speed in construction. The work carried out in the C.R.R.I. had shown that there were two main points that could be taken into consideration with soil cement. One was its resistance to softening effect of water, which was determined by the C.B.R. and the other was the compressive strength which should be enough to withstand the stresses at various depths.

The other raw material in addition to soil is moorum. Recent work carried out by the C.R.R.I. on the use of local material for the construction of a road in Durgapur has shown that ordinary moorum having hardly a soaked C.B.R. value of about 30 to 40, when treated with 2 per cent of lime, gives a C.B.R. of 150 or so. That shows that treated moorum is capable of being surface treated.

Another aspect which is very essential for road construction, more so for stabilized soil roads, is the degree of saturation of the subgrade. The study conducted in India had shown that all the areas are not equally saturated and, therefore, there can be some flexibility in cutting down the thickness of road pavements, depending upon the degree of saturation.

Shri P. L. De did not agree with the contention of **Shri Reddy** that he had been able to reduce the P.I. of the black cotton soil by use of sand for mechanical stabilization as there were lots of practical difficulties in doing this. First difficulty was powdering the black cotton soil to that degree of fineness at which it could be thoroughly mixed with sand. The laboratory test determined the P.I. of the mix in which there were individual sand and clay particles, the latter taking up the same amount of moisture at liquid limit that they would have taken before sand was added. But because there was some amount of sand, the actual calculations gave less amount of water in the liquid limit. So, the P.I. of the clay particles or the activity of the clay still remained there. Inactive material like sand could not reduce the activity of the clay. It required some active material to reduce the P.I. of the clay and that could be done by some chemicals. And the cheapest one was lime.

Regarding low grade aggregates, now that several new steel factories had come up, lot of blast furnace slag will be available for road construction. Slag has got very good abrasion values. Blast furnace slag from Indian Iron and Steel Works at Kulti had the Los Angeles abrasion values round about 20, whereas best quality of stone available in eastern India, known as "Pakur stone", has

13 to 15. The slag compared well with good quality stone and had the possibilities of being used in roads.

Dr. H. L. Uppal, having described the various items of research going on in India, repeated that the major sections under which soil had been used for purposes of roads and airfields was either with mechanical stabilization or stabilization with lime both for alluvial and black cotton soils. In fact, on the basis of research work done in India and abroad, lime had mostly been advocated for use on clayey soils, but work now going on in India has revealed beyond doubt that alluvial soils also react favourably towards lime, with the result that in waterlogged areas such treatment would be of special benefit. Further, lime-treated soil helped in developing the C.B.R. of such an order that one could do with very much lesser thicknesses of road pavements.

The other item mentioned was the use of some waste material like molasses at least for village roads, and it has been found as a result of some experiments, that lime and molasses go very well for unsurfaced stabilized soil-roads.

The other aspect of road research in soils included the study of moisture in the subgrade. In the absence of any information on this subject, all roads in India were being designed at saturated conditions. It was not known how far these conditions were true. In the absence of any information, it also could not be said with certainty whether the road was going to get saturated in its lifetime or not. With that objective in view, an All-India survey had been carried out and it had been shown that all areas were not saturated so as to justify the testing of a subgrade under soaked condition. There is nothing like a field moisture equivalent as in England that, once the road was surface treated, the subgrade attained the equilibrium which was far below saturation.

Shri C. L. N. Iyengar stated that time and again discussions were had on the question of a wearing surface on soil stabilized construction and the grafting of stone as a mechanical aid to the satisfactory bond. But having had an opportunity of seeing soil cement construction in various parts of the country, he wanted to place his views before the house. There should be three factors to be reckoned with while discussing the question of the performance of the wearing surface on stabilized-soil base courses, viz., the type of traffic, the elastic or structural strength of the pavement as a whole, and the bond.

His observations made on the last series of experiments on the test track were that the earliest sections to fail were the soil-sand sections, next in order were the cement stabilized courses, and then

the macadam courses which had been given surface treatment. But along with the same sections there was a certain section along the curved portion of the track which had a much higher structural strength than the rest of the track portions. It was noticed that where grafting was done, there was a drag of the top portion of the stabilized sections along with the wearing surface, whereas in the case of the macadam portions there was no drag but mostly shoving of the base course. Now, between the macadam portion of the test section and the other portions of the macadam in the curved portions which had a much higher structural strength, it was distinctly noticed that the deformation of the macadam was very little and the carpet had alone suffered. All this indicated that in the range where elastic deformations took place, there was a certain amount of the drag of the base course along with the wearing surface. If only the structural strength of the pavement was adequate, he was sure that mere bond through surface adhesion should have been adequate for satisfactory behaviour of the wearing course.

In this connection, he cited the case of a pavement near Mehsana in Bombay which had stood well under traffic for a considerable time.

Another case was quoted where they had experimented with a poor type of construction over the soil cement. The conditions there were extremely adverse to the behaviour of a porous surface on the top of the soil cement. This was in the Bombay Corporation limits. There was traffic in one direction only and road was on a steep grade, with traffic going down grade. In this construction, very severe damage was noticed after the first monsoons. The effects noticed were of two types, one was complete disruption of the surface by the entry of water through the poor surfacing, and, secondly, due to the unidirectional traffic, the creep of the bituminous semi-grouted surface looked as though a 3-in. surface had undulations ranging from 4 to 5 in., giving the appearance as though the whole soil cement had actually subsided. But subsequent excavations at a few places revealed that actually there was no damage to the surface of the soil cement, but only failure of the surface due to inadequate bond.

Shri C. L. N. Iyengar believed that the soil cement technique was still to get its rational explanation both by way of the design method as well as by actually consistent structural performance of the material itself. After all, the idea of soil cement arose out of a situation where economically no other method of road construction could be employed in some of the southern states of the U.S.A., and, secondly, there was also field for large scale experiments of this material during war time when some advance airfields had to be constructed all over the Western Europe without sufficient time even for

proper testing of soils, etc., the empirical methods employed by the engineers in the U.S.A. were transplanted both in the Western Europe as well as on some of the airfields in India. He, therefore, suggested that in addition to the graded C.B.R. method employed for the Agra Taxi Track, a similar pavement on the stabilized-soil base carried right up to within 6 in. of the top of the pavement and over that only a 6 in. depth of structural soil cement giving a compressive strength of about 400 lb per sq. in. in 7 days be constructed and topped with the same bituminous surfacing, so that the design method worked out on the basis of some theoretical formulae could also be verified as well as the performance of the empirical method judged.

About the structure of soil cement laid in West Bengal, some one remarked that two years should not be adequate time to judge whether performance of the pavement was satisfactory or not. **Shri Iyengar** did not agree with that view and thought that two years was a reasonable time for all the traffic factors to affect the pavement. Therefore, the conclusions drawn from those stretches were really of a permanent nature.

Regarding the behaviour of thin wearing surfaces on some of the rigid pavements, **Shri Iyengar** stated that though soil cement does not literally come within the scope of rigid pavements, the cracking pattern of soil cement was governed by the type of soils that were met with. In the case of some of the clayey soils or soils with predominance of clay, the cracking pattern comprised a large number of cracks of small size which did not show up in magnitude, whereas in the case of some of the sandy or silty soils or some of the soils with predominance of sand, the cracking frequency was not very much, though the size of the cracks was of considerable magnitude. In the case of the wearing surface with cracks of smaller order of magnitude, **Shri Iyengar** stated that there was no apprehension about the behaviour of the wearing surface because of the aggregate interlock or the friction at the planes of cracks being sufficient to withstand any relative deformation or settlement on either side of the crack. As far as the cracks of a large magnitude were concerned, definitely they created a great difficulty in regard to the wearing surface. So long as the bituminous wearing surface was fresh for a year or so, there was really no fear of cracking. But the moment the binder content got reduced, either by evaporation or oxidation, the real trouble started. So long as the binder content was replenished by any method, there should be no difficulty in maintaining satisfactorily flexible wearing surface on top of a rigid base.

Dr. A. S. Adke suggested that in view of the extensive improvements to roads and also construction of new roads on a large scale being carried out all over the country, the experiments that had been

carried out in the laboratory should be extended to the field, he was glad to know that some field tests were being carried out in Madras as well as in the Punjab. Dr. H. L. Uppal informed that one mile length of road was being taken up in each State. But on account of the varied conditions from State to State and within the State itself, both in regard to rainfall as well as soils, etc., taking up a mile of road in each State would not help. He would, therefore, like that the C.R.R.I. should, near about the place where the annual sessions of the I.R.C. were held, get suitable length constructed following the specifications found successful in the laboratory, for demonstration.

Dr. Adke stated that he was in charge of the West Coast Road where construction on a large scale was going on and he would appreciate any help and advice by the Institute in stabilizing the soils which were used in the base.

Shri U. J. Bhatt stated that he had no doubt that the C.R.R.I. was always willing to help but it was up to each individual state to put up a more extensive programme instead of one mile, say, 15 or 20 miles, and drew attention of the members to the Presidential Address where also emphasis was laid on research and its application.

In regard to the construction of embankments in the marshy ground, item 4 of salient points under this section, Shri Bhatt stated that work on the construction of embankment on the Eastern Express Highway was being continued and the embankment in some stretches was nearly complete. He added that if any of the engineers happened to come to Bombay, the State would be very glad to take them round to the site where for the first time sand drains were being provided in this country.

Shri S. N. Gupta invited reference to his Paper No. 213 which was the first Paper discussed in the current session containing some studies in soil mechanics.

He then took up the different items in the report serially. West Bengal has some black cotton soil but the C.R.R.I. would not accept it as such. According to the definition, a real black cotton soil must have L.L. of above 50.

Regarding stabilization with lime, he stated that they had carried out some experiments in the laboratory and the results were more encouraging than the C.R.R.I. results, though they had not been able to take up any extensive work on the roads.

Regarding mechanical stabilization, they have been doing large number of works with this type of soil stabilization in Bengal with good results.

Chemical stabilization: As far back as 1950, the two very short stretches of road were laid with chemical stabilization, but the experiments were not conclusive and they did not draw any definite conclusions.

Cement stabilization: The report refers to the work done two years ago only in Bengal. But prior to that, in some of the Community Development Blocks, a soil cement road was adopted as a low cost road and it was reported that the soil cement base and subbase had been standing alright. The wearing course of 1½ in. premixed carpet had been given. The road pavement was only 8 ft wide. Naturally, there was tracking of wheels, and on the flexible wearing course of the bituminous carpet, lateral movements were seen. Under the tracks, the carpet was getting thinner and was moving sideways. It was, therefore, concluded that some method to secure better grip between the base and the wearing course laid directly on the soil cement base should be devised. Then the suggestion came to graft the stone. This technique was used on Barasat-Basirhat road about 30 miles from Calcutta, and the members of the Test Track Committee were shown sections cut from that road. That road has been standing alright till now. As regards the suggestions that just one priming coat should be enough to give adequate grip between the wearing course and the soil cement base, Shri Gupta stated that on the road built in the Community Development Block mentioned above, they did apply the priming coat, but that did not help very much in keeping the wearing coat in proper condition.

As regards bituminous stabilization, Shri Gupta stated that only two stretches were tried on the Government Test Track at Calcutta. The experiments were not very conclusive because they were not fully equipped with all the implements and equipment necessary to have thorough mixing of bitumen with pulverized soil, but there was a possibility of adopting this technique.

Stabilization with lime and molasses: Molasses had not been tried in Bengal. Stabilization with lime has been giving very encouraging results in the laboratory and it would now be tried on the roads.

Regarding low grade aggregates, like brick, moorum, kankar, soft gravel, etc., they were being used extensively in West Bengal. Low grade aggregates are now being adopted as an intermediate layer in the roads.

Shri S. R. Mehra observed that they had been talking about controlled compaction of soils now for a number of years, but psychologically they had not yet accepted that it was possible to treat scientifically compacted soil as a part of the required pavement thickness. It would be an advancement towards a positive attitude

towards providing adequate thicknesses, if instead of looking upon controlled soil compaction as an improvement of the subgrade, they looked upon compacted soil to a given minimum density and to a known bearing value, as a part of the pavement itself. It would make people think in terms of the larger thicknesses of pavements needed today, in the context of increasing traffic loads and traffic intensities. It might also help people to progressively think in terms of the possibility of actually designing the pavement thicknesses instead of sticking to the thicknesses which were being based on the past experience and which are known for certain to be not adequate for present-day traffic. Whereas before construction it is possible to use compacted soil at the bottom of the pavement, it is not possible to do anything about it once the pavement has been constructed. He, therefore, enjoined the engineers to consider the use of compacted soil as a very cheap substitute for foundation and as a very practical way of providing the extra thickness that was needed for the pavements.

Shri M. Meeran referred to the two methods of surface dressing described in the report, viz., one by grafting of chips and the other with priming, and requested information as regards the economics of both the methods. Based on the ruling prices, he would like to have some comparative costs.

TRAFFIC AND TRAFFIC SAFETY

Shri T. S. Khanna introducing the subject, particularly drew attention of the members to the problem of parking meters which were proposed to be installed in Delhi and which seemed to be a little controversial. There were some commercial firms who objected to that, and he would like very much to have members' views about it. It is very difficult to control parking in congested areas unless meters were installed, because people left the cars overnight and also repaired cars in these areas without any check. Used cars for sale were also parked permanently.

Regarding goods traffic survey in Delhi, it was carried out by the Roads Wing and Dr. M. K. Ganguli would perhaps give some more details of this survey as there are a number of interesting results which Dr. Ganguli found out from that survey.

Regarding design of kilometre stones, the work done was presented to the Specifications and Standards Committee and they have taken the decision on new designs.

"Origin and Destination Survey" Paper had already been discussed in the current session but if there were any more point or comments he would like to hear them.

Regarding design of traffic islands on road junctions, Shri Thillainayagam perhaps would like to explain a little more if there were any general results which could be applied all over India or which might help change the geometric standards in any way. Study on operational cost of vehicles was being carried out in Delhi by the C.R.R.I. And if there was any information that could be of use to them, he would be delighted to have.

Shri R. Thillainayagam stated that lot of work was being done in the Highway Research Station, Madras, on geometric designs both for the State Highways Department and for the Corporation of Madras and other Municipalities. Their experience had shown that many of the existing roundabouts put up some years ago in Madras needed to be replaced by traffic signals, because the roundabouts were not functioning properly due to the increased traffic. Also, due to the narrow roads where medians had been put up, the traffic was finding it difficult to manœuvre within the restricted roadway and they were removing the medians and providing lane markings instead.

In Madras, before the war, traffic counts on all State Highways and Major District Roads were taken twice a year, once during the normal period and again during the peak period for one week. At present traffic count was being taken once in three years, once during the normal period and another during the peak period for about a week during that year. A short study appears to have been made by the Central Road Research Institute to expand short traffic count of one hour to get at the probable average of daily traffic. He, therefore, suggested that the Central Government should set up permanent traffic count stations on all National Highways, to take traffic counts throughout the year for a number of years. From the data it might be possible to evolve a factor for expanding short count for the various regions throughout India.

As regards truck traffic, Madras had proposed to set up permanent weigh bridge stations on all State borders where a regular check about the weight of the truck and of the various goods coming into the State could be made.

As regards parking meters, Shri Thillainayagam felt that motor vehicles being already heavily taxed, it would be really a hardship on them if they were going to be taxed again. He suggested that they should ask the building owners to put up private parking accommodation for their customers coming in motor vehicles. If the planners of the buildings had thought of parking requirements before they constructed the building, they could have at least converted the basement floor into parking garages and used the other floors for offices, etc. He added that the Corporation and building

authorities should specify the parking spaces to be provided by the various types of buildings and insist that the building owners should compulsorily provide specified parking places depending on the type of building. Similarly, cinema houses, hotels, and restaurants should provide the prescribed parking spaces before they were given licence to operate or before their licences were renewed.

As regards the provision of road signs and road markings, they were providing quite a lot of signs in Madras State. But unless these signs were enforced, they were of no use. In Bangalore, there were a number of signs indicating "Halt and Proceed", but many did not stop at these signs. In Madras, too, signs restricting speed limit were observed by nobody. So, he felt that the regulations posted must be reasonable and should be followed up by enforcement.

As regards road accidents, Madras had very few records. He suggested adoption of a uniform policy throughout India. The Police authorities, being the investigating authorities and more or less a non-technical body, should be advised about the information to be collected. For collecting this data they should have a common form.

Shri Thillainayagam added that adoption of minimum speed on the roads, was also discussed during the Traffic Seminar at Bombay and it was finally decided that it was too early to adopt this in India, even though in Japan they were going to adopt this on their expressways. Unless separate highways for motor vehicles were constructed, the adoption of minimum speed limit would not be possible.

Shri M. Meeran remarked that parking meter is quite a common thing in the U.S.A., but any experiment in this direction in this country, he was afraid, might not be a practical proposition.

Regarding traffic islands in the city of Madras, referred to by **Shri Thillainayagam** he stated that in Madras they found one difficulty in securing sufficient space at the intersections to put in large circles to suit the long Leyland buses of the Public Transport, etc., which required a minimum turning diameter of about 60 ft and sufficient extra space for carriageway all round. In cities like Madras, they had not only to provide at least two lanes for fast traffic but also extra lanes for slow moving traffic in addition to pedestrians and the cyclists. So, on important road intersections converging round the rotary, a minimum of 34 ft carriage way besides a raised pavement for the pedestrians, was required. On these lines, some of the road junctions were being redesigned in the city of Madras.

Shri Meeran went on to explain that till recently traffic control devices were being executed at the expense of the local body in Madras. About 4 years back, he took up the question whether it was the responsibility of the local body to bear the expenses or the police being the authority charged with the traffic control. The question was examined and it was agreed that the Government would pay for the work and the Corporation would execute it.

He added that the question was now being re-examined as it was considered that the intersections with rotaries were not quite satisfactory in the present context of increased traffic and that the rotaries should be replaced by automatic traffic signals. Though accepted in principle, there was the question of initial cost. One automatic traffic signal, say, a 6-phase signal, might cost about Rs 15,000 or so plus the maintenance expense of the electric devices, etc. Another point for consideration in the case of automatic traffic signals was when there were a number of intersections from the cross roads with the main road at intervals, not spaced at calculated points, there would be difficulty of synchronizing the signals for a number of intersections. Also, there was the slow traffic mixing up with fast traffic. Some of the engineers might have noticed in the States that in the Grid Iron pattern of the planning of cities, the synchronization of the signals was arranged with a view to clear about half a dozen cross roads at one stretch because the spacing of the cross roads was very nicely arranged. But when the spacing of the cross roads was not uniform, it would present some difficulty.

Regarding the Life Insurance Corporation Building in Madras, the original design provided for the entire ground floor for parking, but the design was changed only after providing adequate parking space at the rear of the building. **Shri Meeran** added that there are provisions in the municipal rules to insist on the parking lots in the case of public buildings, cinemas, etc., but there was no provision in the municipal rules to insist on reservations for parking in the case of ordinary shops in the bazar areas. In the latter case, it was the responsibility of the road authorities to provide sufficient parking spaces in all market areas and public roads for the benefit of the shopping public.

Shri U. J. Bhatt observed that to copy or imitate what had been done in the U.S.A. might be out of necessity. The conditions might not be as bad in Madras, but they were desperate in certain parts of Bombay, Calcutta and Delhi. Even in Europe, the main problem facing them in the existing towns and the layout in metropolitan areas was how to provide and control the motor vehicles and their parking. He found in Rome last October that with a population of 2.2 million there were 3,50,000 cars to be provided and parking meters was the only answer to that.

Shri S. R. Mehra, referring to the various arguments offered against parking meters, stated that the telephone system with the penny-slot arrangement was already working over a number of years and there seemed no reason why the parking meters should not work. The whole idea behind parking meters was that if people wanted to enjoy the luxury of going to shop in their own cars instead of public transport, then they should pay for it. It would automatically have the effect of reducing the number of people wanting to park their vehicles in congested areas.

Shri M. Meeran, replying to Shri Mehra's contention about the telephone system working very well, stated that there was difference in the working of this system. There, only by putting in a coin first, one could use the phone. But in the case of parking meters, whether the coin was put in or not, one can park the car there and walk away. And a policeman could not be watching all the time whether people put in the coin or not.

Shri T. S. Khanna stated that when they proposed parking meters, it was presumed that it was clear to everybody how these meters operated. A policeman on duty was always there. If a car was parked, on the parking meter dial would show red and the car would get a challan receipt.

Shri C. L. N. Iyengar wanted to explain a few things going on in Bombay.

In regard to roundabouts in heavily trafficked areas, so long as traffic volume was very small, some sort of weaving arrangement was possible with the slow motion of the traffic which was induced by the interposition of a traffic island. But that position in most of the cities had now got obsolete. They had been trying a few bold experiments to change the traffic islands to more or less a channellizing arrangement. In some cases, they tried a compromise of keeping a traffic island type of arrangement for minor traffic and a channellizing arrangement for through traffic, and the results proved very encouraging. He hoped to publish some of these channellizing arrangements at some future session of the Congress.

Shri Iyengar regretted that the final report of the ECAFFE Session of Traffic Engineering and Highway Safety, as applied to the under-developed areas or the countries where mixed traffic was very predominant, had not been published. As a matter of fact, in that report some rational measures had been suggested for evaluating traffic flow and also regulatory measures required for control of traffic under those conditions.

With particular reference to the minimum speed limit, it had been found that so long as there was even one slow moving vehicle

in the city limits where the intersection frequency was very large, there was hardly any advantage to be gained by enforcing a minimum speed limit. A minimum speed limit would be valuable only in the case of long journeys and not in case of shorter journeys undertaken in the cities. He thought speed limits could be recommended on these lines.

As for metering of parking vehicles, this point had been discussed at the Traffic Advisory Committee in Bombay and at one stage there was a severe objection that it was not within the rights of constitution to subsequently tax the motor vehicles by putting in the meters. But as a progressive idea it was worth experimenting to find out how it would work under those circumstances.

Shri A. A. D. O. P. Saparamado (Ceylon), referring to the controversy over the use of parking meters, stated that they had the same problem of parking in Ceylon within the City of Colombo where over 50,000 vehicles used the roads during daytime. The question of parking meters was taken up several years back, but due to the same controversial issues nothing came out. Some of the earlier speakers mentioned about keeping a check on the use of spaces without putting money into the meter. In the latest type of meter in use, there was no necessity of any control, because once the needle comes down, a red dial appears. This red dial was visible from a distance and any police officer on duty could see it.

The type of parkers was a point to be considered, e.g., there were 3 types of parkers—short-time parkers, shoppers and long-time parkers. By using parking meters, equal opportunities for all these types could be given by controlling the rate per hour. For instance, for short-time parkers in a shopping area, a rate of twenty-five cents per hour could be fixed. It would eliminate long-time parkers from the area due to the high rate. For long-time parkers, parking lots could be arranged $\frac{1}{4}$ mile or so away from the busy areas. By charging a rate of about 50 cents for the whole day, an inducement could be given to long-time parkers to park in that area and walk to their offices or places of business, instead of parking within the congested area.

Regarding the use of traffic signals and rotaries, in Ceylon at a time when traffic was not heavy, it was the practice to put up small traffic circles and it worked well during that time, but the present-day volumes of traffic required a larger area for vehicles to weave. Within a city, bigger circles requiring large areas were not economical. Several of their roundabouts which had worked well some years back had now become bottlenecks. Some of these had been knocked off and a system of one-way streets was evolved as a result of which the congestion within the heart of the city of Colombo had been minimized.

The use of traffic signals had not met with much favour in Ceylon due to the delays caused.

Shri G. C. Khanna stated that the National Highways and State Highways passed through some of the important cities and he suggested that they should start using parking meters in cities on some of the National Highways and they should also be allowed to pay for these out of National Highways' Funds.

Shri Khanna referring to the statement made by Shri Meeran stated that the parking meters had to be imported involving foreign exchange and suggested that they should, therefore, take steps to get these manufactured in India. If India could make telephone equipment, including complicated telephone exchanges, it should not be difficult for India to manufacture these meters, and suggested a reference to be made to the Ministry of Commerce and Industry.

He invited the attention of the members to the necessity of parking places and suggested, especially in big cities, construction of multistoreyed buildings for parking of cars. A car normally required about 180 sq. ft. of plinth area for garaging it. By adding 100 per cent extra space for traffic circulation, etc., the maximum area required would be about 360 sq. ft. The cost of such a multistoreyed building made of reinforced concrete would be about Rs 10 per sq. ft. So, the investment per car will be about Rs 3,600 according to Delhi and Punjab rates. This excluded cost of land as land could be provided free by a Municipal Corporation. Even if cost of land was added, as the building might be four-storeyed high, the cost of land per storey of building would be 25 per cent of the total cost of land. Assuming that land would cost Rs 60 per sq. yd., the cost of land per storey of the building would come to Rs 15 per sq. yd. Assuming that land required was double the area of the building, they would require 80 sq. yd., viz., 720 sq. ft. of land per garage. The total cost of garage including land would thus be Rs 4,800. Calculating interest at 6 per cent, the annual return should be Rs 288. Any motorist living in Chandni Chowk or Connaught Place would be willing to pay easily Rs 30 to Rs 40 per month. He suggested that this matter might be brought to the notice of Corporations like Bombay, Madras and Delhi where traffic congestion was great and they be requested to construct multistoreyed garages as in Western countries.

Shri U. J. Bhatt, Chairman, winding up the discussion stated that it not only proved interesting but also very stimulating. He thanked all the members who had taken part in the deliberations on the General Report on Road Research.

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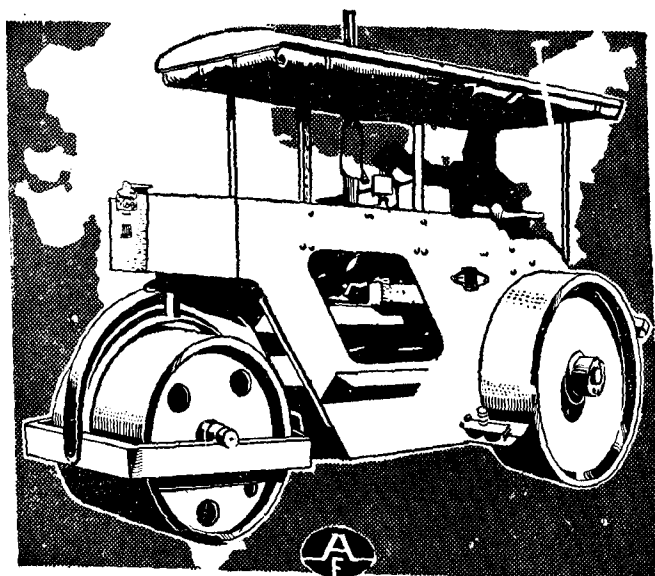
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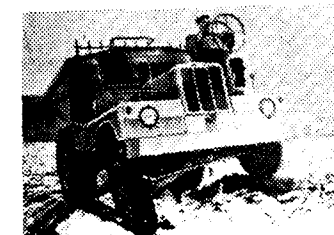
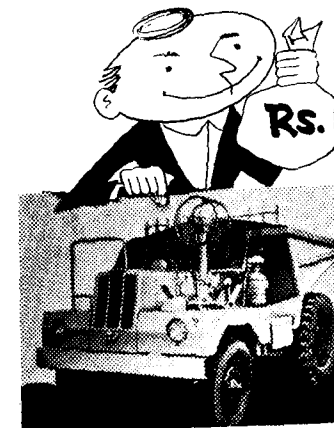
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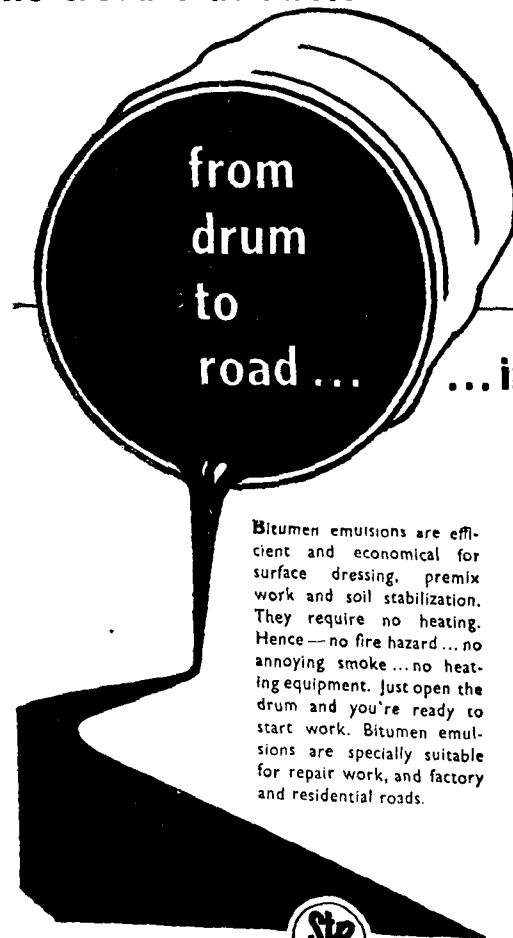
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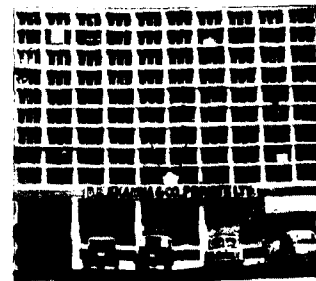
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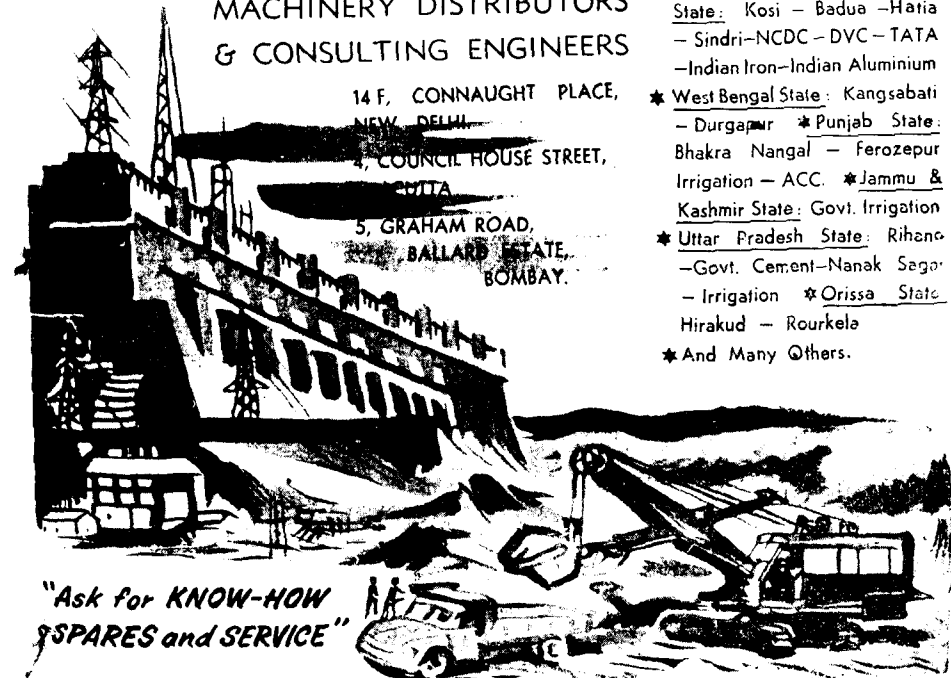
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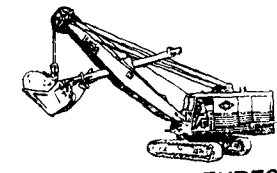
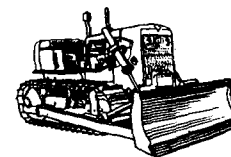
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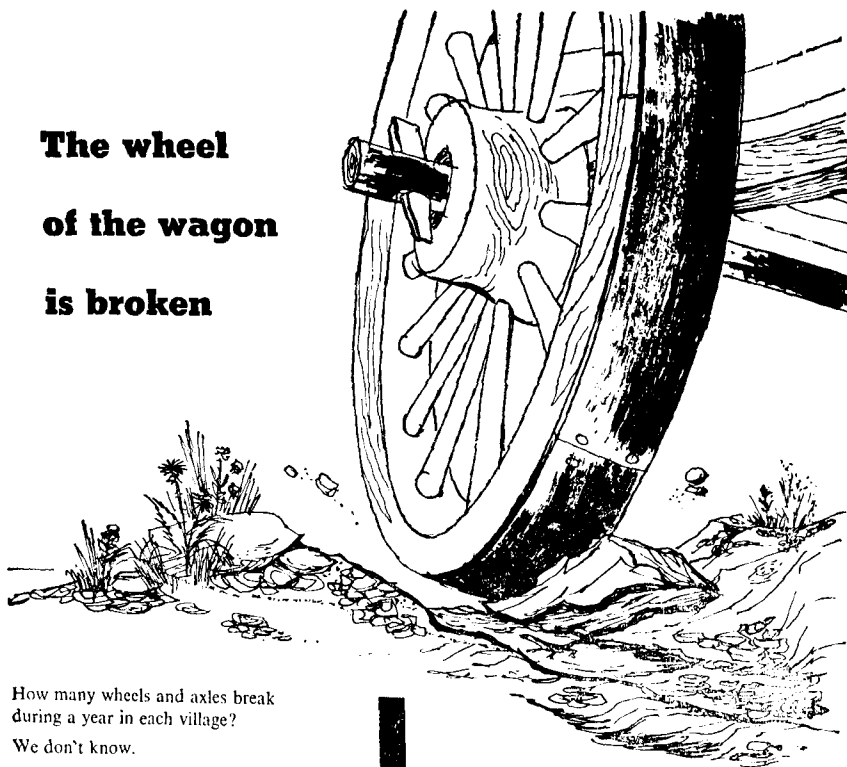
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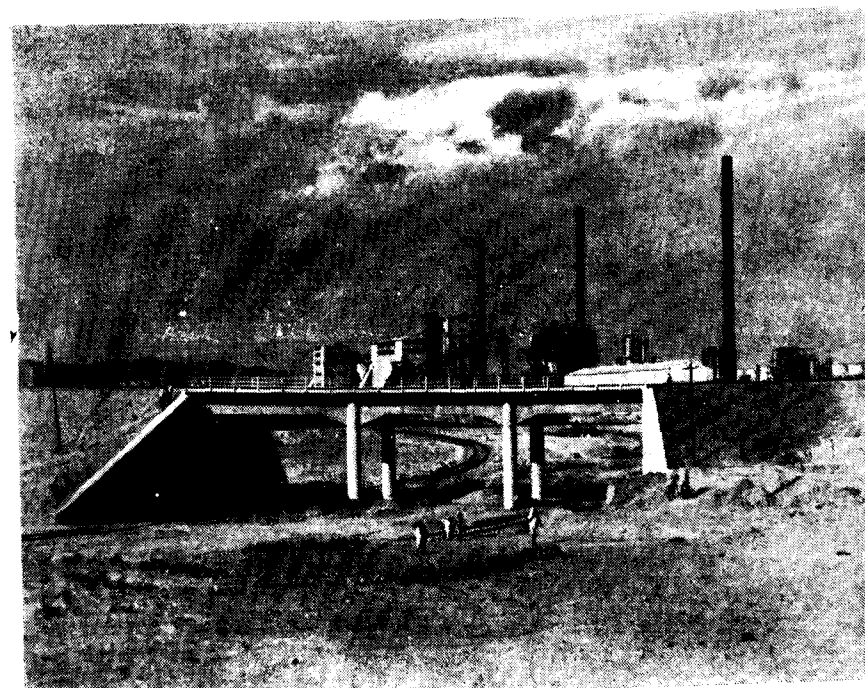
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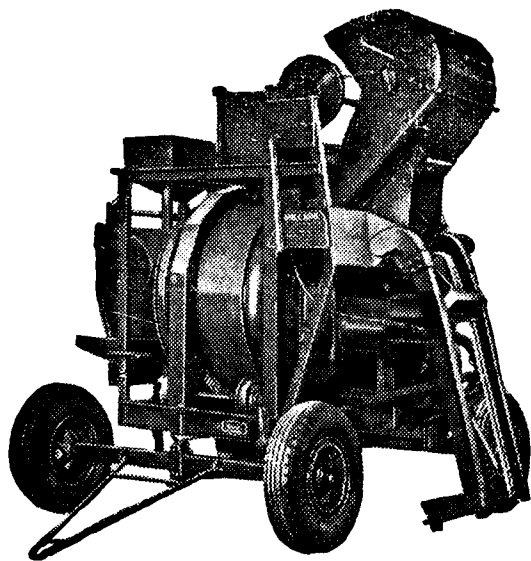
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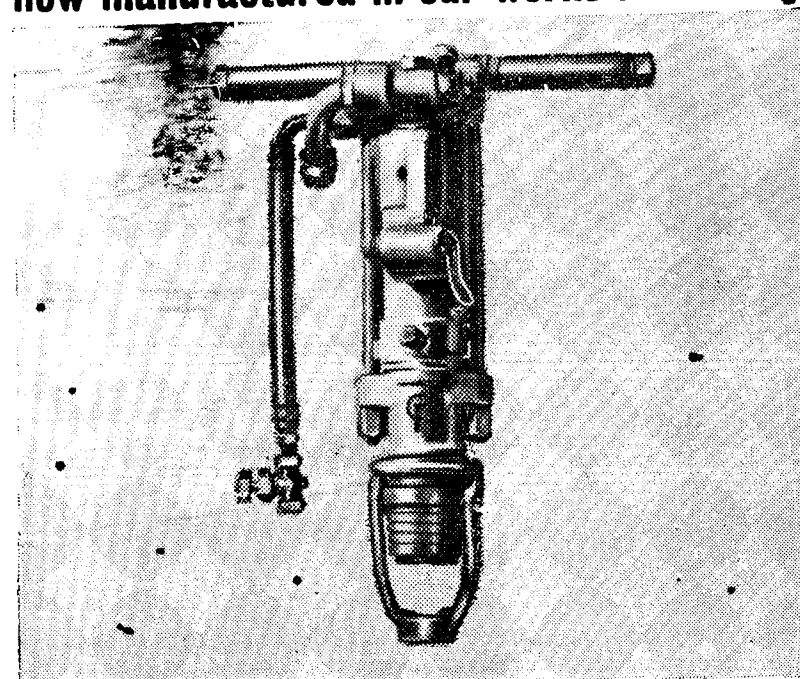
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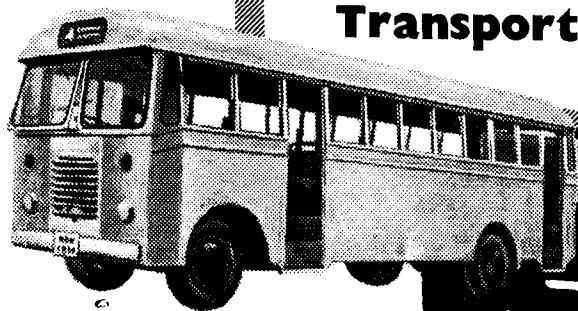
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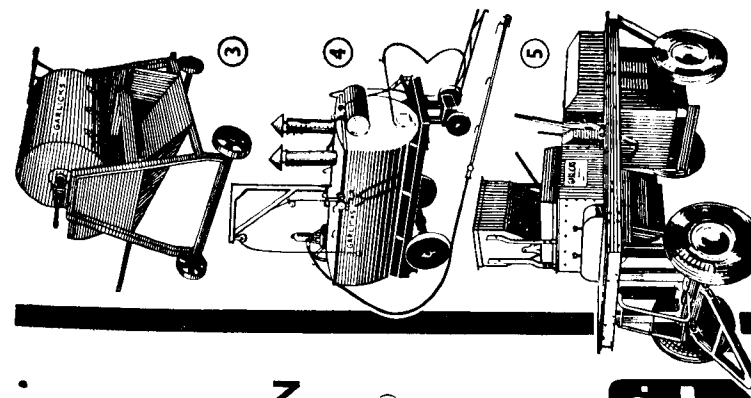
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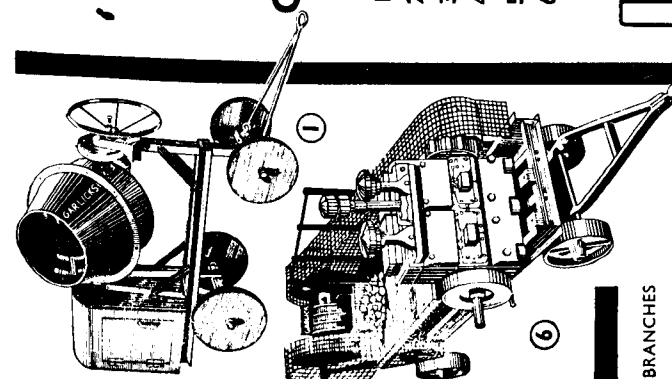


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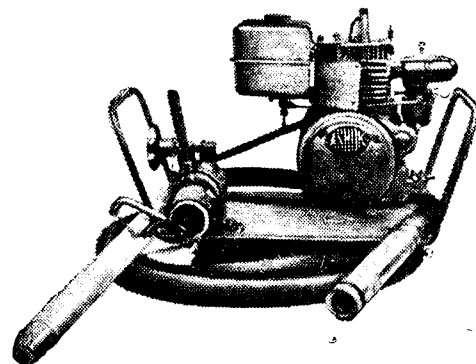
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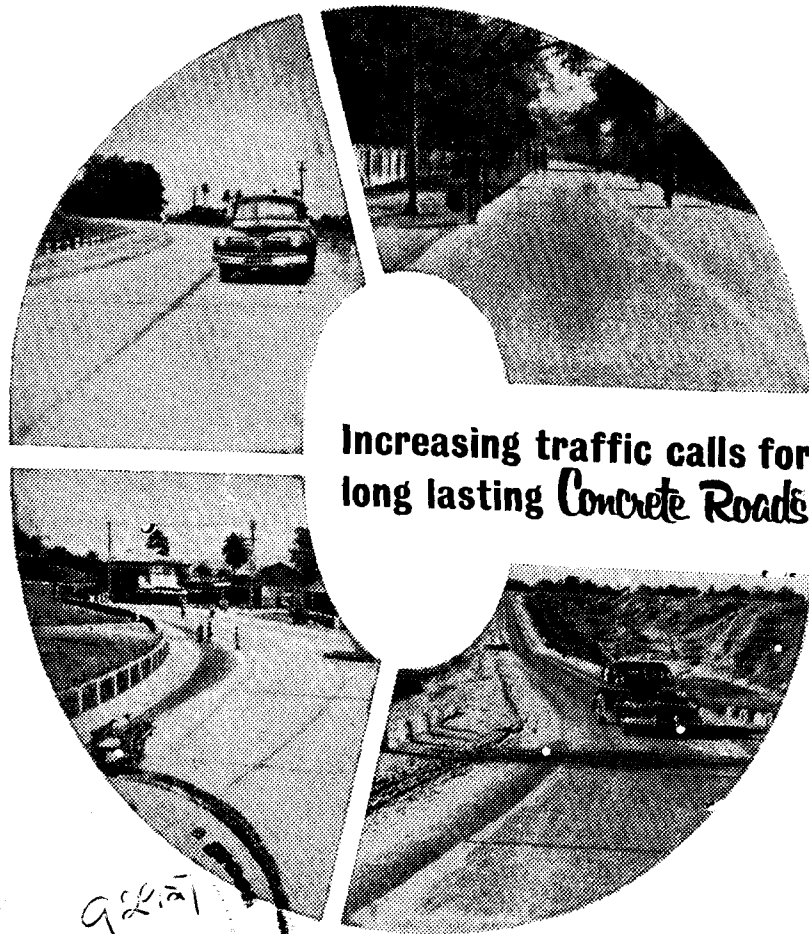
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