The Indian Roads Congress

V. XXV — 4

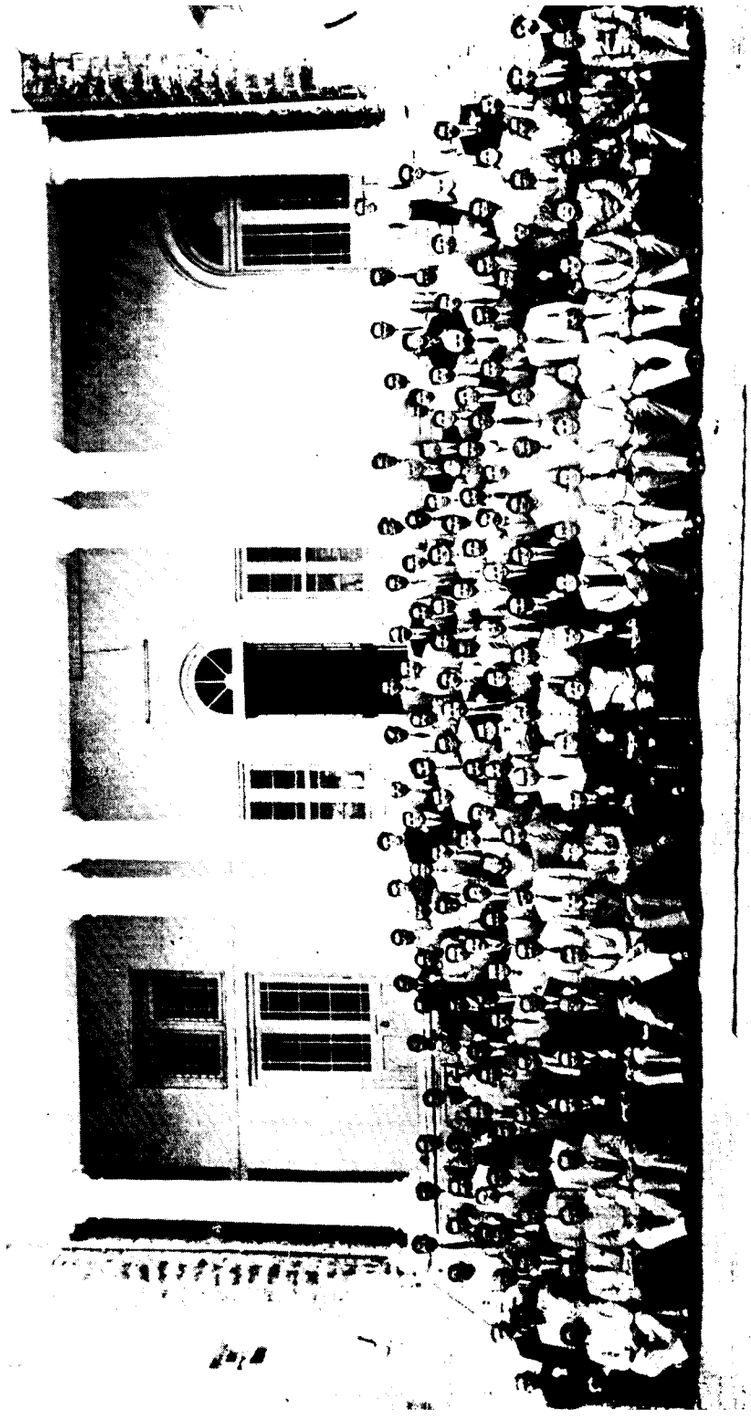
1960-61

1961

LIST OF MEMBERS OF THE COUNCIL FOR 1960-61

1. M. P. Apte
2. H. H. Campbell
3. M. R. Mahadevan
4. K. K. Nambiar
5. C. J. Fielder
6. Dr. Lal C. Verman
7. S. P. Narke
8. D. S. Thakur
9. B. P. Chanda
10. C. L. N. Iyengar
11. K. C. Mathur
12. M. Meeran
13. N. Durrani
14. K. Barua
15. B. Prasad
16. U. J. Bhatt
17. J. Mukand
18. H. K. Gandotra
19. T. S. Chatunny
20. S. N. Tripathi
21. K. K. Kartha
22. G. C. Khanna
23. Kishore Lal
24. Jagdish Prasad
25. S. N. Gupta
26. N. G. Dewan
27. S. R. Mehra
28. W. X. Mascarenhas
29. Major General Harkirat Singh
30. M. S. Bisht
31. Chief Engineer, P.W.D., Maharashtra

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 this Volume.



INDIAN ROADS CONGRESS, TWENTY-FIFTH SESSION, BHOPAL, JANUARY, 1961.

Shri H. P. SINHA, I.S.E.,
PRESIDENT, INDIAN ROADS CONGRESS, 1960—61.

Born in 1906, Shri H. P. Sinha passed out as Civil Engineer from the Thompson College of Engineering, Roorkee, in 1928, joined the Irrigation Department of the State of Uttar Pradesh and served there for nearly five years.

In 1932, Shri H. P. Sinha was appointed to the Indian Service of Engineers and, in 1934, was transferred to the Central Public Works Department, Government of India. In Januray, 1951, Shri Sinha joined the then Roads Organization of the Ministry of Transport as Deputy Consulting Engineer (Roads). After a short period, he became the Additional Consulting Engineer (Roads) and, in 1956, was appointed as the Consulting Engineer (Road Development) and Joint Secretary to the Government of India.

As the Consulting Engineer (Road Development), Shri Sinha is directly responsible for the development and administration of nearly 15,000 miles of National Highways which form the main trunk road system of the country. In addition, he administers all roads in the centrally administered areas. He is also responsible for the administration of the Central Road Fund, and for giving advice to the Government of India on all matters relating to road development.

Among Shri Sinha's manifold activities, special mention may be made of the keen interest taken by him in the field of planning of road development. One of the outstanding contributions of Shri Sinha in this field is the "Report on Road Development Plan for India (1961—81)" prepared by Chief Engineers under his Chairmanship. The Report suggests a 20-year Road Development Plan for the country and aims at 100 per cent increase in her present road mileage by 1981 at a total cost of nearly 52,000 million rupees. This Report shall be the guiding star for future road development in India.

Another activity of Shri Sinha which needs special mention is the interest taken by him in furthering the cause of Highway Engineering in the country. He is the moving force behind the Indian Roads Congress which is a premier body of highway engineers in India. Hs is also closely associated with the Institution of Engineers (India) and had been a member of its Council for many years. He was elected its Vice-President during 1951—52.

Shri Sinha represented the Government of India at the 9th Session of the International Association of Road Congresses held at Lisbon in 1950, and led the Indian delegation to the Seminar on Low-Cost Roads and Soil Stabilization held at New Delhi in January, 1958, under the auspices of the ECAFE. He also led the delegation from India to the Permanent International Association of Road Congresses held at Rio de Janerio in 1959.

INDIAN ROADS CONGRESS

NOTICES AND ANNOUNCEMENTS

I. CONTRIBUTION OF PAPERS FOR THE TWENTY-SIXTH SESSION OF THE INDIAN ROADS CONGRESS

The next General Session of the Indian Roads Congress will be held at Patna from the 13th to the 20th December, 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 26th 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.**

Past experience has shown that most of the Members send in their contributions at the last moment, when the Congress Office is busy on work connected with arrangement for the Annual Session. It is desirable that Members should have sufficient time to study the Papers well in advance of the date of the Session. It is also desirable that I.R.C. Journal should reach the Members quarterly. As it takes a long time to get Papers printed in the Journal, Members are particularly requested **to make an effort to send their contributions as early as possible.**

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

5. **Medals**: The following Medals are awarded for the Papers depending on the merits of the Papers :

(i) **The Mitchell Medal**:

For exceptionally good Papers contributed to the Indian Roads Congress in any year. This has been instituted to perpetuate Sir Kenneth Mitchell's connection with the Congress.

(ii) **The Indian Roads Congress Medal**:

For Papers considered by the Council of the Indian Roads Congress to be of a decidedly more than average merit.

6. The Council have reserved the right to award more than one Medal in any year or to withhold the award of a Medal in any year without assigning any reason. All Members are eligible for the award of the Medals.

7. Rules and Regulations for the contribution of Technical Papers and the award of Medals are published on pages 11 to 16 of Volume XXV—Part 1 of the Journal of the Indian Roads Congress, November, 1960.

II. NEW ADMISSIONS

LIST OF MEMBERS OF THE INDIAN ROADS CONGRESS

ENROLLED FROM 1-10-60 TO 20-4-61

Serial No.	*Roll No.*	*Name.*	*Address.*
1	2820	A. K. Das	Burmah-Shell, Hongkong House, **Calcutta.**
2	2821	Harcharan Singh	Assistant Engineer, P.W.D., **Mathura** (U.P.).
3	2822	Abdul Jamil Mallick	Assistant Professor of Civil Engineering, Ranchi School of Engineering, **Ranchi** (Bihar).
4	2823	P. K. Sharma	Assistant Engineer, P.W.D., Provincial Division, **Jhansi** (U.P.).
5	2824	Koushik Roy	Assistant Construction Engineer, Roads Division II, Durgapur Steel Project, P.O. Durgapur-4, **Dist. Burdwan** (W. Bengal).
6	2825	S. N. Mishra	Assistant Engineer, Hind Construction Ltd., Ramganga Bridge, **Bareilly** (U.P.).
7	2826	S. N. Tandon	Instructor, Punjab Polytechnic, **Nilokheri.**
8	2827	Virinder Sethi	Assistant Engineer, Sunderbani Sub-Division, **Sunderbani** (J. & K. State).
9	2828	R. L. Choubisa	Junior Engineer, Ghanti, **Dungarpur,** (Rajasthan).
10	2829	K. M. Bhatia	Additional Chief Engineer, C.P.W.D., 'G' Block, **New Delhi.**
11	2830	M. S. Ahmed (Hon. Member)	Chief, Transport & Communications Division, ECAFE, **Bangkok** (Thailand).
12	2831	Robert Graham Hennes	Professor, The University of Wisconsin TCM Project, Bengal Engineering College, P.O. Botanic Garden, **Howrah** (W. Bengal).
13	2832	C. K. Puri	Sub-Divisional Officer, P.W.D., B. & R., C/o Shri T. C. Chopra, Retired Professor, Near Jollowkhana, **Kapurthala** (Punjab).
14	2833	Gajendra Kumar	Consulting Engineer, 5, Lower Rowdon St., **Calcutta-20.**

Serial No.	Roll No.	Name.	Address.
15	2834	B. S. Mathur	Assistant Engineer, N.H.W. Sub-Division, Bhim, **Dist. Udaipur** (Rajasthan).
16	2835	Surindar Singh	Assistant Engineer (Designs), Capital Project. C/o Chief Engineer, **Chandigarh** (Punjab).
17	2836	P. G. Patankar	Civil Engineer, Tramway Bungalow, Accommodation Road, Colaba, **Bombay-1.**
18	2837	A. Sethunarayanan	Junior Engineer, Block Development Officer, **Ramanathapuram** (Madras State).
19	2838	K. H. Thakore	Executive Engineer, B. & R., Jabalpur Division, **Jabalpur** (M.P.).
20	2839	M. R. Jayanty	Assistant Engineer (Highways), P.O. Chintapalli, **Vizag District.**
21	2840	K. S. Mathur	Assistant Engineer, P.W.D. (B. & R.), **Shahpura** Jaipur Division (Rajasthan).
22	2841	H. C. Gupta	Construction Engineer, Gr. I. H.S.L., Purnapani Division, **Rourkela-2** (Orissa).
23	2842	P. N. Rao	Assistant Engineer, (H) Special, Chodavaram, **Vizag** (A.P.).
24	2843	N. C. Jain	Assistant Engineer Narmada Bridge Construction Sub-Division, **P.O. Barwani** (M.P.).
25	2844	C. S. Naidu	Municipal Engineer, Ootacamund Municipality, **Ootacamund.**
26	2845	K. P. Agrawal	Sub-Divisional Officer, P.W.D., (R. & B.), Sitamarhi Sub-Division, P.O. Sitamarhi Court, **Muzaffarpur** (Bihar).
27	2846	Y. P. Somayajulu	Associate Lecturer in Civil Engineering, I.I.T., Kharagpur Technology P.O., **Kharagpur** (S.E. Rly).
28	2847	S. M. Valliappan	Reader in Civil Engineering, 8-Sivapuri Quarters, **Annamalai Nagar.**
29	2848	S. C. Gupta	Assistant Engineer, P.W.D., Gajraula, **Dist. Moradabad** (U.P.).
30	2849	S. P. Sharma	Assistant Engineer, S.D.O., P.W.D. Incharge, Construction Sub-Division No. III, Ranchi Construction Division No. II (Medical), Bariatu, **Ranchi** (Bihar).

Serial No.	Roll No.	Name.	Address.
31	2850	S. M. Agrawal	S-14, Post-Graduates Hostel, University of Roorkee, **Roorkee** (U.P.).
32	2851	Surjit Singh	Assistant Engineer, P.W.D. (B. & R.), P.O. Dantewada, **Dist. Bastar** (M.P.).
33	2852	C. J. Khisty	Lecturer in Civil Engineering, Govt. Polytechnic, **Jabalpur** (M.P.).
34	2853	N. V. Parthasarathy	Resident Engineer, M/s. Gammon India (P) Ltd., Harohar Bridge Construction, P.O. Mankatha (Via) Luckeesarai, **Monghyr District** (Bihar).
35	2854	D. S. Paul	Executive Engineer, C.P.W.D., 14, Shan Nagar, **New Delhi.**
36	2855	T. Natarajan	Junior Engineer, P.W.D., **Manjeri** (Kerala State).
37	2856	A. S. Patwardhan	Lecturer, Civil Engineering Department, Indian Institute of Technology, P.O. I.I.T. Powai, **Bombay-76.**
38	2857	S. V. Subramanyam	Deputy Director (R. & S.), Central Water & Power Commission (Water Wing), Curzon Road Barracks, **New Delhi.**
39	2858	S. Kotoswara Rao	Lecturer in Civil Engineering, I.I.T., **Kharagpur** (S.E. Rly).
40	2859	G. A. Venkatachelam	Divisional Engineer (H), Thanjavur, **Tanjore** (Madras State).
41	2860	Om Parkash Sharma	Consulting Engineer, 73-Masjid Road, Jangpura, **New Delhi-14.**
42	2861	Bharat Prasad	Assistant Engineer, P.W.D. (B. & R.), Chief Engineer's Office, (P.W.D.), Secretariat, **Patna** (Bihar).
43	2862	K. C. Kshetrapal	Assistant Engineer, P.W.D. B. & R., Superintending Engineer's Office, Ujjain Circle, **Ujjain** (M.P.).
44	2863	Sheo Mohan Prasad	Assistant Engineer (Designs), Design Circle, P.W.D. (B. & R.), Main Secretariat, **Patna-1** (Bihar).
45	2864	Shankar Vishnu Dravid	Executive Engineer, Construction Division No. I, P.W.D., **Bhopal** (M.P.).
46	2865	Gopal Shridhar Palnitkar	Assistant Engineer, Sub-Division No. III, Construction Circle (Capital Project), P.W.D., **Bhopal** (M.P.).
47	2866	H. Mohd. Ismail	Lecturer in Civil Engineering, Indian Institute of Technology, **Kharagpur** (W. Bengal).

Serial No.	*Roll No.*	*Name.*	*Address.*
48	2867	P. D. Mungee	Assistant Engineer, P.W.D. B. & R., Construction Sub-Division IX, **Bhopal** (M.P.).
49	2868	R. B. Mathur	Assistant Engineer, P.W.D., Research Institute, **Lucknow.**
50	2869	I. S. Durrani	Executive Engineer, Schore Division, **Schore** (M.P.).
51	2870	H. R. Agrawal	Assistant Engineer, West Sub-Division, P.W.D., **Bhopal** (M.P.).
52	2871	H. N. Chakrabarty	Sub-Divisional Officer, Engineering College, Construction Division, **P.O. Jorhat** (Assam).
53	2872	R. C. Sachdev	Sachdev & Co., James Street, **Secunderabad-Dn.**
54	2873	P. V. Sathe	Executive Engineer, Buildings & Communications Department, **Chanda,** (Maharashtra).
55	2874	B. S. Gupta	Executive Engineer, P.W.D. (B. & R.) **Balaghat** (M.P.).
56	2875	Sheikh Ghulam Mustafa	Assistant Engineer (R. & B.), **P.O. Batote** (Jammu).
57	2876	D. K. Darwhekar	Deputy Engineer, B. & C. Deptt., Sachivalya, **Bombay-1.**
58	2877	U. K. Agrawal	Sub-Divisional Officer, P.W.D., P.O. Barh, **Patna** (Bihar).
59	2878	C. Visweswaria	Executive Engineer, Kolar Division P.W.D., C/o. Shri K. Srikantia, B.A., LLB., Advocate, **Tumkur** (Mysore State).
60	2879	S. Ramanatha Pillai	Assistant Engineer, Chief Engineer's Office (B. & R.) Kerala P.W.D., **Trivandrum.**
61	2880	K. S. Saxena	Assistant Engineer, P.W.D., P.O. Phoolbagh, **Dist. Nainital** (U.P.).
62	2881	R. B. Mathur	Sub-Divisional Officer, P.W.D., **Lansdowne** (Garhwal) (U.P.).
63	2882	J. B. Das	Assistant Engineer, Bhadrak (R. & B.) Sub-Division, P.O. Bhadrak, **Dist. Balasore** (Orissa).
64	2883	T. V. Sundareshan	Assistant Engineer, No. 2 Special West Coast Sub-Division, Mercara Hill, **Mangalore.**

Serial No.	*Roll No.*	*Name.*	*Address.*
65	2884	H. K. Hedge	Junior Engineer, Special West Coast Division, **Coondapur** (Mysore State).
66	2885	N. K. Mittal	Assistant Engineer, Additional Bridge Design Division, P.W.D., **Lucknow** (U.P.).
67	2886	A. V. Sukhadeo	Deputy Engineer, Designs Division No. I, Hutment Nos. 4 & 5, **Bombay-1.**
68	2887	R. T. Atre	Executive Engineer, Designs Division II, Hutment Nos. 4 & 5, Opp. C.C.I. **Bombay-1.**
69	2888	Chandra Bhushan	Executive Engineer, P.W.D. (B. & R.), **Sirohi** (Rajasthan).
70	2889	G. M. Khadki	Deputy Engineer, Attached to the Office of the Superintending Engineer (R. & B.) Circle, **Rajkot** (Saurashtra).
71	2890	F. H. Shaikh	Deputy Engineer, P.A. to Superintending Engineer, Capital Project Circle, **Ahmedabad.**
72	2891	J. D. Chavan	Engineer, District Local Board, 21, Ruikar Colony, **Kolhapur.**
73	2892	S. D. Desai	Engineer, District Local Board, **Kolaba,** Pen (Bombay).
74	2893	A. J. Pinto	Executive Engineer, P.W.D., **Rewa** (M.P.).
75	2894	L. K. Narain	Executive Engineer, P.W.D., (B. & R.), **Satna** (M.P.).
76	2895	C. D. Gupta	Assistant Engineer (Roads), Birhata P.O., **District Burdwan** (W. Bengal).
77	2896	Y. R. Phull	Senior Scientific Officer, Central Road Research Institute, P.O. C.R.R.I., Okhla. **New Delhi-20.**
78	2897	A. K. Dutta	Assistant Engineer, Design Division No. I, Development (Roads) Department, Anderson House, **Calcutta-27.**
79	2898	P. Jagannatha Rao	Senior Scientific Officer, Central Road Research Institute, P.O. C.R.R.I., Okhla, **New Delhi-20.**
80	2899	N. G. Joshi	Deputy Chief Engineer, P.W.D., Mysore, **Bangalore.**
81	2900	S. B. Kulkarni	Bitumen Engineer, Burmah-Shell, 3-Kalpana Colony, **Ahmedabad-9.**

Serial No.	Roll No.	Name.	Address.
82	2901	B. Das Gupta	Executive Engineer, P-256, Jodhpur Park, **Calcutta-31** (W. Bengal).
83	2902	Ashis Dutta	Assistant Engineer, P.W.D., West Bengal, 23/26/1, Jyotish Roy Road, **Calcutta-33** (W. Bengal).
84	2903	S. K. Sen	Assistant Engineer, P.W.D., West Bengal, Vaduripara, Kalna P.O., **Dist. Burdwan** (W.B.).
85	2904	Mohindar Singh Bains	Sub-Divisional Officer, Provincial Sub-Division, Punjab P.W.D. (B. & R.) Branch, **Hoshiarpur.**
86	2905	D. P. Ghose	Assistant Engineer (Roads), **P.O. Kalna** (W.B.).
87	2906	D. R. Guha	Sub-Divisional Officer (Roads), P.O. Malda, **Dist. Malda** (W.B).
88	2907	S. Samajdar	Assistant Engineer, 112-Ballygunge Gardens, **Calcutta-19.**
89	2908	Dayawanso Petiya-goda	Superintending Engineer, P.W.D., **Colombo**, Ceylon.
90	2909	T. M. Parikh	Principal, Govt. Polytechnic, **Rohad** (Gujerat).
91	2910	S. S. Mongia	Sub-Divisional Officer, P.W.D., (B. & R.), **Abohar** (Punjab).
92	2911	U. J. Matai	Engineer Officer to Addl. Chief Engineer III, C.P.W.D., 'G' Block, **New Delhi.**
93	2912	C. P. Srivastava	Superintending Engineer, P.W.D., (B. & R.), **Bilaspur** (M.P.).
94	2913	H. S. Kalsi	Sub-Divisional Officer, P.W.D. (B. & R.), Gupta Kashi, **Dist. Chamoli** (U.P.).
95	2914	S. H. M. Rezvi	Executive Engineer, P.W.D., Bettiah, **Dist. Champaran**, N.E. Rly. (Bihar).
96	2915	R. N. Khanna	Assistant Engineer, P.W.D. (B. & R.), 5-Kampoo, **Gwalior.**
97	2916	K. Vudayachalam	Superintending Surveyor of Works, C.P.W.D., **New Delhi.**
98	2917	Chakradhar Maha-patra	Assistant Engineer, Nimapara Sub-Division, New Capital, **Bhubaneswar** (Orissa).
99	2918	B. Venugopalachar	Professor of Applied Mechanics, L.E. College, **Morvi** (Gujerat).
100	2919	S. R. Dubey	Assistant Engineer, **Raisen** (M.P.).

Serial No.	Roll No.	Name.	Address.
101	2920	Dal Chand Jain	Assistant Engineer, Construction Sub-Division (Bhopal Division), P.W.D., **Bhopal.**
102	2921	G. N. Chhoker	Sub-Divisional Officer, M/48/3, Hamidia Hospital, **Bhopal.**
103	2922	N. G. Vakharia	Deputy Engineer, Designs Division I, P.W.D., L.D. Engg. College, Navrangpura, **Ahmedabad-9.**
104	2923	C. S. Padmanabha Aiyar	Chief Engineer, Buildings & Roads, Kerala State, **Trivandrum.**
105	2924	Lt.-Col. S. P. Joga Rao	Chief Engineer & Area Manager, Gammon India Ltd., 63-Richmond Road, **Bangalore.**
106	2925	V. D. Deodhar	Regional Engineer, Sahu Cement Service, 5, Hamidia Road, **Bhopal** (M.P.).
107	2926	M. D. Arora	Assistant Engineer, P.W.D., Project Circle, C-4, Sub-Division, **Bhopal** (M.P.)
108	2927	L. N. Agarwal	Assistant Engineer, U.P., P.W.D., **Tehri** (U.P.).
109	2928	Babu Lal Jain	Engineer, B. & R., Neemka Thana, **Sikar Dist.** (Rajasthan).
110	2929	M. L. Bansal	Executive Engineer, Rampur Division, Himachal Pradesh, P.W.D. Rampur Bushahr, P.O. Rampur, **Rampur** (H.P.).
111	2930	K. C. Bansal	Executive Engineer, P.W.D., Border Works, Temporary Division, Bhatwari, **Dist. Uttarkashi** (U.P.).
112	2931	H. B. Francis	Executive Engineer, B. & C. Deptt., **Osmanabad** (Maharashtra State).
113	2932	R. Parthasarathy	Bitumen Engineer, Burmah-Shell, 32, Sarojini Devi Street, P.B. No. 11, **Secunderabad** (A.P.).
114	2933	Shiveswarup Mathur	Assistant Engineer, P.W.D., (B. & R.), Mandi Division, **Kota** (Rajasthan).
115	2934	V. N. Vijayvergiya	Lecturer, C/o Prof. P. N. Vijayvergiya, Shahd Pratap Ashram, **Lashkar** (M.P.).
116	2935	B. L. Dhakar	Sub-Divisional Officer, P.W.D. (B. & R.), Survey Sub-Division, **Jagdalpur** (M.P.).
117	2936	S. C. Mithal	Assistant Engineer, P.W.D. (B. & R.), H.Q. Sub-Division, Jagdalpur, **Dist. Bastar.**
118	2937	Kuldip Singh	Sub-Divisional Officer, Punjab P.W.D. (B. & R.), Winterfield, **Simla-3.**

Serial No.	Roll No.	Name.	Address.
119	2938	K. Sankaran	C/o Mr. T. S. Venkataraman, Manager, South Indian Concerns Ltd., 401, Tolang Road, Matunga, **Bombay-19.**
120	2939	D. D. Amin	Resident Engineer, Rati Nivas, Deshra, Via Bilimora, **Dist. Surat** (Gujerat State).
121	2940	S. V. Rama Rau	Junior Engineer (Designs), Office of the Chief Engineer (R. & B.), Bhubaneswar, **Dist. Puri** (Orissa).
122	2941	R. A. Goyal	Sub-Divisional Officer, P.W.D., Provincial Sub-Division, Kulu, **Dist. Kangra** (Punjab).
123	2942	Vidyadhar Rao	Assistant Engineer, P.W.D. (R. & B.), Yellandu, **Dist. Khammam** (A.P.).
124	2943	M. S. Iyengar	Deputy Engineer, Bridge Works Sub-Division, Room No. 889, Willingdon Crescent, **Jamnagar** (W. Rly).
125	2944	K. Prasad	Sub-Divisional Officer, Project Sub-Division, P.W.D., **Ranchi** (Bihar).
126	2945	T. P. Bose	Assistant Engineer, Sub-Divisional Officer (W. & B.), Chandraipara, **P.O. Ambassa** (Tripura).
127	2946	S. Muthuveeru	Junior Engineer (Highways), Investigation Division, Guindy, **Madras-25.**
128	2947	Shio Pujan Singh	Assistant Engineer, P.W.D. (B. & R.), C/o. Dr. H. N. Singh, M.D., M. R.C.P. Khudabux Library Road, **Patan-4**).
129	2948	Brig. Om Mani	Chief Engineer, Project Tusker, C/o 56 APO
130	2949	M. M. Shah	Deputy Engineer, Bridge Works Sub-Division, Khambalia, **Dist. Jamnagar** (Saurashtra).
131	2950	S. B. L. Shrivastava	Lecturer in Civil Engineering, Govt. Polytechnic, **Jabalpur** (M.P.).
132	2951	Narain Singh	Assistant Engineer, P.W.D., (B. & R.), **Hanumangarh Town** (Rajasthan).
133	2952	B. V. Raghavaswamy	Junior Engineer (H), Vasista Bridge, Sidhantam, **West Godavari District** (A.P.).
134	2953	Brig. Shamsher Singh	Director, Technical Administration, Directorate General of Border Roads, Kashmir House, **New Delhi-11.**

Serial No.	Roll No.	Name.	Address.
135	2954	S. C. Jain	C/o Highways Deptt., Punjab Engineering College, **Chandigarh.**
136	2955	N. Iyasami	Asstt. Engineer (H. & R. W.), Ammapet, **Thanjavur Dist.** (Madras State.)
137	2956	Chandrama Ojha	Assistant Engineer, Industries Deptt., New Secretariat, **Patna-1.**
138	2957	S. B. Khare	Assistant Engineer, (South), P.W.D., Provincial Division, **Moradabad** (U.P.).
139	2958	N. S. Bhal	Assistant Engineer, P.W.D., Bridge Design Division, U.P. P.W.D., **Lucknow.**
140	2959	V. S. Vasudevan	Asstt. Engineer, C/o Shri V. S. Desekan, City Engineer-I, Corporation of Lucknow, 1347 Narahi, **Lucknow.**
141	2960	R. Prabhakara Rao	Asstt. Lecturer in Civil Engineering, Regional Engineering College, **Warrangal** (A.P.).
142	2961	C. S. Sanwal	Assistant Engineer, Border Works Temporary Division, P.W.D., **Uttarkashi** (New Distt.) (U.P.).
143	2962	B. N. Sahay	Assistant Engineer, P.W.D. Sub-Division No. 2, Combined Office Building, **Dhanbad.**
144	2963	A. K. Jain	Assistant Engineer, P.W.D., P.O. Askote, **Dist. Pithoragarh** (U.P).

ASSOCIATE MEMBERS

1	88	M/s. Lakshmichand Balchand	Engineers & Contractors, 3-4-849, Barkatpura, **Hyderabad-Dn.** (A.P.).
2	89	B. S. Sandhu	M/s. Shalimar Tar Products (1935) Ltd., E-Block, Connaught Place, **New Delhi.**
3	90	J. G. Awasty	Sales Engineer, M/s. William Jacks & Co., **New Delhi.**
4	91	Samuel Joseph Prabhakar	Sales Engineer, M/s. William Jacks & Co., Ltd., First Line Beach, National Bank Building, **Madras-1.**
5	92	Surjit Singh	Sales Executive, M/s. William Jacks & Co., Ltd., Hamilton House, Bellard Estate, P.O. Box No. 335, **Bombay.**

III. DEATHS

The Council have received with regret intimations of the following deaths:

Serial No.	*Roll No.*	*Name.*	*Address.*
1	2220	D. R. Das	Executive Engineer, Chandra Kamal Road, Uzan Bazar, P.O. Gauhati, **Dist. Kamrup** (Assam).
2	1619	V. D. Bhandari	Additional Chief Engineer, Central P.W.D., 26, Sundarnagar, **New Delhi.**
3	2282	H. Kakati	Executive Engineer, **Gauhati** (Assam).
4	559	J. M. Rijhwani (L.M.)	Development Commissioner, Kandla Port, **Gandhidham** (Kutch).
5	389	H. Sunder Rao (L.M.)	Head of Department of Engineering, Indian Institute of Technology, **Kharagpur** (West Bengal).
6	562	V. S. Annaswami	No. 14, Chergamalam Rajaji Road, Ramnagar, **Coimbatore.**

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	323	Chambers, J. (Lt.-Col.)	'Artistry House', 15, Park Street, **Calcutta-16.**
2	2126	Malik, Sikandar Lal	Executive Engineer (Retired), Sector 18, Qr. No. C 2/9B, **Rourkela-3.**
3	2076	Shaik Mahboob	Executive Engineer, P.W.D., **Osmanabad.**
4	417	Parang, Hari Ram (L.M.)	Retired Executive Engineer, Lal Chowk, Quila Gujar Singh, **Lahore** (Pakistan).
5	12	Sowani, D. G. (L.M.)	Bhide Wada, Shevde Bol, 851-A, Sadashiv, **Poona-2.**
6	86-Ass.	Tylee, C. J.	C/o. U.P.C.C. Private Ltd., 6, Ganesh Chandra Avenue, **Calcutta-13.**

A BRIEF ACCOUNT OF THE TWENTY-FIFTH SESSION OF THE INDIAN ROADS CONGRESS

Bhopal, the beautiful city of lakes, was the venue of the 25th Session of the Indian Roads Congress. The Session was inaugurated on 4th January, 1961, by Shri H. V. Pataskar, Governor of Madhya Pradesh. His Excellency in his Address greatly appreciated the useful work done by the Indian Roads Congress.

The President, Indian Roads Congress, receiving the Governor

He mentioned about the backwardness of the State of Madhya Pradesh in matter of roads and emphasised the necessity for improvement of road communication in the State. He also emphasised the necessity of directing research to find out ways and means for speedy and cheaper methods of road construction.

Shri H. P. Sinha, Consulting Engineer (Road Development) and Joint Secretary to the Government of India, President of the Indian Roads Congress, in his Address reviewing the progress of development of road and road transport in the country emphasised that much remained to be done for meeting the future transport requirements of the country. He mentioned that the Chief Engineers of States in their Report of the 20-year Road Development Plan had estimated that long distance transport pertaining to an average lead of 300 miles, would increase from 182 million tons in 1960-61 to 800 million tons in 1980-81. The Railways were expected to carry 162 million tons at the end of the Second Five-Year Plan and 523 million tons in the year 1980-81. There would, thus, be a gap of 20 million tons in 1960-61 which should be carried mainly by road transport, and 246 million tons which was over ten times the 1960-61 figure should have to be carried by road in 1980-81. Both road construction and vehicles production therefore should be stepped up considerably to meet the very large future demand.

The Finance Minister, Madhya Pradesh, addressing the delegates at the opening of the Exhibition

The President then said that road revenues in the next Five-Year period including normal annual increases could be assessed conservatively at about Rs 900 crores. That revenue justified a much larger development plan for roads in the Third Plan, than that

indicated by Rs 250 crores which was the same as that allotted for the Second Plan. Taking into consideration the fact that the Third Plan is much bigger than the Second, and that the earnings from road transport were likely to be doubled, it was obviously unfair that such a small sum should have been provided in the Third Plan.

Other subjects dealt at length by the President in his speech were construction of bridges and the improvement of existing roads for taking care of the increase in traffic, both in volume and laden weights, prevention of ribbon development, taxation of road transport, road research, etc. He also emphasised the need of constituting a Road Board at the Centre on the lines recommended by a Special Committee of the Indian Roads Congress.

A very successful Technical Exhibition depicting the current developments in the road and bridges construction and maintenance techniques in the country was arranged during the Session. Various charts and models explaining the latest progress on highway development were also shown. The exhibition was opened by Shri Mishri Lal Gangwal, Minister for Finance.

The following technical committees of the Indian Roads Congress met during the Session :

(i) The Traffic Engineering Committee among other subjects

Traffic Engineering Committee meeting

considered, Indian Standard Code of Practice for design of street lighting, design pattern for street crossings, and prevention of ribbon development along important roads.

(ii) The Research Organization Committee which is entrusted with the co-ordination of road research in the country reviewed the progress made on various items of research being carried out in road research laboratories. They also discussed (1) specifications for pre-moulded joint fillers and sealing compound, (2) investigation regarding temperature stresses in rigid pavements under Indian conditions, and (3) points arising out of the discussion on the last General Report on Road Research.

(iii) The Education Committee considered the syllabus of Highway Engineering for Diploma Courses for Overseers and Supervisors. Other important subjects dealt with by this Committee were the syllabus for Post-graduate Degree in Highway Engineering. Highway Engineering has become a specialised science and it is, therefore, necessary that intensive training is imparted to Road Engineers in India. With this object in view the question of conducting refresher courses at various centres was considered. The syllabii for such courses were also examined.

(iv) The Prevention of Ribbon Development Committee in

Research Organisation Committee meeting

their meeting considered the ways and means for expediting matters regarding control of ribbon development which is presenting a serious problem along important roads in the country. The Committee was of the unanimous opinion that immediate steps should be taken to arrest further deterioration of the situation.

Prevention of Ribbon Development Committee meeting

(v) The Road Operation Cost Committee set up 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 their meeting considered the final report on the cost of operation of motor vehicles on different types of roads in plains. The Committee will continue their studies on hill roads.

(vi) As the mileage of roads constructed under the Community Project and National Extension Service Scheme forms a considerable percentage of the total mileage of roads in the country, it was felt that there was need for a satisfactory arrangement for maintaining these roads. The Community Project Road Maintenance Committee had already issued a Recommended Practice for construction and maintenance of roads under Community Development Projects. The Community Project Road Maintenance Com-

Road Operation Cost Committee meeting

mittee in their meeting held at Bhopal suggested certain amendments to the abovementioned Recommended Practice.

(vii) The Specifications and Standards Committee in their meeting considered alignment of roads on top of tank bunds, recommended practice for borrowpits for road embankments, specifications for roadside arboriculture, standards for the construction of pick-up bus stands on National Highways, type design for toll, octroi or check barriers on roads and standards for roads in urban areas.

(viii) The Soil Research Committee at their meeting considered the recommendations regarding the procedure to be adopted in carrying out stabilized soil construction (with soft aggregate) in dry as well as in wet areas, a method for the stabilization of black cotton soil with lime, a method for the compaction of embankment (both low or high), a method for use of natural soil, blended soil, and processed soil, as a cheap material for road construction, road construction in sandy areas, stabilization of sand to give a firm base, introducing the use of soil as a road construction material, Indian Standard Classification and Identification of Soils for General Engineering purposes.

(ix) The Stabilized Soil Roads Committee at their meeting discussed the formulation of a standard procedure for condition surveys of stabilized soil roads so that the effects of various factors on the quality and service of the pavements could be correctly evaluated, criteria for soil cement in areas subject to periodical inundation, a tentative programme for inspection of stabilized soil roads in other regions such as Andhra Pradesh, West Bengal, Maharashtra, Gujerat, etc.

(x) The Road Transport Development Committee at their meeting emphasized the necessity for formulation of a scientific taxation policy on road transport. Their suggestion is that the revenues from road transport should be earmarked for maintenance of roads, interest towards capital invested after contributing a specific amount to the general revenues, the balance being kept as reserve for road development. In addition, the Committee also took up the question of strengthening and widening the road crust of arterial routes to make them fit for modern heavy vehicles and truck trailer combinations. The Committee noted that certain States had already carried out required surveys for the above purpose and felt that the remaining States should expedite action in this matter so that a long standing demand of the people and the trade can be met without further delay.

Water-Bound Macadam Subcommittee meeting

(xi) The Manufacture of Road-making Machinery and Mechanization Committee examined the question of the indigenous manufacture of various items of road-making machinery.

(xii) Other Committees which held their meetings during the Session are (1) Bituminous Pavements Subcommittee, (2) Cement Concrete Road Surfacing Committee, (3) Concrete Road Construction Subcommittee and (4) Water-Bound Macadam Subcommittee.

The Council of the Indian Roads Congress held two meetings. In the first meeting, the Council reviewed the work of the Executive Committee, and various other Committees. The Council also considered the recommendations of a Special Committee suggesting the formation of a Road Board at the Centre and strongly endorsed this recommendation.

57th Council meeting

The Council appointed a Research Implementation Committee for the implementation of the results of research carried out in road research laboratories and to overcome the difficulties in the way of such implementation.

The new Council at their meeting held on the 8th January, elected Shri K. Barua, Chief Engineer, P.W.D., Assam, as the President for the next year. Shri S. N. Tripathi, Chief Engineer, P.W.D., B. & R., Madhya Pradesh, Shri G. C. Khanna, Chief Engineer, P.W.D., B. & R., Punjab, and Shri P. D. Shivdasani, Chief Roads Engineer, M/s. Standard Vacuum Oil Co., were elected as Vice-Presidents, Shri N. Sen, was re-elected as Secretary. The Council accepted the invitation of the Government of Bihar to hold the next Session of the Indian Roads Congress at Patna towards the end of this year. Chairmen of various technical committees were appointed. The Council also discussed the question of obtaining more finance for roads and road transport in the Third Five-Year Plan and stressed the need for exploring ways and means of augmenting the resources for road development in the years to come.

58th Council meeting

Six Papers were discussed during the Session. Brief synopsis of the Papers are given below :

1. "An Investigation for Evaluating an Airfield Pavement" by Dr. H. L. Uppal and H. S. Bhatia

An investigation on the evaluation of an airfield has been carried out by using the LCN system of classification with the object of assessing its structural adequacy to carry the existing type of traffic. Such investigations would be useful for other airfields also.

The investigation showed that the existing pavement failed due to lower LCN number.

In the Paper the designs for the existing as well as for the anticipated future traffic have been given.

It has been suggested that such investigations should be extended to the evaluation and design of roads.

2. "A Study in Road Failures" by S. N. Gupta and P. L. De

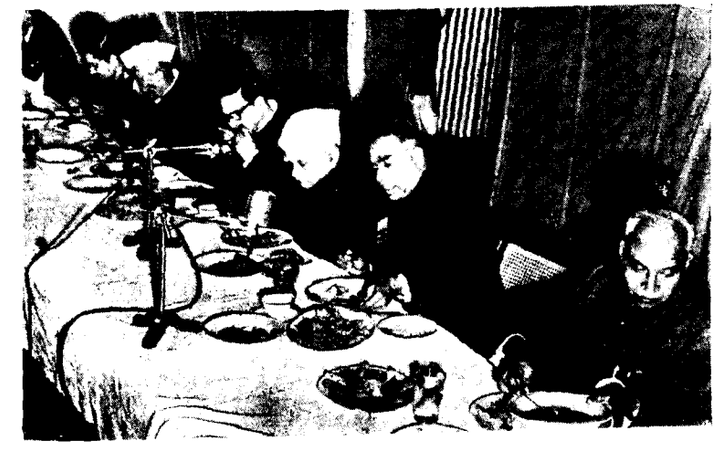
The Paper deals with the investigation of common types of road failures associated with subgrade, the embankment, and the natural ground on which embankment is built. Typical examples of some road failures which have recently occurred in West Bengal have been studied with particular reference to the principles of soil mechanics and remedial measures necessary for proper design and construction of an embankment have also been described.

3. "Stresses in the Corner Region of Thin Bonded Concrete Road Slabs" by S. Koteswara Rao and V. Venkatasubramanian

This Paper gives results of experiments of load stresses in the corner region of a thin bonded concrete road slab constructed under field conditions taken up at the Indian Institute of Technology, Kharagpur, and the results verified with the existing theories. It

A Paper Discussion

was found that observed corner load stress agreed closely with Westergaard's theoretical values for corner load formulae. It was also found that in the vicinity of the corner bisector where the observed strains were maximum, the locus of the maximum strain and the shape of the actual load break were nearly straight lines, thus justifying Westergaard's assumption. The studies revealed that Westergaard's corner load formula can be used in the design of thin bonded concrete road slabs.



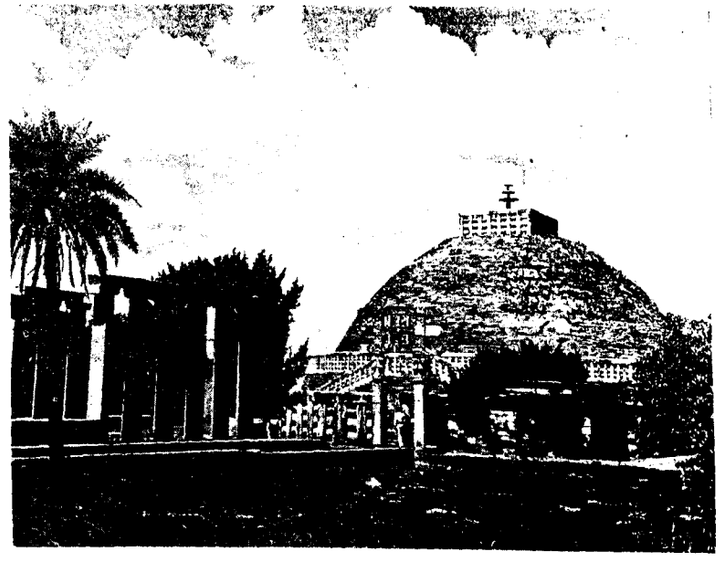
The Annual Dinner

4. "Study on the Stability of Well Foundations for Major Bridges" by A. Banerjee and S. Gangopadhyay

Based on assumptions specified in the Paper, formulae have been worked out taking into consideration various combinations of vertical and horizontal forces including active and passive earth pressures. Use of formulae has been explained by working out examples.

5. "Design and Construction of Udyavar Bridge" by Dr. A. S. Adke and C. Chidambaram

The difficulties encountered in sinking wells for foundation, and methods by which the same were surmounted are described. Details of construction of sub-structure and superstructure, including the hydraulic data and design are also furnished in the Paper.



Buddhist Shrine at Sanchi visited by delegates

6. "Study of Parking Problems—Connaught Place and Connaught Circus Area, New Delhi" by Joginder Lal

The study has been carried out to assess the parking demand and to suggest improvements in the layout of parking facilities in one of the busiest centres of New Delhi, keeping in view the present and reasonable future growth of traffic as far as possible and the innate desire of the users to park their vehicles as close to their destination as possible.

The delegates discussed the General Report on Road Research carried out in the country during 1959-60. A very encouraging feature is the beginning of research on bridges and structures. It has been noticed that soil stabilization techniques, particularly the mechanical stabilization and stabilization with the use of lime, and cement are attracting more and more attention in many parts of the country. The discussion was very lively and interesting indeed.

The delegates also discussed a note on "The use of low grade aggregates in road construction". The results of systematic study have shown that there are large deposits of the low grade aggregate fairly well spread out throught the country which can be made use

of economically even in those cases where the cost of the hard stone metal is not very high, provided scientific control on usage is exercised. Many speakers took part in the discussion.

Other highlights of the Session included interesting social functions and cultural shows. Several technical films were shown and a lecture was delivered on (1) Second World Conference on Earthquake Engineering and (2) Prestressed Concrete Bridge on the River Yoshi under construction by Shri R. N. Joshi. Inspection of works in and around Bhopal were also arranged.

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

Vol. XXV-Part 4 BHOPAL January 1961

PRESIDENTIAL ADDRESS

The Twenty-Fifth Session of the Indian Roads Congress was held at Bhopal from the 3rd to the 10th January, 1961 and was formally opened by Shri H. V. Pataskar, Governor of Madhya Pradesh, on Wednesday, the 4th January, 1961. The proceedings opened with an Address by Shri H. P. Sinha, the President, the full text of which is given below:

Shriman Rajyapalji, Ladies and Gentlemen,

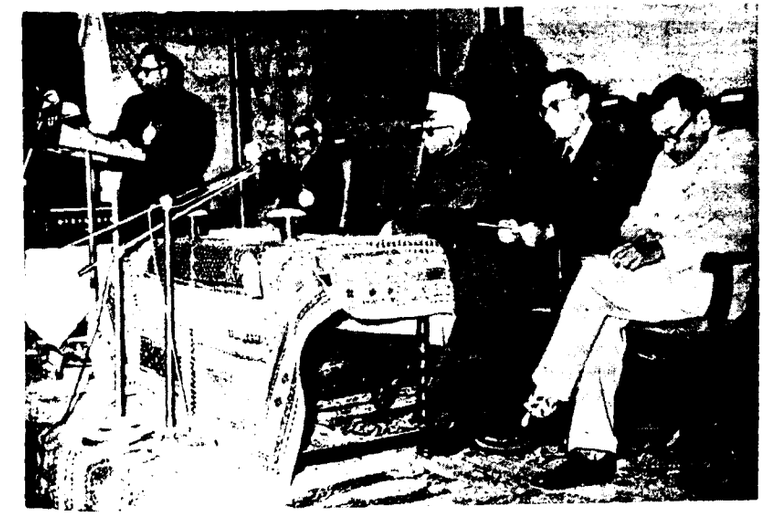
As President of the Indian Roads Congress it is my privilege and honour to extend to you, Sir, a most respectful welcome and to express our gratitude for your having kindly consented to inaugurate this, the 25th Session of the Indian Roads Congress. To members and delegates, I offer my cordial greetings on this happy occasion of our annual re-union to discuss, understand and compare notes of our past year's work and experience.

We are deeply indebted to the Government of Madhya Pradesh for inviting the Congress to hold the meeting at Bhopal, the new capital. We are meeting here for the first time in the 25 years' history of our Institution although the Congress sessions were held twice before in Madhya Pradesh, the 8th Session at Gwalior (now in Madhya Pradesh) and the 20th Session at Nagpur (now outside Madhya Pradesh). Bhopal has historical and cultural associations going back to the early centuries. It is now one of the most important cities of the country and is rapidly expanding to meet the multifarious needs of a capital. This session of the Congress is therefore most opportune. I am sure every one of us will carry home very pleasant memory of this city of lakes.

The Indian Roads Congress, Sir, is a technical Society. It is an all-India forum for examining and assessing the needs of road communications, pooling knowledge and perfecting techniques of construction of roads and bridges, of traffic engineering and other allied matters, through which we hope to play our appropriate role in the nation's march to prosperity.

ROAD AND ROAD TRANSPORT

In an expanding economy like India's, with production rising from 130 million tons in 1950–51 to over 700 million tons by 1975–76, it is essential to develop all modes of transport. Road



The President, I.R.C., delivering his Address

Transport must, therefore, play its part wherever it is most beneficial to the nation. The basic advantages of road transport in certain fields have influenced most of the advanced countries to lean increasingly on this form of transport. The volume of traffic carried by road transport is consequently growing day by day in such countries. Thus while in India Road Transport is estimated to carry only about 10 per cent of all the goods traffic, in U.S.A. it carries about 20 per cent, in Great Britain about 55 per cent and in Australia about 52 per cent. At present, the Railways provide the means for the bulk of transport in India.

It has been the aim of the Government since independence that the country should develop in such a manner as to provide the basic necessities of life to everyone. One of the major decisions taken in this context is the policy of rapid industrialisation. For the success of this policy it is not enough to make advancement, howsoever great, in isolated fields. All the sectors of activites must be integrated and should unitedly move forward in harmony so as

to avoid lopsided development and to provide maximum benefit. As an example, it will not be possible to derive the fullest advantage if we put up a fertiliser factory but omit to arrange for economical procurement and movement of all the raw materials and also for the effective distribution of the finished product. The co-ordination and co-operation that are absolutely essential for the success of the present-day industries depend, to a large extent, on the overall efficiency of transport available in the country. It will not do if the transport is cheap but not sufficiently speedy. It will also not do if during transit the articles are liable to damage or pilferage or if the cost of subsidiary transport at the terminals is disproportionately high.

RAIL-ROAD CO-ORDINATION

The demand for transport in India has already increased considerably and it is bound to grow with greater acceleration. In spite of all the effort that has been put in so far, it has not been possible to meet the demand in full. The over-crowding in trains and buses, the difficulty in obtaining wagons and the relatively high rates one has to pay for transporting goods by road because of the pronounced shortage of vehicles, are indicative of the unsatisfactory position.

No single type of transport can be suitable for the need of all forms of industries. It is the people in the industries themselves who can really decide which type of transport should be preferred. All the types of transport should, therefore, be developed. The ideal position will be to give weightage to none and let each perform the duty, which it is capable of, in the fields in which it is acceptable to the industries or other consumers. But, in practice, it is not always possible to adhere to the ideal considerations because of several other conflicting needs of the country, specially in situations of emergencies such as wars and famines. Still it does not necessarily follow that the weightage given to one system of transport should be so great as to throttle the other system. The co-ordination of various means of transport has, therefore, to be carried out in such a manner that the needs of the country, both for day-to-day requirements as well as for emergent situations, are adequately served. We have before us the examples of several advanced countries which have already faced this situation. Each of these countries has evolved a solution suitable to its individual needs and circumstances. No two solutions will be found to be identical because every country is confronted with some uncommon peculiarities. On the whole, however, the trend in the development of transport can be seen quite clearly and leaves no one in doubt about the increasing demand on road transport.

The initial development of mechanical transport in all the countries took place by the expansion of railways. After a certain stage, road transport came in to share more and more of the total transport. Later on, the inland water transport in certain regions captured a good deal of traffic, and last of all, the pipeline monopolised the transport of some special commodities, such as oil, in certain situations. In 1957, the share of various forms of transport in U.S.A. was as below :

Railways	...	47	per cent
Road	...	19	,,
Inland Water Transport	...	17	,,
Pipeline	...	17	,,

India, though not as large as the U.S.A., is certainly large enough to have ultimately a pattern of development of the same variety as the U.S.A. I, therefore, think that similar distribution of transport will apply to our country also when it has developed industrially in accordance with our aims and efforts. At the present time no reliable figures are available for the carriage of goods by road because most of the transport is done by small operators who are not able to maintain proper records. But it is reckoned that the goods traffic moved by road is about 10 per cent of the total traffic in ton miles. A very great leeway has, therefore, to be made up in the road transport system before it can attain its right place.

While there has been a visible progress in road tansport, both in the field of roads as well as vehicles, during the last ten years, it is necessary to point out that the pace at which this progress is being made is altogether inadequate. Unless a concerted effort is made for accelerating this pace, road transport is bound to become a bottleneck and, instead of helping the industrial growth, may actually retard its progress. A great deal has been said on the question of rail-road competition and on the priorities that should be assigned for the development of railways or roads, but the real position is that even if both of them are developed to the maximum extent possible within our limited resources, it would not be possible to catch up with the growing needs of the country for the movement of goods and passengers. Let us therefore, consider how much each system of transport can be improved, both in capacity as well as in efficiency. The question of priority will really arise in the consideration of long range policy for development of transport. The decision on that subject must take some time because of the multifarious aspects that have to be balanced before arriving at a satisfactory solution.

It has been pointed out from time to time that railway rates do not bear as close a relationship to costs as rates for transportation by road do. The railway rates are adjusted in the interest of

economic development of the country so that raw materials and low priced goods pay lower rates than manufactured goods or high priced goods. The roadway carriers are alleged to capture the high rated traffic over the longer hauls because their cost of carrying such goods is lower than the rate charged by the railways. Further, after carrying high rated traffic one way at considerable profit, the road transport operators can even underbid the railways for low or medium rated traffic on their return journey.

While this allegation may be seemingly true, the real fact of the matter is that there are a number of other advantages which tilt the balance in favour of road transport in many situations in spite of the very high rate of taxation on this industry.

The Masani Committee on Road Transport Reorganization have pointed out:

"The advantage of low rail freight is nullified in many cases by the slow speed of a railway wagon, which covers only about 48 miles per day at an average as against about 150 miles covered by a truck. This is the main reason why distributors of consumer goods, among others, prefer road transport even if the cost be somewhat higher. It is also argued that if the present restrictions on road transport are removed, bridges strengthened to carry economic loads, road surfaces modernized and truck-trailers and articulated vehicles permitted, road costs can be brought down materially and that as a result road transport, with the added advantage of speed, will be more economical to the consumer."

In this context I can do no better than quote an extract from the text of speech delivered in April, 1960 by Mr. S. H. Turner, Chairman, Hindustan Lever Ltd. He said:

"With so many hundred thousands of movements to consider, we are necessarily deeply interested in everything that goes in transport. First, our transport costs were, in 1959, equal to nearly half of our profits. They added up to considerably more than our proposed dividend; naturally, therefore, it is of utmost importance to us that they should be as low as possible. Secondly, every ton of oilseed or oil held up at the collection points for want of transport or delay in transit, every case of SUNLIGHT or tin of DALDA that is sitting in a railway wagon or truck instead of in a consumer's kitchen, is capital tied up earning nothing.

"We use every form of transport available to us, having regard to the nature of the product and its packings, distance, transit time, cost and convenience of consignee.....Last year about 50 per cent of our despatches were made by road; another 2 per cent were made by quick transport service, a service the railways simply did not offer ten years ago. Our average transit time has been

reduced from the 21 days of 1950 to 5 days now..... The result is that both we and our dealers can operate with less stock in the pipeline. The minimum pipeline stocks of Vanaspati, for example, have been cut by some 2,000 tons or nearly a third, over the last 3 years. This has led to a reduction of Rs 40 lakhs in the capital, invested in packed stocks."

A high-powered Committee on Transport Policy and Co-ordination has already been set up by the Government. This Committee has been called upon to recommend a long term transport policy and suggest suitable mechanism for the co-ordination of the various means of transport. We look forward to the findings of the Committee and are confident that road and road transport will receive their due share for development in the right direction.

TRANSPORT REQUIREMENT

The requirement of transport for the entire country can be worked out on the basis of the targets of production for various commodities such as foodgrains, steel, coal and cement. It is necessary for those in charge of country's development to take a decision in respect of the production targets. This has been done. The Chief Engineers of all the States, when they were charged with the task of making recommendations for road development for the next 20 years, i.e., 1961-81, met together during 1958 and 1959 and assessed the total requirement of transport for the country during this period, basing their calculations on the targets of production accepted for various commodities. They came to the conclusion that long distance transport, which really pertains to an average lead of 300 miles, will increase from 182 million tons in 1960-61 to 800 million tons in 1980-81. At the end of the Second Five-Year Plan, the Railways are expected to carry 162 million tons. There will, thus, be a gap of 20 million tons, which has to be carried mainly by road transport. Similarly, the Chief Engineers assessed that at the end of 1980-81, the railways would carry 523 million tons and the roads would be required to carry about 246 million tons, i.e., ten times of what they carry to-day. These estimated figures cannot be considered as firm, but they cannot be far out in view of the trend of road transport in other developed countries of the world. Both road construction and vehicles production must, therefore, be stepped up suitably to meet the future demand which is bound to be very large indeed.

The Chief Engineers have also calculated the number of motor vehicles that should be produced each year for meeting the demand on road transport. They have also worked out the revenue that would be available to the Government from these vehicles and the expenditure on development of roads to adequate standards. In the end, they find that the total expenditure on roads over a period of

20 years (1961 - 81) should be of the order of Rs 5,200 crores for development and Rs 1,350 crores for maintenance. At the same time they expect that revenue realised from motor transport taxation would be of the order of Rs 6,150 crores, which means that the entire programme can be self-supporting. Their recommendation for expenditure on road development during the Third Five-Year Plan is Rs 590 crores.

I have purposely mentioned the figures given in the Chief Engineers' report because if road transport has to keep abreast of the country's requirements, its development should commence at a proper pace without loss of time. We are, however, much concerned to learn that the provision of road development during the Third Plan would amount to Rs 250 crores only. Obviously, if we give road transport such a poor start, there is no likelihood for it to make its full contribution towards the development of the country. No doubt, in the draft Plan, it is mentioned that the amount of Rs 250 crores is not a firm figure and may be altered on further deliberations, but we would be deluding ourselves if we think that this figure can be altered materially during the process of final adjustments. What is necessary is to appreciate that this amount is altogether inadequate and has to be enhanced on its own merit.

EMPLOYMENT POTENTIAL

Because of the inherent advantages of road and road transport, their high employment potential and capacity to bring quick and larger returns, further utilisation of roads by promotion of the automobile industry is bound to be of great consequence in developing the country. In an under-developed region where economic activity has to be initiated, one of the most profitable and least capital intensive form of employment appears to lie in road construction and in the development of road transport. Apart from offering immediate employment, it provides an incentive for the growth of other economic activities by making the place accessible. In U. S. A., road transport industry stands second, next to agriculture, in providing facilities for employment. The automobile industry also offers considerable scope to small industries. It may be mentioned that more than half of the automobile industry in U. S. A. is served by small firms employing less than 50 persons each. In India too, road transport, being scattered all over the country, can sustain a large population receiving employment through small-scale industries. The regional diversification of employment in road works and in the road transport industry is conceptually as important as the magnitude of employment potential.

The proportion of unskilled labour utilised in the road and road transport activities is very large as compared to skilled and semi-skilled labourers. The investment in road works, therefore, becomes

doubly rewarding because it generates, not only considerable employment but also provides jobs to local untrained labour whose proportion is very high.

REVENUE FROM ROAD TRANSPORT AND EXPENDITURE ON ROADS

In the past expenditure on road development and maintenance was far too low in relation to revenue derived from road transport. Only at the beginning of the Second Five-Year Plan the position improved and the expenditure on road construction and maintenance became nearly equal to the revenue realised from motor transport. But the position has since deteriorated again. The revenue from road transport in India and the expenditure on roads for the last 5 years are indicated below :

REVENUE FROM ROAD TRANSPORT AND EXPENDITURE ON ROADS

(In lakhs of rupees)

	Revenue from road transport			Expenditure on roads		
	Centre	State	Total	Development	Maintenance	Total
1955–56	4555	2583	7138	5502	2715	8217
1956–57	5231	2849	8080	5586	2906	8492
1957–58	6363	3778	10141	4789	2599	7388
1958–59	6414	4514	10928	5841@	2832@	8673
1959–60	8760*	4694†	13454	5355@	3115@	8470

Source : (i) State Budgets, (ii) Supplements to Basic Road Statistics.

Road revenues in the next Five-Year period including normal annual increases can be assessed conservatively at about Rs 900 crores. This revenue justifies a much larger developement plan for roads in the Third Plan than indicated by Rs 250 crores proposed to be allocated and which is no higher than the amount provided for roads in the Second Plan. Considering that the Third Plan is much bigger than the Second, and specially when the earnings from road transport are likely to be doubled, it is obviously not fair that such a small sum should have been provided in the Third Plan.

* Revised Estimate. † Budget Estimate. @Revised Estimate for Centre and Budget Estimate for States.

In the opinion of several authorities, not only the entire revenue from road transport should be earmarked for roads but also some additional funds from the general revenues should be provided for road development in recognition of the role of roads in the country's general economy like national defence, postal services, etc. The Chief Engineers in their report on Road Development for India (1961—81) have shown, however, that the road development programme can be self-supporting without any assistance from general revenues. They have stated :

'Road construction is inescapable because roads are the only means for linking the remotest parts of the country. But it will pay if the roads are built and motor vehicles production lags behind. If the production of motor vehicles is stepped up to meet the steadily increasing demand arising from the rapidly growing economy of the country, the tax receipts from those vehicles will be sufficient to cover both the construction and maintenance costs of roads under the new Road Plan (1961—81).'

TRAFFIC NEEDS

Construction of bridges and the improvement of existing roads, to cope with the increase in traffic both in volume and laden weights are the most pressing needs in the field of road development to-day. At the same time, further expansion of the road mileage cannot be held back as it is absolutely essential to open up new areas and reach the heart of the country as quickly as possible.

The network of our existing roads is very sparse and even in the arterial routes there are a number of gaps and unbridged river crossings. These routes have mostly one-lane carriageway and many of the old existing bridges and culverts are not capable of taking the load of the present-day heavy transport vehicles. The surface of these roads also needs to be strengthened. It is expected that even our National Highway System consisting of about 15,000 miles of roads, will be deficient in the following respects at the end of the Second Five-Year Plan :

(1) Eighty major bridges will remain unbuilt ;

(2) Four-hundred miles of missing links will remain to be constructed ;

(3) One thousand miles will have single-lane water-bound macadam surface ;

(4) 11,300 miles will have only a single lane asphalted or cement concrete carriageway, about 2,300 miles only having a two-lane carriageway ;

(5) Hundreds of road-rail level-crossings will remain to be replaced by over or underbridges ; and

(6) Bypasses around most of the towns will remain to be built.

Similar deficiencies will also be found in important State road systems.

A study has been made regarding the requirement of roads during the Third Five-Year Plan period from the point of view of the volume and intensity of traffic likely to be generated during that Plan. Apart from the entire local and feeder traffic which must be carried by roads, a fair share of long-distance traffic will also have to be carried by roads. The Jha Committee on Automobile Industry have recently recommended that, by 1965-66, the number of passenger cars including jeeps, buses and trucks should be about 400,000, 100,000 and 300,000 respectively. To provide roads for the traffic generated by these vehicles, at least 50 per cent of the National Highways and 25 per cent of the State Highways will require widening to two-lane carriageway. Besides, it will be necessary to strengthen the road crust of many sections so as to withstand the load of the heavy vehicles that have already started plying on these routes. Upgrading of the major district roads to water-bound macadam or higher standard will also be necessary in many cases.

A considerable length of rural roads has been constructed under the Community Project and National Extension Service Schemes. These roads have been constructed mostly by voluntary labour. To make this mileage of roads a permanent addition to the road system of the country, it is necessary to improve the standard of these roads and ensure a satisfactory arrangement for their future maintenance. The final responsibility for the upkeep of these roads has to be vested in some agency which will be in a position to look after these roads. Before transferring this responsibility, it is desirable that certain minimum standards are provided to the agencies undertaking the construction so that all the new roads conform to an integrated plan of road development for the country as a whole.

A special drive is necessary in respect of rural roads for linking up all the villages with the road system. The requirements are so large that only a dynamic and sustained effort can produce results. Some Central and State assistance is being given for these roads. This is, however, too small in view of the magnitude of the problem. The extent and scope of the assistance has to be considerably enlarged in the context of our growing needs in rural areas.

The Second Taxation Enquiry Commission suggested that for larger expenditure on rural communications, an All-India Rural Communications Fund should be created, which should be both substantial and non-lapsable. Contribution from this fund should

be available to all States and the Central contribution should, in each State, be supplemented by the State Government as well as by Local Boards and Village Panchayats (where suitable, in the shape of free labour, etc.). From a broad appraisal of the problem of developing rural communications, the Commission considered that there was justification for :

(1) an annual contribution to the proposed All-India Rural Communications Fund by the Central Government of a sum equivalent to the proceeds of the Central Customs and Excise duty on motor spirit to the extent of 4½ annas per gallon, and

(2) for the provision by each State Government for expenditure on rural communications of a sum not less than 25 per cent of the Central grant to the State from this fund, the Central grant being conditional on such provision by the State.

In view of the pressing need for rural road development in the country, the recommendations of the Taxation Enquiry Commission deserve serious consideration. A similar contribution could also be made from the proceeds of the Central Excise duty on diesel oil.

MOTOR FUEL

One of the significant factors in improving the economy of motor transport is the introduction of the dieselised commerical vehicles. Higher thermal efficiency of the diesel engine provides about 30 per cent saving in fuel consumption, i.e., the volume of fuel used. High speed diesel oil is also subject to a negligible loss by evaporation. In addition, petrol is more expensive in our country than diesel oil. These factors go to reduce considerably the cost of operation of a motor vehicle using diesel oil. Consequently there has been a steep rise in the consumption of high speed diesel oil during the last two or three years, while the consumption of motor spirit has remained static, notwithstanding the fact that there is physical surplus of motor spirit available in the country. The total consumption of high speed diesel oil is now, and will hereafter be, increasingly greater than that of motor spirit. This consumption pattern has created the twin problem of foreign exchange expenditure on increasing imports of high speed diesel oil and of finding export market for the surplus of motor spirit. The establishment of the two new refineries based on Assam will alleviate the first problem but will accentuate the second.

Fiscal measures have been taken from time to time to discourage the use of high speed diesel oil and to correct the present imbalance but the basic advantage of a diesel engine cannot be done away with. Simultaneously with fiscal measures, a multi-pronged attack on the problem is essential. Already the proposal to encourage the use of a fuel which would be an admixture of petrol and diesel is receiving serious attention of the trade and at the same time a sustained effort is being made to increase the number of cars (especially small cars) to utilize the surplus petrol. With an intensive programme of oil exploration in the country and the encouraging results at Cambay, let us hope the country's production pattern of fuel oil will match the demand.

OTHER PROBLEMS

The efficiency with which the road transport can operate is getting seriously hampered due to the fast-growing ribbon development along the country's roads. Apart from unauthorised occupation of the road land and extensive encroachments made even wilfully in many cases on the roadside property have assumed a serious character and enforcement of an effective control has become essential. If this is not done early, the problem will create serious impediments in proper utilization of highway facilities. It seems incumbent that the authority in charge of roads should be vested with adequate powers to preserve the highway property and control its functional use. He should also have quick and speedy means to acquire land, etc., whenever found necessary for furtherance of a road project. The Bombay Highways Act, it is seen, contains an appropriate answer for this purpose as it confers the necessary powers on the Highway Authority. The adoption of this Bill is earnestly commended to other State Governments and necessary enactment may be initiated by the Legislatures of the States as speedily as possible.

The fact that the road transport operator is in a position to extract premiums both on permits and also on the resale of vehicles is enough evidence to prove that there is a wide gap between the demand and the supply of motor vehicles in our country. Due to limited production of and high demand for vehicles, the proportion of over-aged vehicles retained in the service is very high. About 35 per cent of the stage carriages and 50 per cent of the goods trucks are over 10 years old. Obviously, the effective utilization of these vehicles will be relatively poor. At the same time, roads in India cannot be ulilized to their full capacity on account of the limited number of vehicles on roads. There is only one motor vehicle per mile in India against 25 in Britain, 21 in U.S.A., 13 in Malaya and 8 in Ceylon.

The densely-settled regions of the country with their large cities and industrial establishments require a good network of modern highways to cater to the needs of concentrated traffic. But the majority of the population dispersed over the vast expanses of the country must also be provided with roads as the basic necessity of

civilized living. It is, therefore, necessary to build roads of all types so as to have a balanced development. The rational approach would, no doubt, be to construct a road in stages according to the needs dictated by the development of traffic.

For efficient functioning of the road transport industry it is also very important that vehicles are kept in good repair. This requires not only garage equipment and tools but also a timely supply of spares at reasonable price. At the present time, vehicles of all types require roughly a sum of Rs 40 crores annually for the import of spare parts, but the imports are allowed to an extent of Rs 28 crores only due to shortage of foreign exchange. Thus there is a gap of Rs 12 crores, i.e., about 30 per cent on the supply side. The prices of spare parts have naturally gone up due to this scarcity. It is essential to organise in the country itself the manufacture of spare parts of standard quality. Any spare part which does not reach such minimum standard is a national waste of scarce material and scarcer skilled labour. In this matter, organised small-scale industry should play a very important role.

The motor vehicle industry is still far from being self-sufficient though, during the last few years, the proportion of the indigenous contents has shown considerable rise as is evident from the table below:

S. No.	Type of vehicles	Indigenous content (October 1959 to March 1960)
		per cent
1	Hindustan Ambassador	70.5
2	Fiat 1100	47.0
3	Dodge Diesel with Perkins Engine	68.0
4	Standard Ten	32.5
5	Tata-Mercedes-Benz Truck	64.0
6	Tata-Mercedes-Benz Bus	71.0
7	Leyland Comet	38.5
8	Jeeps	65.0
9	Meadows Engine	50.0
10	Perkins P. 6 V Bare Exh. Diesel Engine	64.0
11	Bedford Diesel with Perkins Engine	46.0

Currently the main reason for limited number of vehicles produced is the restricted quantum of foreign exchange allowed for the import of the components not manufactured in the country. While every effort should be made to make more and more components in the country, it is also necessary to permit the import of the requisite components in sufficient quantity in the meantime so that there is no shortage of vehicles. It has been estimated that for an expenditure of Rs 6,000 in the form of foreign exchange for a motor vehicle, the Government gets a revenue of Rs 12,000. The expenditure in foreign exchange is thus a very good investment for raising revenue. Further, the higher the foreign exchange quantum provided with a view to increase the indigenous content of the vehicle, the sooner will the country be self-sufficient in respect of automobile manufacture and thus be independent of the needs of foreign exchange.

While I am on the question of foreign exchange, I might discuss a subject in which the shortage of foreign exchange affects road engineers adversely. India does not produce high tensile steel which is a special steel used in prestressed concrete construction. This technique of prestressed concrete construction has made rapid strides in all advanced countries. For the construction of bridges, this technique effects considerable economy (about 10 to 15 per cent) in the cost of large span bridges. This technique has a great uture in India where the rivers are very large and where a large number of such rivers remain to be bridged. It is understood that a few schemes for the manufacture of high tensile steel wire within the country have already been sanctioned. But, in the meantime, it is essential to release necessary foreign exchange to enable us to import the requisite quantity of high tensile steel and accessories for the important bridges the lack of which constitutes one of the major bottlenecks in road system. The requirement of foreign exchange for the next three years is about Rs 3 crores, which is comparatively a small amount and its expenditure can be amply justified by the savings in the cost of bridges.

TAXATION OF ROAD TRANSPORT

It is perhaps known to most of you that the incidence of taxation on motor vehicles in India is the highest in the world. The average incidence of all taxes on a motor vehicle comes to over Rs 2,000 annually against about Rs 500 in the U.S.A. In the European countries, such taxes range from Rs 800 to Rs 1,500.

In spite of the pressing demand of the trade for reducing the tax burden, there has been a progressive increase in the various imposts during recent years. It has been possible for the transport

Elaborate studies on this specific problem have been conducted in advanced countries, like U.S.A., U.K., etc., extended over several years. An estimate made in the U.K. indicates that the annual saving to the Road Transport in Britain would be as much as Rs 125 crores if a programme of road construction and improvement aggregating to Rs 720 crores was undertaken. With adequately surfaced roads, the resultant annual saving in the total operation cost of motor transport is estimated in a small country like Belgium at Rs 13 crores. In order to bring to light the effect of the condition and type of road surfaces on the cost of operation in our country, the Indian Roads Congress arranged to have controlled experiments conducted by the State Transport Undertakings of U.P. and Bombay for the last 5 years. The results show that the change of road surface from bad water-bound macadam to good cement concrete or bituminous surface reduces the fuel cost to the extent of 25 per cent; the wear and tear of tyre and spare parts are also much less on good roads; and in terms of cost per vehicle mile there is a saving of 60 to 70 per cent in the consumption of tyre and spare parts when the road surface is good. The experiment is now being extended to hilly regions to have a wider inference under varying conditions of roads. There is, however, no doubt, that the saving in vehicle running cost due to the improvement in the condition of road surface can, many a time, meet the full cost of improvement in the course of a decade, if the existing road surface is poor. This aspect of highway economics is apt to be overlooked perhaps because the upkeep of the track and the vehicles is not the responsibility of the same agency. Sub-standard roads in relation to the traffic intensity can, therefore, be more expensive than a higher type of road in the long run. That is the reason why it is said that:

"A country pays for its roads whether it has them or not—and it pays more for those it does not have."

ROAD RESEARCH

The Indian Roads Congress has, through its various Committees, been making its contribution towards research work on highway and transport problems. In order to utilize the researches and improved methods of road construction, it is necessary to test them under field conditions on a fairly large scale, so that their performance and economics can be assessed objectively. It has, therefore, been accepted that each State should devote 1 per cent of its Third Plan allocation for road development schemes on experimental specifications and new techniques. The selection of experimental roads will be made from those already included in the development programme so that there is no reduction in the physical targets of the Plan. In order, however, to cover any possible risks of failure of any experiment or any extra expenditure that might be incurred for the new specification, a suitable sum will be set apart as a sort of "Risk Fund".

An Assessment Committee will be formed under the aegis of the Indian Roads Congress for selecting the experimental roads and assessing their performance during the test. The Indian Roads Congress in this way will be able to render further help in the progress of roads and road transport.

INTERNATIONAL HIGHWAYS IN THE ECAFE REGION

As most of you already know, the United Nations Economic Commission for Asia and the Far East (ECAFE for short) have proposed a network of international roads in the region. These international roads will be built to certain minimum standards which have been laid down after discussions among experts of the countries concerned. Further development and improvement will be by stages as the requirements of traffic demand. The network of the highways has been decided upon in consultation with the Governments of the countries. The total length of these International Highways, as at present envisaged, will be 49,713 kilometres.

These highways are divided into two categories. The first category consists of main arterial routes joining the capitals of the countries by a route as direct as possible and either existing in passable condition or likely to be completed in the near future. This category also includes certain routes which could be built to improve the alignment of the main arterial routes. The second category includes some other routes joining main cities, ports, etc., with the main arterial network included in the first category.

Out of the total length of 49,713 kilometres, the length of category I routes is 28,806 kilometres and that of category II routes 20,907 kilometres. In India, the length of category I routes is 7,040 kilometres and that of other routes, 8,376 kilometres.

Almost the whole length of international routes in India, in both categories, lies along our National Highways. While in most cases the National Highways satisfy the minimum standards of international roads, a few sections will have to be constructed or upgraded. Besides the geometrical and structural requirements there are certain other facilities which have to be provided along international routes. These include the provision of service stations and petrol filling stations, facilities for rest and meals for the travellers in the form of hotels, "motels", rest-houses, etc., telephone booths for inter-communication, first-aid posts, water tanks in the less populated difficult areas like dry zones and mountainous areas and so on.

Action has, at the same time, been initiated by ECAFE for easing frontier facilities to encourage international road traffic. The new road links between the countries of the region will give an impetus to commerce and trade and particularly to social and cultural contacts between the peoples of neighbouring countries.

Through the International Highways in Turkey this system of Asian Highways will link up with the similar system already established in Europe. When the Asian Highways are also established, road travel between Asain and European countries will lose its hazards and will knit the people of the two continents more closely and help in international co-operation and understanding, besides promoting trade and commerce. Every effort is being made to complete at least the priority routes within a few years.

ROAD BOARD

The need for rapid and extensive development of roads and road transport, and the various associated factors connected with them, brings up the question of provision of an organisation capable of directing and controlling the agency of transport in a unified manner. Such an organisation has to have a central high-powered body in the form of a Road Board. To-day roads are facing the same situation as the railways did prior to the constitution of the Railway Board. In spite of the fact that the earnings of the Railways were considerable in 1920-21, they were in a state of acute underfeeding. Few development works were taken up and maintenance and renewals were far from adequate. The Railway Budget was, therefore, separated from the Central Budget.

The revenue from road transport has gone up from about Rs 10 crores in 1938-39 to about Rs 135 crores in 1960-61 and still the total expenditure on road development and maintenance is not likely to be about Rs 85 crores in 1960-61. The roads are thus in a state of considerable financial starvation.

All the National Highways are now the direct responsibility of the Central Government. An Inter-State Transport Commission has also been set up with the necessary powers to develop, co-ordinate and regulate the operation of motor transport on inter-State routes. But for a fuller utilisation of roads, timely production of vehicles, balanced development of traffic and allied matters and effective co-ordination in all fields of activity, it is absolutely necessary to establish a suitable Central Organisation.

Recently, the Council of the Indian Roads Congress appointed a Special Committee to consider the question of setting up a Road Board at the Centre. This Committee have recommended that a Road Board is essential and its constitution should not be delayed. The Council will be considering this important recommendation during this session and then submit their suggestion to the Government for consideration.

We should also visualise the possibility of co-ordinated functioning of the Road Board and the Railway Board and other transport organisations under an authority like the British Transport Commission or the United States Inter-State Commerce Commision in the not too distant future.

In the end, Sir, I would like to express the hope that Road Transport which plays such a vital role in the economy of the Nation and provides a most potent means for the cultural and emotional integration of the country will receive the fullest attention and care by all concerned.

With these words, Sir, I request you kindly to declare the Congress open.

INAUGURAL ADDRESS

By

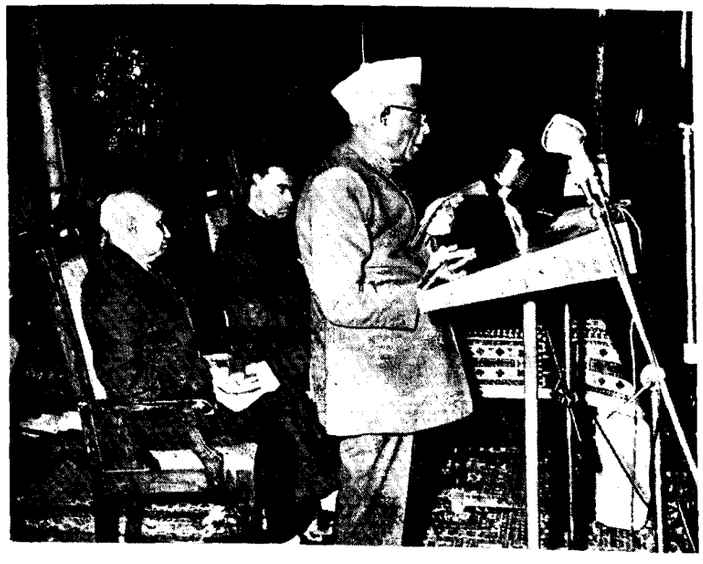
SHRI H. V. PATASKAR,

Governor, Madhya Pradesh at the inauguration of Twenty-Fifth Session of the Indian Roads Congress at Bhopal on the 4th January, 1961

Mr. President, Ladies and Gentlemen,

I consider it a great honour and proud privilege to have been invited to inaugurate this Twenty-fifth Session of the Indian Roads Congress. I am glad to see before me a very distinguished gathering of persons engaged in the task of reconstruction of this country by finding solutions to the various problems of transport and road communications facing us.

I have been watching with great interest the origin and development of this organisation ever since the Jayakar Committee Report, and that has given me an idea of the useful work done so far by this Organisation and its future potentialities.



The Governor delivering the Inaugural Address

Mr. President, I congratulate you on your learned and lucid address, and I have no hesitation in saying that it poses before this august gathering of Engineers various problems that face the politician, the administrator and the technician in the development of transport and road communications. In your address you have rightly stressed the role that this Congress is playing as an all-India forum for examining and assessing the needs of road communications, pooling together knowledge and information and perfecting techniques of construction of roads and bridges, of traffic engineering and other allied matters.

Your analytical examination of the whole problem in its relation to the Nation is very exhaustive and thorough and I feel sure it will receive due consideration from the Planning Commission as well as the Government of India and the various State Governments.

I would take this opportunity of placing some aspects of this problem in relation to my State, the largest in extent in our country but with very poor and disjointed means of communication. This new State, rightly called Madhya Pradesh, is at the centre of our country and as such the solution of its problems of transport will be not only to its advantage but to the advantage of the whole of the nation ; and it is primarily with this view that I am placing before this all-India body some of them. I may begin by giving a few figures which have a bearing on the point I propose to make. They are :

Area of the State	...	171,052 sq. miles
Population	...	26,071,637
Density of population	...	152
Forest area	...	33,443,000 acres
Tribal population	...	3,865,254
Rail mileage	...	2,830 miles
Road mileage	...	17,236 miles

I have no doubt that a glance at these figures will bring to your mind the special features and the special difficulties of this State. In point of area it is the largest State in India; but in point of density of population, it stands 14th, the last two being Assam and Rajasthan. It is thus one of the most sparsely populated State. From the point of view of large forest tracts and abundance of tribal population, it is second only to Assam. Its rail route works out to 1.65 per 100 sq. miles and the existing road mileage, I need hardly say, is extremely inadequate. As you all know, this State is comprised of four regions—Mahakoshal, Madhya Bharat, Vindhya Pradesh and Bhopal. Three of these four regions comprised of a

number of former princely States, about 74 in number. This historical fact is not without its significance in regard to the present state of communications in this State. The meagre road communications of each of the former princely States were so developed as to link the areas in each State with its own capital. The road communications in the Mahakoshal area were also so developed as to link that area with its former capital Nagpur, and with the other areas like Vidarbha which formed part of the former State of Madhya Pradesh. Whatever bridges were constructed they were constructed to suit this system of communication. A casual glance at the road map of our present State will show that apart from the meagreness of the length of road, whatever length is there is also disjointed from the point of view of this large State with its capital Bhopal.

Madhya Pradesh occupies a very central position in the country, and as such unless the road communications of this State are properly rearranged as also developed and brought to the level required by modern standards, the improvement and the benefits that are sought to be achieved for the country as a whole in the matter of road transport and communications will be difficult to achieve. The first and foremost necessity in this matter is of the construction of bridges at a number of places on the river Narmada such as the bridges at Hoshangabad, Onkar-Mandhata, Manot, Rajghat, Barwani, etc., and other rivers such as Dhasan, Sindh and Mahanadi. Unless all these bridges are constructed, I do not see any prospect of through traffic in goods and passengers being moved through this State with speed and economy. Not only this, but I think that so long these bridges are not constructed and road communications rearranged to suit the requirements of this new State, the task of achieving emotional integration of the people of the State will not make much progress.

The overall paucity of road communications in Madhya Pradesh has another far-reaching effect. The area occupied by forests in this State is as large as 33,443,000 acres, the largest in any State in India, and the absence of proper communications in and around this area is a great handicap to the development of the region and the progress of the Adiwasi population living in these forest areas. Let us, for example, take the case of Bastar district, which has an area of 14,492 sq. miles and a population of 9,13,746. Development of the proper means of communication inside the area as well as with the adjoining areas outside is a prime necessity for the development of this backward area and the betterment of people who live there.

There is still another aspect, looked at from which, extensive road communications in Madhya Pradesh appear urgently necessary in the interest of the nation itself. Madhya Pradesh has extensive

belts of mineral deposits and as many as 25 different minerals are being exploited at present. One of the largest steel plants in the country has started production at Bhilai. At Bhopal we are erecting the first and the largest factory for the manufacture of heavy electrical machinery. These industries cannot be made to thrive and be of full use to the nation so long as the communications and road transport are not adequately developed in this State.

Rail communications in this State are also not adequate nor are they convenient for inter-communication in this large State. Attempts to improve them are being made, but the increasing cost of construction and the huge initial capital required are great hurdles in making early progress. Road construction requires less capital investment and less time for completion. The needs of this State and the nation can be met earlier by a properly planned programme of road development.

I have placed some of these difficulties of our State for your consideration. You can view these difficulties as part of the problem of communication and road development of the nation as a whole and suggest adequate solutions to meet them.

Another aspect of your work to which I would like to allude to in passing with a great amount of hesitation is the need for directing your research to finding out ways and means for speedy and cheaper methods of road construction for a country like ours. One effect of Five-Year Plans has been to rouse the consciousness of people for all types of conveniences and comforts and people are loth to wait for them over a long period. It is, therefore, of the utmost importance to find out ways to increase the pace of road construction. We are not a rich country and it is necessary for us to find out methods which would in the circumstances of our country reduce the cost of road-making.

I have no doubt that all these points are already in the minds of you all who are assembled here for this session and that you will be able to suggest solutions for many of the problems that face us in the matter of adequate and proper road communications.

Gentlemen, I now declare the session of the Congress open and wish you success in your deliberations.

JAI HIND

VOTE OF THANKS

By

DR. F. P. ANTIA

Vice-President, Indian Roads Congress

Your Excellency,

Permit me, Sir, to thank you warmly on behalf of all the delegates and guests present here. Your very gracious presence is evidence of your keen interest in the development of roads and road transport. It is such sincere interest which provides inspiration and encouragement to us to persist in our efforts—notwithstanding the set-backs that we keep on receiving now and again.

Dr. F. P. Antia proposing a vote of thanks

Gone are the days, Sir, when roads and road transport were looked at askance by those in authority, and especially those interested in competing agencies of transport. Today, poised as we are on the brink of the Third Plan, there are few dispassionate observers and students of the subject who deny the vital role roads and road transport are playing in the implementation of the country's economic destiny. In view of this, it was with no little pain and surprise that we learnt that although the total size of the Third Plan at Rs 10,800 crores would be more than twice the size of the Second Plan at Rs 4,500 crores, the allotment for roads will stand at the same figure of Rs 250 crores. It would be a source of great comfort to us here to feel that we have Your Excellency's sympathy and support in the case we have presented to the Government of India for increase in this meagre allotment.

And now, Sir, if you will extend to me a little indulgence may I be permitted to blow our own trumpet—that of the Indian Roads Congress, for just a minute.

You may have noticed, Sir, the progress this premier body of road engineers in India has been able to achieve through the various technical committees by bringing out standards for road layout, construction and maintenance for uniform application in the country. I am sure, Sir, you will share our joy with us when I state that the Bureau of Public Roads, U.S.A., while extending good wishes for the success of the 25th Session, have expressed the view that the contribution of our Congress towards the advancement of technique and technology of highway engineering has been remarkable, and that our work has benefited the development of highways not only in India but in many other countries as well. Though our country is considered under-developed as compared with its opposite numbers in North-West Europe and North America, it is a matter of gratification and pleasure that the technical literature issued by us should already have proved of assistance to other countries.

Nor, Sir, may I assure you is our interest confined to the technical aspects of road construction and maintenance. The Congress is well aware of the fact that the use of roads by modern mechanical vehicles brings in its train innumerable problems, each more baffling than another. With pardonable pride may I be allowed to say that the Congress has them all under their ever-seeing eyes. Committees are in session not only to consider problems such as adequacy of vehicles vis-a-vis traffic offering, the fair measure of taxation thereon, but also those of traffic engineering and highway safety, and the wider sociological issues of ribbon development and of consequent urban layouts. If the Congress has not been able to produce a greater impact on the highway transport in this country on these non-technical sides, it is not because of want of effort on their part.

Poised as we are today on the brink of the Third Plan, it hardly lies in my mouth to emphasise that increased production cannot carry us far without adequate means of distributing that output, and to reiterate the importance of developing to the fullest extent the possibilities of road and roads transport in this country. It is not so much a competitive agency of transport as one complementary to other agencies. And, indeed, we can neglect it only at our peril.

On behalf of the President and members of the Indian Roads Congress, may I thank you, Your Excellency, for having done us the honour of being with us this afternoon.

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MESSAGES

Dr. S. RADHAKRISHNAN

Vice-President of India

I am glad to know that the Indian Roads Congress will be held in January at Bhopal. I hope the Congress will be successful and it will help to make road travel safe and satisfactory.

Shri JAWAHARLAL NEHRU

Prime Minister of India

I send my good wishes to the Indian Roads Congress Session at Bhopal. Our programme for roads has been an expanding one and is likely to grow. It is important, therefore, that we should study the latest methods of road-making and to do so as economically as possible.

Dr. P. SUBBARAYAN

Minister of Transport & Communications, India

Development of roads especially in an under-developed country like India is an absolute necessity. Rural economy can hardly progress unless agricultural produce of the villages is transported quickly to cities by means of good roads. As railways cannot cater fully to the transport needs of the county, development of roads is very essential for ensuring rapid industrialisation of the country, for bringing about its cultural and emotional intergration, as also for promoting tourist traffic, and thus earning valuable foreign exchange. Construction and improvement of roads for strategic reasons hardly needs any emphasis.

I send my good wishes for the success of the Conference.

Shri KAILAS NATH KATJU

Chief Minister, Madhya Pradesh

I am happy to see the Indian Roads Congress meeting in Bhopal for its 25th Session. I would have very much liked to welcome you personally and be present during your deliberations but my other pre-occupations prevent me from doing so.

Roads are the arteries of a Nation and the life lines of administration. The contribution which the Indian Roads Congress is making towards their improvement and development in our country is commendable.

I am sure the delegates will during their stay in this lake-studded capital of the largest State of India, make acquaintance with its picturesque surroundings. The Capital Project and the Heavy Electricals which symbolise the emergence of New Bhopal and New Madhya Pradesh—indeed in some measure of New India, will be well worth a visit. Not far from here are the sacred and ancient monuments of Sanchi which represent in many ways the eternal spirit of India.

I need hardly stress that what we need today is not only a rational planning of our communication system, but also a practical approach which would make its execution expeditious and within our means. I hope you will show us the way in this direction. I wish you all success in your deliberations.

Shri S. L. TIWARI

Minister for Public Works, Madhya Pradesh

It is Bhopal's privilege this year to play the host to the 25th Session of the Indian Roads Congress. I welcome the delegates to this city known for its charming surroundings and hospitable climate. The city has been generously treated by nature; now, the planner, builder, architect and the engineer are at work to make it the city beautiful of Madhya Pradesh. I hope you will enjoy your stay here.

The Indian Roads Congress has played an important role in giving shape to an integrated road map of India. This is a task vital in every respect to the life of the Nation. In the era of reconstruction today, the roads stand out as the heralds of prosperity. I would urge your attention now to the need for evolving methods of cheap and quick road-building from indigenous materials. This alone will make it possible to bring our gigantic road-construction programmes within the compass of reality in a reasonable time. I hope, the deliberations of the Congress will prove fruitful in this respect and mark the turning point in our thinking regarding the baffling problem of matching resources with the demand for roads. I wish you all success.

TECHNICAL EXHIBITION

TWENTY-FIFTH SESSION OF THE INDIAN ROADS CONGRESS, BHOPAL, JANUARY, 1961

The Technical Exhibition at the Indian Roads Congress Session is a regular feature of the annual session. The exhibition mirrors the progress made on roads and bridges in the country and also brings to light developments in road research and the latest techniques and machinery for the road and bridge construction.

Shri Mishrilal Gangwal, Finance Minister, Madhya Pradesh, opening the Exhibition

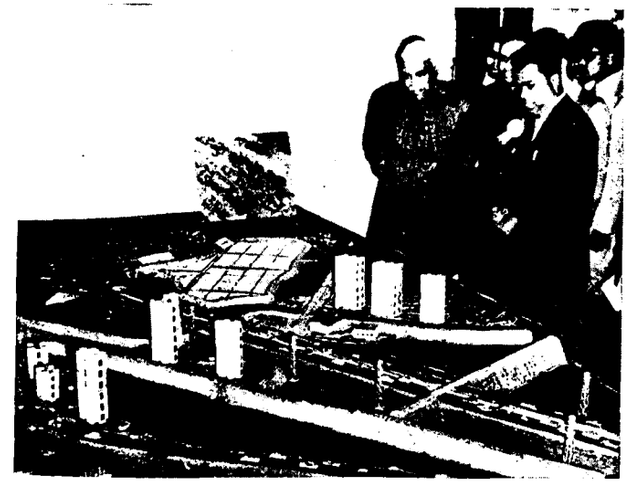
Shri Mishrilal Gangwal, Finance Minister, Madhya Pradesh, on opening of the exhibition on 5th January, 1961, expressed that the entire economy of the country would undergo tremendous change for the better if we succeeded in providing in speedier and efficient means for transporting our produce from one place to another. He stressed the role of the engineers in building up a new India and said that rapid industrialization of the country cannot be achieved without adequate and efficient means of transport. He added that due to insufficient finances being available for road construction, necessity of finding cheaper methods of road construction were all the more greater.

The Hon. Minister was happy to note that targets set out for the first 20-Year Plan of Road Construction have been exceeded and the second 20-Year Plan envisages double the road construction achieved in the First Plan. The Finance Minister went round the stalls and evinced considerable interest in the various methods adopted for maintenance and construction of roads. Names of the various Governments and engineering firms who took part in the exhibition are given below:

1. **Ministry of Transport, Government of India**: Exhibited charts, maps, etc., depicting the progress of road development in the country and comparison with other countries: income derived from road revenues and expenditure on roads, future trends of road and road transport development in India.

2. **Tourist Bureau of the Government of India**: Displayed and distributed literature about historical places in Madhya Pradesh and other parts of India.

3. **Central Road Research Institute, New Delhi**: The importance of continued research and its utility and the application of research in the field was exhibited by means of models, charts and diagrams. In addition to other exhibits, the following models, charts and diagrams were of special interest to Engineers and Scientists:



A stall at the Exhibition.

(a) Model of the Eastern Express Highway, Bombay, showing the application of sand drains for embankment construction in slushy pits.

(b) The road construction project in Heavy Electricals (Private) Ltd. Project, Bhopal.

(c) The charts and models showing the accident study and other traffic problems and their solutions.

4. **Bihar**: Displayed models of major R.C.C. and prestressed concrete bridges constructed, showing the details of foundations and reinforcements. Photographs of important bridges, maps and charts showing development, samples of materials used, and soil stabilization works were exhibited. A film show depicting bridge construction and stabilization of soil was also shown.

5. **Gujerat**: Models of bridges in addition to various interesting photographs and charts were displayed.

6. **Madhya Pradesh**: This stall covered activities of Buildings and Roads Branch, Town-Planning and Capital Project Scheme. Besides, models of major bridges, photographs and charts were shown. The models of proposed building activities of capital project scheme and their layout were also exhibited. The present layout of certain towns and their proposed improvement were shown by maps and charts by the Town-Planning Section.

7. **Madras Highways Research Station**: Out of the exhibits by the Highways Research Station, Madras, the following were of special interest:

(a) Model of apparatus for determining 'K' value,

(b) Model of test-track,

(c) Photos of Tiruvanmuir-Muthukodu road,

(d) Model of Laboratory Van with apparatus for determining the C.B.R. value in the field fixed on the van.

8. **Maharashtra**: Models, charts, photographs, etc., about bridge building activity in Maharashtra.

9. **Punjab**: Charts, models and photographs. Exhibits illustrating the results of laboratory research with regard to cheap roads and damp proofing the bricks were of special interest.

10. **Orissa**: Five important bridge models over rivers Nagavali, Brahmani, Mahanadi, Nuanai over Surlake cut and Suktal river

besides about a dozen photographs of bridges, maps and charts were shown.

11. **Uttar Pradesh**: Models of important bridges besides photographs, charts and maps showing the road development programme in Uttar Pradesh.

FIRMS

1. **Associated Instrument Manufacturers (I) Private Ltd., New Delhi**: Exhibited a comprehensive range of soil testing, cement testing, concrete, aggregate and bitumen testing instruments including motorised version of triaxial shear and direct shear equipment. A Marshall stability equipment, motorised tensile testing machine, wagner turbidimeter, C.B.R. were also on display.

2. **Burmah-Shell Oil Co. Ltd.**: Their exhibits included pictures and technical data showing the role of bitumen in road construction.

3. **Caltex India, Ltd., Bombay**: Pictures and technical data about asphalt roads.

4. **Greaves Cotton & Co. Ltd., Bombay**: Besides the technical data they exhibited Avelling Torepher road roller in action.

5. **Gupta Iron and Steel Co., Bhopal**: Elco and Typhoon Cisterns and other items of sanitary fittings.

6. **Kailash Bros. Private Ltd., Chandni Chowk, Delhi**: Their main exhibits consisted of testing instruments of soil, lime, concrete, aggregate, etc. A wide range of bitumen testing equipment were also exhibited. Motorised self-compensating accurate triaxial shear apparatus for soil and bitumen, as well as, Deep Soil Sampling Kits were shown in complete range.

7. **Killick Nixon & Co. Ltd.**: Their exhibits included equipment for prestressing concrete, concrete vibrators and road lighting fixtures for illuminating roads and bridges in addition to interesting charts and maps.

8. **Millers' Timber & Trading Co. Ltd., Bombay**: They exhibited photographs and literature of Millers' mixers, asphalt plants and other road-making and testing equipment.

9. **Shalimar Tar Products Ltd.**: Their exhibits included pictures and technical data of road-building and allied subjects.

10. **United Provinces Commercial Corporation Private Ltd., Calcutta** : Displayed literature on Agrind-Moore road roller.

11. **William Jacks Co. Ltd., Calcutta:** Besides exhibiting the working of diesel operated stone crusher and electrically operated concrete mixer, models and charts of earthmoving and construction equipments and jack boards were displayed.

OTHERS

Concrete Association of India, Bombay, exhibited photograps depicting details of construction and outstanding examples of concrete roads, bridges in reinforced and prestressed concrete, analytical charts, statistics, models, etc.

Minutes of the 57th Council Meeting of the

INDIAN ROADS CONGRESS

held at Bhopal on the 3rd January, 1961

Present :

Sinha, H. P. – President

Antia, Dr. F. P.	Joshi, K.M.
Apte, M. P.	Mahadavan, M. R.
Behera, S. S.	Mehra, S. R.
Bhagat, D. G.	Nambiar, K. K.
Barua, K.	Natu, S. V.
Chanda, R. P.	Rajwade, M. V.
Durrani, N.	Sinha, S. N.
Gandotra, H. K.	Thakur, D. S.
Gupta, S. N.	Tripathi, S. N.
Iyengar, C. L. N.	Vishrampuri
Jagadish Prasad	

Hukam Singh – Tech. Secretary
Sen, N. – Secretary

The following co-opted members attended :

Bannerjee, J. K. Nadirshah, E. A.
Vagh, B. V.

The following attended by invitation :

Bhalla, R. S.	Iyengar, Dr. R. K. N.
Ganguli, Dr. M. K.	Trehan, J. M.
Hardyal	Vaidaynathan, P. H.
Sujan Singh	Shivdasani, P. D.

Item I. Approval of the minutes of the meetings of Executive Committee :

The minutes of the meetings of the Executive Committee held at New Delhi on the 30th and 31st August and the 7th December 1960, were approved.

Item II. Increased contribution towards the funds of the Indian Roads Congress :

The Council noted the latest position of the response from the State Governments to the appeal for increasing their contributions

towards the funds of the Indian Roads Congress. The Council felt that it was very necessary that those states which had not increased their contributions to their full share on the basis of ¼% of their allocation from Central Roads Fund or 1½ times their present contribution whichever is greater, should do so as early as possible. In some cases it may appear that there is a great difference between their present contribution and the share proposed. This was only because those States had not raised their contributions earlier in response to the appeal in 1949 to the amounts proposed on the basis of ½ per cent of their share from Central Road Fund allocation. The Council, therefore, again urged the Governments of West Bengal, Bihar, J. & K., Maharashtra, Madhya Pradesh, Gujerat and Kerala to reconsider the matter with a view to increase their contribution to the amounts proposed.

Item III. Audit Report for the year 1959-60:

The Audit Report for the period 1st October, 1959, to the 30th September, 1960, was recorded.

It was decided that the list of members who fall in arrears for more than one year should be sent to Chief Engineers of States with the request to use their good offices for the realisation of arrears.

Item IV. Budget:

The budget estimates for 1960-61 and the actuals for 1959-60 were aproved.

Item V. Draft Report of the Council to the General Body of Members from the 1st January to the 31st December, 1960:

The Draft Report with a slight modification was approved.

Item VI. Draft certificate about the award of "Mitchell" and "Indian Roads Congress" Medals:

The draft certificates were approved.

Item VII. Draft syllabus for Refresher Courses for Highway Engineers:

The draft syllabus for Refresher Courses for Highway Engineers was referred back to the Education Committee for reconsideration in light of the syllabus for Refresher Courses prepared by Shri S. R. Mehra, Director, Central Road Research Institute.

Item VIII. Report of the Road Transport Operation Cost Committee:

The Council decided that the Report on the cost of operation of Motor Vehicles on Different Types of Roads in Plains should be

circulated to the members of the Council and then finalised in light of their comments prior to its forwarding to the Government of India.

Item IX. Proposed Road Board:

The Council felt that in order to meet the need for rapid and extensive development of roads and road transport and the various associated factors connected with them, an organisation capable of directing and controlling the agency of transport in a unified manner was very essential. And such an organization has to have a central high-powered body in the form of a Road Board.

The Council, therefore, accepted the recommendations of the Special Committee and desired that those recommendations should be brought to the notice of the Government.

Item X. Research Implementation Committee:

The Government of India having examined the question of field scale experiments for application of the results of road research done in road research laboratories decided that (i) each State may be requested to devote 1 per cent of its provision for road development in the Third Five-Year Plan for schemes of experimental specifications and new techniques; (ii) a sum of Rs 75 lakhs be set apart as a sort of 'Risk Fund' in the Central Sector of the road programme in the Third Plan for covering risk of losses or extra expenditure on approved experimental work and (iii) a Central Assessment Committee be formed under the aegis of the Indian Roads Congress. Accordingly, the Council appointed a Research Implementation Committee with the following personnel for the implementation of the research results and to overcome the difficulties in the way of such implementation:

Consulting Engineer (Road Development)—Convenor

President, I.R.C.

Director, Central Road Research Institute.

The Chief Engineers of States.

Two Directors of State Road Research Laboratories.

Two co-opted members from the State concerned (one Chief Engineer and the other representative of the State Road Research Laboratory) in case none of these persons is already in the Committee.

One member from non-Governmental Organization.

Three experts to be co-opted who have special knowledge of the subject under consideration.

The names of the members will be discussed in the next meeting of the Council.

Item XI. Draft Recommended Practice for Location and Layout of Roadside Motor-Fuel-Filling-Cum-Service Station :

Shri Shivdasani pointed out that in the draft standard presented to the Council for approval, certain important changes had been made as compared to the draft standard approved by the Specifications and Standards Committee at its Bangalore meeting. He wondered how this had happened. The Member-Secretary of the Committee explained that when the minutes of the Bangalore meeting were circulated for confirmation, certain members suggested some amendments. These amendments were circulated to all the members of the Committee and their approval sought in a very pointed manner to the inclusion of the suggested amendments in the draft standard. No objection was received from any member of the Committee. It was, therefore, presumed that the amendments had the approval of the Committee and draft standard, therefore, went up to the Council.

Shri Shivdasani then stated that he had raised definite objections to some of the amendments and had written a detailed letter to Indian Roads Congress. As this communication had apparently gone astray, the Council decided to postpone consideration of this item and desired the Committee to reconsider the draft in the light of Shri Shivdasani's objections.

Item XII.

The Council passed the following resolution in appreciation of the services of Shri A. J. D'Costa :

> "The Council of the Indian Roads Congress places on its record its appreciation of the services rendered by Shri A. J. D'Costa during his tenure of office as Secretary."

Item XIII. Miscellaneous :

(1) The Council desired that the Chief Engineers should be requested to encourage their young engineers to write Papers and if necessary help them by way of allowing them necessary time for this purpose.

(2) The Council considered a note from the Chief Engineer (Highways), Andhra Pradesh, explaining the position which led to the Department in charge of Highways to take over rural development as well following the pattern of highways and rural works department of Madras. The Council appreciated the reasons put forward in the note but felt that the extra work might come in the way of intensive attention being paid to highway work. But as most of the new works would be related to rural highways and as the prevailing arrangement suited administrative convenience at the present time, the change may be reviewed in detail later after watching the working for some time.

(3) It was decided that more efforts should be made to obtain greater number of advertisements for T.C.M.R. If necessary, the rates of advertisements might also be raised. Further it was decided that in order to make T.C.M.R. more useful, the views of Chief Engineers in the matter should be obtained.

(4) The Council discussed the question of encouraging the adoption of Indian Roads Congress Bullock-cart wheel. It was felt that as the steps so far taken have not brought about the desired change in the width of steel-tyre it was necessary that the full details of the investigation carried out by the Indian Roads Congress on the subject should be clearly brought to the notice of the Government. The Council then discussed the effect of narrow and wide-tyred wheels on road surfaces, the feasibility of adopting pneumatic-tyre and the usefulness of the introduction of ball-bearings. After detailed discussion, it was decided that the Road Transport Development Committee should be requested to study this matter in detail and report to the Council.

Minutes of the Business Meeting of the

INDIAN ROADS CONGRESS

held at Bhopal on the 7th January, 1961.

The Twenty-fifth Annual General meeting of Members was held at Bhopal on Saturday, the 7th January, 1961, at 9 a.m. In all 276 Members and 12 invitees attended the Session.

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

The minutes of the last Business Meeting held at Bangalore on the 1st February, 1960, as printed on pages 763 to 812 of the Journal of the Indian Roads Congress, Volume XXIV—Part 5, November, 1960 were confirmed.

3. Audit Report.

(i) The Audit Report for the period 1st October, 1959, to the 30th September, 1960, was recorded.

(ii) It was decided to re-appoint Messrs Walker, Chandiok & Co., Chartered Accountants and Auditors, Delhi, to audit the accounts of the Indian Roads Congress for 1960-61.

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

The report of the Council to the General Body of Members for the period 1st January, 1960 to the 31st December, 1960, was approved.

5. Resolutions of thanks.

(i) The Indian Roads Congress thank the Government of Madhya Pradesh for inviting the Indian Roads Congress to hold their Twenty-fifth Session at Bhopal and for the very excellent arrangements made.

(ii) The Indian Roads Congress thank Shri H. V. Pataskar, Governor of Madhya Pradesh, for kindly inaugurating the Twenty-fifth Session of the Indian Roads Congress and for his very instructive and inspiring Address on the occasion and also for his permission to print his Address.

(iii) The Indian Roads Congress thank Shri Mishrilal Gangwal, Minister for Finance, Madhya Pradesh, for kindly declaring open the Technical Exhibition organized by the Indian Roads Congress.

(iv) The Indian Roads Congress thank Dr. S. Radhakrishnan, Vice-President, for his good wishes for the success of the Session.

(v) The Indian Roads Congress thank Shri Jawahar Lal Nehru, Prime Minister, for his inspiring and instructive message and good wishes to the Congress.

(vi) The Indian Roads Congress thank Shri P. Subbarayan, Minister of Transport and Communications, Goverment of India for his encouraging message and good wishes to the Indian Roads Congress.

(vii) The Indian Roads Congress thank Shri N. V. Gadgil, Governor of Punjab, Shri V. V. Giri, Governor of Kerala, Shri Vishnu Sahay, Governor of Assam and Shri Bajrang Bahadur Singh, Raja Bhadri, Lt.-Governor, Himachal Pradesh, for their good wishes for the success of the Session.

(viii) The Indian Roads Congress thank Shri Kailas Nath Katju, Chief Minister, Madhya Pradesh, for his very encouraging message and good wishes for the success of the Session.

(ix) The Indian Roads Congress thank Shri B. D. Jatti, Chief Minister of Mysore, for his kind message and good wishes to the Congress.

(x) The Indian Roads Congress thank Shri S. L. Tiwari, Minister for Public Works, Madhya Pradesh, for his very instructive message to the Congress.

(xi) The Indian Roads Congress thank Shri G. M. McKelvie past President of the Indian Roads Congress, for his good wishes for a very successful Session.

(xii) The Indian Roads Congress thank Shri M. Ananthasayanam Ayyanger, Speaker, Lok Sabha, for his message of good wishes for the success of the Congress.

(xiii) The Indian Roads Congress thank ECAFE for their good wishes for the success of the Session.

(xiv) The Indian Roads Congress thank institutions and other well-wishers who have sent messages of goodwill and encouragement.

(xv) The Indian Roads Congress thank Shri S. N. Tripathi, Chief Engineer, P.W.D., B. & R., Madhya Pradesh, Shri S. B. Dube and Shri K. S. Bansal, Superinten-

ding Engineers, Shri A. G. Vaidya (Local Organizing Secretary, Indian Roads Congress), Executive Engineer, P.W.D., B. & R., Bhopal and other officers and staff of the P. W. D., B. & R., Madhya Pradesh, for the very excellent arrangements made by them for the Session and for the convenience of the delegates.

(xvi) The Indian Roads Congress thank Shri Khirwadkar and other artists for kindly arranging a cultural show for the delegates.

(xvii) The Indian Roads Congress thank the Publicity and Information Department of Madhya Pradesh for (i) Drama Show, (ii) Supply of interesting pamphlets on historical places in Madhya Pradesh to delegates and (iii) for giving wide publicity to the proceedings of the Session.

(xviii) The Indian Roads Congress thank the Ministry of Information and Broadcasting, Government of India, for kindly covering in their newsreel selected moments of the proceedings of the Session.

(xix) The Indian Roads Congress thank the firms and Government Departments who participated in the Technical Exhibition organized on the occasion of the Session and showed the films.

(xx) The Indian Roads Congress thank the Secretary Vidhan Sabha, for kindly placing at the disposal of the Indian Roads Congress M.L.As' Rest House for the stay of the delegates.

(xxi) The Indian Roads Congress thank the Heavy Electricals for providing facilities to the delegates to visit the works.

(xxii) The Indian Roads Congress thank the Director, All-India Radio, for kindly recording the proceedings of the Session.

(xxiii) The Indian Roads Congress thank the State Bank of Bhopal, Railway Authorities, Madhya Pradesh Electricity Board, P.G.B.T. College, Medical Department, Indian Airlines, Post & Telegraph authorities for their co-operation to make the function a success.

(xxiv) The Indian Roads Congress thank the various newspapers, and periodicals for giving prominence to the proceedings of the Indian Roads Congress.

6. **Scrutineers for the Election of Council Members.**

Sarvashri D. G. Bhagat, B. G. Naik, Hukam Singh and D. N. Endlaw 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.	Nambiar, K. K.
Apte, M. P.	Patel, L. R.
Fielder, C. J.	Shivdasani, P. D.

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

Verman, Dr. Lal C.

9-h. Representative of District Board Engineers :

Chavan, J. D.

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

Shoba Ram

9-j. Representatives elected by the General Body :

Basu, K. N.	Iyengar, C. L. N.
Dube, S. B.	Sinha, S. N.

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	Lall, Y. K.
	Gujerat	Bhatt, U. J.
	Himachal Pradesh	Mukand, J.
	Jammu & Kashmir	Wanchoo, P. N.
	Kerala	Iyer, C. S. Padmanabha
	Madras	Sirajuddin, P.
	Maharashtra	C.E., P.W.D., Buildings Communications.
	Madhya Pradesh	Tripathi, S. N.
	Mysore	Joshi, K. M.
	Orissa	Behrea, S. S.
	Punjab	Khanna, G. C.
	Rajasthan	Kishore Lal
	Uttar Pradesh	Prasad, Jagdish
	West Bengal	C.E. (Road Development)
9-b.	Engineer-in-Chief, Army Headquarters	Maj.-Gen. Harkirat Singh
9-c.	Central P.W.D.	Endlaw, D. N.
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.	Mascarenhas, W. X.	

LIST OF MEMBERS WHO ATTENDED THE TWENTY-FIFTH SESSION OF THE INDIAN ROADS CONGRESS HELD AT BHOPAL IN JANUARY, 1961

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) Central Board of Irrigation and Power	... 1
	(c) Central Public Works Department	... 6
	(d) Engineer-in-Chief's Branch	... 4
	(e) Ministry of Railways (Railway Board)	... 2
	(f) Planning Commission	... 1
2.	**Central Building Research Institute**	... 1
3.	**Central Road Research Institute**	... 16
4.	**Heavy Electricals Limited**	... 1
5.	**Hindustan Steel Limited**	... 3
6.	**Andhra Pradesh**	... 8
7.	**Assam**	... 5
8.	**Bihar**	... 13
9.	**Gujerat**	... 12
10.	**Kerala**	... 2
11.	**Madhya Pradesh**	... 37
12.	**Madras**	... 10
13.	**Maharashtra**	... 42
14.	**Mysore**	... 12
15.	**Orissa**	... 9
16.	**Punjab**	... 8
17.	**Rajasthan**	... 5
18.	**Uttar Pradesh**	... 20
19.	**West Bengal**	... 25
20.	**Delhi**	... 11
21.	**Himachal Pradesh**	... 1
22.	**Jammu & Kashmir**	... 6
23.	**Tripura**	... 1
24.	**Pakistan**	... 1
25.	**Ceylon**	... 2
		Total 288

LIST OF DELEGATES WHO ATTENDED THE 25TH SESSION OF THE INDIAN ROADS CONGRESS HELD AT BHOPAL FROM THE 3RD TO THE 10TH JANUARY, 1961

S. No.	Roll No.	Name
		1. GOVERNMENT OF INDIA
		(a) Ministry of Transport & Communications, Department of Transport (Roads Wing)
1.	2020	Balwant Rao, B.
2.	266	Bhagat, D. G.
3.	1446	Bhalla, R. S.
4.	*Invitee*	Brij Ratan Lal
5.	*Invitee*	Ganguli, Dr. M. K.
6.	879	Goverdhan Lal
7.	1078	Gurshahni, R. L.
8.	785	Hardyal
9.	1880	Kathuria, S. L.
10.	2083	Keswani, N. H.
11.	705	Mirchandani, N. D.
12.	—	Murthy, B. S. N.
13.	2008	Muthuswamy, C.
14.	950	Nagarsheth, M. P.
15.	774	Rajagopalan, S. K.
16.	*Invitee*	Sachdeva, D. B. S.
17.	2293	Seetharaman, S.
18.	1515	Sen, N.
19.	2453	Sikka, R. P.
20.	191	Sinha, H. P.
21.	723	Subrahmanyam, J.
22.	918	Trehan, J. M.
23.	1879	Venkatasulu, G.
		(b) Central Board of Irrigation and Power
24.	*Invitee*	Vaidyanathan, P. H.
		(c) Central Public Works Department
25.	86	Enlaw, D. N.
26.	2911	Matai, U. J.
27.	2854	Paul, D. S.
28.	303	Rastogi, H. S.
29.	738	Vaish, V. R.
30.	2916	Vudayachalam, K.
		(d) Engineer-in-Chief's Branch
31.	*Invitee*	De, G.
32.	16-Ass.	Duboy, Maj.-Gen. K. N.
33.	*Invitee*	Narurkar, Lt.-Col. R. J.
34.	1540	Rao, K. V.

S.No.	Roll No.	Name
		(e) Ministry of Railways (Railway Board)
35.	43-Ass.	Mukerjee, P. K.
36.	*Invitee*	Sud, P. N.
		(f) Planning Commission
37.	2526	Sarup Singh
		2. CENTRAL BUILDING RESEARCH INSTITUTE
38.	74-Ass.	Ramesh, Dr. C. K.
		3. CENTRAL ROAD RESEARCH INSTITUTE
39.	*Invitee*	Bhupinder Singh
40.	*Invitee*	Chadda, L. R.
41.	833	Iyengar, Dr. R. K. N.
42.	2898	Jaganatha Rao, P.
43.	1857	Khanna, T. S.
44.	1907	Mazumdar, B. C.
45.	277	Mehra, S. R.
46.	1913	Mohan Rao, N.
47.	2202	Natarajan, T. K.
48.	2896	Phull, Y. R.
49.	2349	Puri, Dr. M. L.
50.	*Invitee*	Srinivasan, N. R.
51.	1311	Subbaraju, Dr. Bh.
52.	847	Uppal, Dr. H. L.
53.	2655	Venkatesan, M. S.
54.	*Invitee*	Verma, P. M.
		4. HEAVY ELECTRICALS LIMITED
55.	2560	Kaul, A. K.
		5. HINDUSTAN STEEL LIMITED
56.	1413	Bhattacharya, S. P.
57.	2053	Ganapathy, C. P.
58.	1550	Ghose, M. B.
		6. ANDHRA PRADESH
59.	88-Ass.	Das, Lakshman—Rep. M/s. Lakshmichand Raichand, Engineers, A. P.
60.	246	Durrani, N.
61.	2541	Prasad, J. R. K.
62.	638	Raj, P. V.
63.	2472	Ramayya, T. A.
64.	2540	Rao, G. Bapu
65.	1945	Rao, K. V.
66.	2544	Rao, P. C.

S. No.	Roll No.	Name.
160.	2849	Gupta, A. Y.
161.	833	Iyengar, C. L. N.
162.	1474	Jagus, P. J.
163.	2033	Jayawant, M. B.
164.	1430	Joshi, R. N.
165.	2340	Kale, K. G.
166.	2806	Key, J. W.
167.	76-Ass.	Marathe, S. S.—Rep. M/s. S. S. Marathe & Co., Bombay
168.	75-Ass.	Meadows, S. F.—Rep. M/s. William Jacks & Co. Ltd., Bombay
169.	696	Mohile, N. H.
170.	23	Nadirshah, E. A.
171.	268	Nambiar, K. K.
172.	1723	Natu, S. V.
173.	1528	Patkar, B. B.
174.	1008	Raghavan, P.
175.	1803	Rajwade, M. V.
176.	2886	Sakhadeo, A. V.
177.	33-Ass.	Sani, G. H.—Rep. M/s. Caltex Ltd., Bombay
178.	2353	Sarkar, B. B.
179.	2873	Sathe, P. V.
180.	82-Ass.	Sethi, G. K.—Rep. M/s. William Jacks & Co. Ltd.
181.	1570	Sethna, H. K.
182.	2462	Shenoy, D. S.
183.	1148	Shivdasani, P. D.
184.	83-Ass.	Sirdeshpande, P. P.—Rep. M/s. Millars' Timber & Trading Co. Ltd., Bombay
185.	2351	Thakur, D. S.
186.	1475	Unwalla, B. T.
187.	84	Vagh, B. V.
		14. MYSORE
188.	243	Adke, Dr. A. S.
189.	2780	Chidambaram, C.
190.	2715	Desai, K. A.
191.	2884	Hedge, H. K.
192.	2924	Jaga Rao, Col. S. P.
193.	2660	John, G.
194.	2283	Joshi, K. M.
195.	2899	Joshi, N. G.
196.	2748	Magdum, I. M.
197.	2778	Sachdev, R. C.
198.	2883	Sundareshan, T. V.
199.	2878	Visweswaria, C.
		15. ORISSA
200.	328	Behera, S. S.
201.	2882	Das, J. B.
202.	2917	Mahapatra, C.
203.	625	Mohanty, A. B.
204.	2813	Mohanty, M. R.
205.	2204	Mukherjee, P. K.
206.	1759	Padhi, A. C.

S.No.	Roll No.	Name.
207.	564	Padhi, S. R.
208.	513	Parija, K. C.
		16. PUNJAB
209.	2904	Bains, Mohinder Singh
210.	446	Khanna, G. C.
211.	2910	Mungi, S. S.
212.	338	Nangea, G. R.
213.	2197	Satinder Singh
214.	1432	Sujan Singh
215.	79	Uppal, Dr. I. S.
216.	—	Vidyarthi, R. N.
		17. RAJASTHAN
217.	2630	Gupta, K. P.
218.	2301	Mathur, B. L.
219.	427	Nayyar, S. L.
220.	1903	Puri, Vishram
221.	643	Rastogi, D. P.
		18. UTTAR PRADESH
222.	1186	Bapat, M. S.
223.	860	Bhatnagar, P. S.
224.	2653	Goel, J. P.
225.	1787	Gupta, G. C.
226.	2812	Gupta, R. C.
227.	2849	Gupta, S. C.
228.	52	Jagdish Prasad
229.	2102	Jain, D. C.
230.	1398	Johorey, M. C.
231.	2913	Kalsi, H. S.
232.	2981	Mathur, R. B.
233.	2869	Mathur, R. B.
234.	759	Mathur, S. B.
235.	2885	Mittal, N. K.
236.	859	Patel, A. T.
237.	2638	Rao, V. V. Subba
238.	2880	Saxena, K. S.
239.	490	Shobha Ram
240.	960	Sinha, K.
241.	954	Zutshi, Y. N.
		19. WEST BENGAL
242.	962	Banerjee, J. K.
243.	1421	Basu, K. N.
244.	15-Ass.	Bhattacharjee, B. B.—Rep. M/s. Heatly & Gresham Ltd., Calcutta
245.	1324	Chanda, R. P.
246.	1347	Chatterjee, P. N.
247.	2895	Das Gupta, C. R.
248.	41-Ass.	De, K. C.—Rep. M/s. Bengal Chemical & Pharmaceutical Works, Calcutta
249.	2250	De, P. L.
250.	2902	Dutta, Ashis
251.	2897	Dutta, A. K.
252.	231	Fielder, C. J.

S.No.	Roll No.	Name.
253.	1942	Ghosh, D. K.
254.	808	Ghosh, S. K.
255.	2905	Ghosh, D. P.
256.	2906	Guha, D. R.
257.	936	Gupta, S. N.
258.	2831	Hennes, R. G.
259.	2037	Karnik, A. V.
260.	2858	Koteswara Rao, Senapati
261.	1544	Ray, S. N.
262.	1553	Samaddar, S. K.
263.	2907	Samajdar, S.
264.	862	Sen Gupta, P. N.
265.	2903	Sen, S. K.
266.	65-Ass.	Wahi, K. M.—Rep. M/s. Agrind Fabrications Ltd., Calcutta
		20. DELHI
267.	90-Ass.	Awasthy, J. G.
268.	2174	Bijlani, H. U.
269.	1615	Hukam Singh
270.	67-Ass.	Mahadevan, M. R.—Rep. M/s. U.P.C.C., New Delhi
271.	23-Ass.	Malhotra, K. D.—Rep. M/s. Willcox Buckwell, New Delhi
272.	89-Ass.	Sandhu, B. S.
273.	1785	Shah, Z. S.
274.	40-Ass.	Shahani, T. C.
275.	69-Ass.	Taxali, R.—Rep. M/s. R. C. Abrol & Co. Pvt. Ltd., New Delhi
276.	81-Ass.	Thadani, N. M.—Rep. M/s. Sahu Cement Service
277.	2168	Visvesvaraya, Dr. H. C.
		21. HIMACHAL PRADESH
278.	2536	Mukand, J.
		22. JAMMU AND KASHMIR
279.	1607	Dogra, N. N.
280.	1457	Gandotra, H. K.
281.	1696	Laharwal, G. R.
282.	2875	Mustafa, S. G.
283.	1963	Rajinder Singh
284.	1583	Wanchoo, P. N.
		23. TRIPURA
285.	2570	Debnath, D. C.
		24. PAKISTAN
286.	1549	Doctor, P. K.
		25. CEYLON
287.	2908	Petiyagoda, D.
288.	2721	Saparamado, A. A. D. O. P.

LIABILITIES

		Rs	nP.	Rs	nP.
SUNDRY LIABILITIES					
Sundry Creditors for Expenses	...	6,259	18		
Income tax payable on salaries	...	311	00		
Shri McKelvie's Silver Salver Fund	...	120	84		
Advance for Publications	...	80	35	6,771	37
CHEQUES ISSUED BUT NOT ENCASHED				13,340	04
SUBSCRIPTIONS RECEIVED IN ADVANCE FROM:					
Ordinary Members					
1960—61	743 00				
1961—62	95 00	838	00		
Associate Members					
1960—61	...	120	00	958	00
MITCHELL MEDAL FUND (invested as per contra)					
Balance as per last Balance Sheet	...	1,980	77		
Add: Interest realised	...	47	50	2,028	27
BUILDING, MUSEUM & TECHNICAL FUND					
Balance as per last Balance Sheet	...	1,91,199	24		
Add: Amount of Life Membership	...	923	00		
Interest on Investments	...	7,202	00	1,99,324	24
RESERVE FOR BAD & DOUBTFUL DEBTS				10,000	00
PROVIDENT FUND DEPOSITS				49,012	87
PROVIDENT FUND INTEREST DISTRIBUTABLE					
Balance as per last Balance Sheet	...	711	61		
Add: Interest earned	...	1,367	95		
		2,079	56		
Less: Distributed	...	1,161	56	918	00
AMOUNT HELD IN SUSPENSE (pending adjustment)				242	47
INCOME & EXPENDITURE ACCOUNT					
Balance as per last Balance Sheet	...	1,53,880	06		
Less: Balance being excess of Expenditure over Income as per annexed Income and Expenditure Account	...	5,413	51	1,48,466	55
Note:—No details are available for Rs 70 deposited into the Bank, and credit whereof has not been given by the Bank.					
Total	...			4,31,061	81

(Sd.) N. SEN,
Secretary.

AUDITORS' REPORT.

We have audited the Balance Sheet of the INDIAN ROADS CONGRESS (excluding Transport-Communications Monthly Review) as at 30th September, 1960, 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 affairs of the Congress according to the best of our information and explanations given to us and as shown by the books.

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

41-L, Connaught Circus,
New Delhi.
Dated, this 16th day of December, 1960.

ASSETS

		Rs	nP.	Rs	nP.
EQUIPMENT					
Balance as per last Balance Sheet	...	6,729	90		
Additions during the year	...	1,459	36		
		8,189	26		
Less: Sold during the year	...	31	40		
		8,157	86		
Less: Depreciation written off	...	986	24	7,171	62
LIBRARY BOOKS AND PERIODICALS					
Balance as per last Balance Sheet	...	3,086	22		
Additions during the year	...	377	63		
		3,463	85		
Less: Depreciation written off	...	346	38	3,117	47
DRAWING MATERIALS					
Balance as per last Balance Sheet	...	15	37		
Additions during the year	...	13	52		
		28	89		
Less: Depreciation written off	...	2	83	26	06
INVESTMENTS					
Rs 44,000/- 12 years National Savings Certificates	...	44,000	00		
Rs 74,600/- 10 years Treasury Savings Deposits Certificates	...	74,600	00		
Rs 21,300/- 3% Loan 1963-65	...	20,271	62		
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
INTEREST ACCRUED ON INVESTMENTS					
PROVIDENT FUND					
12 years National Savings Certificates	...	40,700	00	17,107	84
Interest accrued thereon to 30th Sept., 1960	...	5,997	50		
Balance with State Bank of India, New Delhi	...	1,257	37		
Loans Advanced	...	1,303	00	49,257	87
MITCHELL MEDAL FUND					
Rs 1,600/- 3% Loan 1963-65	...	1,652	93		
Interest accrued thereon	...	16	00		
Balance with State Bank of India, New Delhi	...	359	34	2,028	27
STOCK-IN-HAND					
(Certified as to quantities & values by the Secretary)					
Journals	66,343 96				
Paper	3,597 24				
Stock of C.R.R.I. Paper	847 65			70,788	85
SUNDRY DEBTORS					
SUBSCRIPTIONS IN ARREARS FROM:					
(i) Ordinary Members	15,182 41				
(ii) Associate Members	360 00	15,542	41		
Outstandings - Publications		1,985	06		
SUBSIDIES RECOVERABLE FOR					
1954—55	1,000 00				
1958—59	11,000 00				
1959—60	43,500 00	55,500	00		
ADVERTISEMENTS					
Considered good	681 50				
Considered doubtful	0 00	681	50		
SESSION EXPENSES RECOVERABLE					
Transport Charges					
(Rs 48.75 considered doubtful)	1,178 75				
Delegation Fees	5,965 00	7,143	75	80,852	72
ADVANCES					
The Deputy Controller of Stationery & Printing, Calcutta		384	02		
Staff against Cycles Purchased	...	700	29		
Advances for Library Books	...	121	10		
Due from Technical Secretary—Shri Hukam Singh	...	1,285	50		
Staff for Festival	...	857	00		
Due from C.R.R.I.	...	1,655	00		
Due from T.C.M.R.	...	18,724	54		
CASH & OTHER BALANCES				23,727	45
With State Bank of India, New Delhi	...	23,110	80		
Cheques pending realisation (includes Rs 70/- not so far credited by the Bank)	...	1,044	84		
Stamps in hand (including Rs 14/- Revenue Stamps)	...	17	28	24,172	92
Total	...			4,31,061	81

INCOME & EXPENDITURE ACCOUNT FOR THE YEAR ENDED 30TH SEPTEMBER, 1960.

EXPENDITURE		Rs	nP.	INCOME		Rs.	nP.
To Paper Consumed	...	9,173	94	By Sales and Subscriptions of the Journal	...	2,956	20
,, Printing Charges (including Rs 600/- paid as proportionate salary to Representative at Madras and other incidentals)	...	8,463	38	,, Advertisements	...	7,262	00
,, Postage	...	1,642	80	,, Balance being Excess of expenditure over Income carried to Balance Sheet	...	9,139	04
,, Miscellaneous Expenses (includes Revenue Stamps)	...	77	12				
Total	...	19,357	24	Total	...	19,357	24

BALANCE SHEET AS AT 30TH SEPTEMBER, 1960.

LIABILITIES		Rs	nP.	ASSETS		Rs	nP.	Rs	nP.
SUNDRY CREDITORS				BOOK DEBTS					
				For Advertisement	...	2,706	25		
				For Sale of Journal	...	141	70		
Proportionate Salary of Representative at Madras for the month of September, 1960	...	50	00					2,847	95
DUE TO GENERAL ACCOUNT	...	18,724	54	STOCK IN HAND (Certified as to quantities & values by the Secretary)	...			6,609	57
				STAMPS IN HAND (including Revenue stamps)	...			59	99
				INCOME AND EXPENDITURE ACCOUNT					
				Debit Balance as per last Balance Sheet	...	117	99		
				Add : Balance being excess of Expenditure over Income for the year as per annexed Income & Expenditure Account	...	9,139	04	9,257	03
Total	...	18,774	54	Total	...			18,774	54

(Sd.) N. SEN,
Secretary.

AUDITORS' REPORT

We have audited the Balance Sheet of the INDIAN ROADS CONGRESS (Transport-Communications Monthly Review) as at 30th September, 1960, 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 16th day of December, 1960.

(Sd.) J. C. CHANDIOK,
B.A., A.C.A. (England & Wales), F.C.A.,
For Walker, Chandiok & 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 1960

1. GENERAL

The Silver Jubilee Session of the Indian Roads Congress held at Bangalore in January/February 1960 was attended by 317 members and 20 invitees. In that Session, 10 Papers published in the Journal of the Indian Roads Congress, Volume XXIV-Parts 1 to 4, were discussed, eighteen Technical Committees were reconstituted to deal with various engineering and administrative problems, a Special Committee was appointed to examine the question of formation of a Road Board and to find out ways and means of speedy execution of works and make necessary recommendations.

The Executive Committee held meetings at New Delhi on the 30th and 31st August and the 7th December, 1960.

2. ADMINISTRATION

Shri H. P. Sinha, Consulting Engineer (Road Development) and Joint Secretary to the Government of India, Ministry of Transport and Communications, Department of Transport (Roads Wing), New Delhi, was elected President at the Bangalore Session. He also continued to function as Honorary Treasurer. Shri D. G. Bhagat, Deputy Consulting Engineer to the Government of India (Roads) continued to work as Honorary Deputy Treasurer.

Shri Hukam Singh continued as Technical Secretary.

Shri A. J. D'Costa continued to work as Honorary Secretary till the 7th September, 1960 when Shri N. Sen was appointed as Honorary Secretary.

3. OFFICE

The office continued to function in New Delhi. It disposed of 15,000 receipts and issued 50,611 letters during the period under report.

The staff worked satisfactorily.

4. MEMBERSHIP

(1) The number of members on the rolls on the 30th September, 1960 was 1,972 (1 Honorary, 1 Associate Honorary, 165 Life Members, 1756 Ordinary and 49 Associates). During the year, there were 197 new admissions and 30 removals from the rolls. The removals were the result of 20 resignations ; 9 death ; 1 for want of whereabouts.

(2) **Life Membership**: During the Congress year, 1st October 1959 to the 30th September 1960, 14 members were enrolled as Life Members bringing the total to 165. The fees received from life Members 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 :

R. N. Saxena
Daya Ram Das
R. N. Gupta
V. D. Bhandari

6. BUDGET

The budget for the year 1960-61 and the " Actuals " for 1959-60 were placed before the Executive Committee at their meeting held on the 7th December 1960. The estimates have been placed before the Council at their 57th meeting. The actuals for 1959-60 show a deficit of Rs 14,552 against an estimated deficit of Rs 38,356. The reduction in the deficit was mainly due to better realization of unpaid subsidies from Governments and subscription from members, and savings in budgeted expenditure on account of non-printing of certain publications, non-purchase of certain items of furniture, typewriter, etc., and for certain vacancies not filled during the year and other small savings under the head " Establishment ", due to Revised Pay Scales being announced later.

The total contribution received from the Central and State Governments during the year ending the 30th September 1960 amounted to Rs 94,500 against an estimated amount of Rs 94,000 and Rs 1,04,500 asked for.

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 a number of official and 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. 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 Govts. who had kindly agreed to contribute towards the funds of the Congress on the basis proposed, the Council hoped that other States also would soon agree to contribute towards the funds of the Congress at the scale proposed. The State Governments which had not sanctioned contributions at enhanced scale were again approached in the matter. The States of Bihar, Maharashtra, Gujerat, Madhya Pradash, West Bengal, Kerala and J. & K. have not yet increased their contribution to full. Upto date position is given below :

State	Old contribution	Contribution proposed by the I.R.C		Amount sanctioned
	Rs		Rs	Rs
Andhra	3,000		4,500	4,500
Assam	3,000		4,500	4,500
Bihar	2,500		4,500	3,500
Bombay	6,500	Maharashtra	11,000	6,500
		Gujerat	5,500	Reply awaited
Madhya Pradesh	5,000		7,500	6,000
Madras	2,500		5,500	5,500
Orissa	2,000		3,000	3,000
Punjab	2,500		4,500	4,500
U.P.	4,000		6,500	6,500
West Bengal	2,000		12,000	2,000
Mysore	2,000		5,500	5,500
Rajasthan	1,500		3,000	3,000
Kerala	2,000		4,000	3,000
Jammu and Kashmir	1,000		3,000	1,500
Himachal Pradesh	1,000		2,000	1,000
Total (States) :	40,500		84,500	60,500
Govt. of India :	10,000		20,000	20,000
Grand Total :	50,500		1,04,500	80,500

The arrears of subscription from the members at the beginning of the Congress year 1959–60 amounted to Rs 17,984 which were due from 343 members. Out of this, a sum of Rs 3,131 was realised during 1959–60.

After adding the arrears for 1959–60, the total arrears on the 1st October, 1960 stood at Rs 25,042 due from 328 members. Efforts are being made to realize as much arrears as possible.

7. AUDIT

At the Twenty-fourth Session at Bangalore, it was decided to appoint M/s. Walker, Chandiok & Co., Chartered Accountants and Auditors, Delhi, to audit the accounts of the Congress for 1959–60. The report was examined by the Executive Committee on the 7th December, 1960. It was also placed before the Council at their 57th meeting on the 3rd January, 1961.

8. PUBLICATIONS

There was markedly increased demand for the publications of the Indian Roads Congress during the year under report. Sale of publications amounted to Rs 19,310 during the year against Rs 18,299 realised on this account last year and Rs 10,231 in the year prior to that.

During the year, finalised Section II of the Bridge Code dealing with "Loads and Stresses" and Bound Volumes XXII and XXIII were issued. In addition, the Revised edition of Section I of the Bridge Code dealing with "General Features of Design" was reprinted. The following new standards were printed during the year under report:

(a) Recommended Practice for Numbering Bridges and Culverts.

(b) Type Designs for Highway Kilometre Stones.

In addition, the second and enlarged edition of the booklet "Bridging India's Rivers" was published. This publication contains an account of 50 bridges built during the 1st and 2nd Five-Year Plans and is illustrated with a number of photographs and is being sold fairly fast.

Copies of I.R.C. 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 Appendix.

The Transport-Communications Monthly Review:—The official Journal of the Indian Roads Congress is published to keep our leaders and public men informed regarding our cause and to keep the road engineers informed regarding the latest in development, research and technique of the science and practice of construction and maintenance of roads. In addition to the original articles on roads and bridges, abstracts from a great number of technical Papers are also published in the Review.

The members of the 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 about 300 subscribers for this publication. Vigorous action is being taken to get the number of subscribers increased.

Complimentary copies of the Review are being issued to a big number of Central and State Ministers and important public men in addition to the Engineering Colleges in India. Complimentary copies of the issue of February 1960 were also given to all members of the Indian Roads Congress.

9. TECHINICAL ASSISTANCE

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 XXV—Part 1 of the Journal of the Congress. Lists of additions to the two libraries are published every month for the information of members in the "Transport-Communications Monthly Review" in addition to lists of selected literature, classified according to subjects. Abstracts of more important books and articles are also published. Members are requested to make free use of the library.

138 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 2,000. Members are requested to make greater use of these libraries.

11. MEDALS AND PRIZES

The Papers Committee after considering the Papers discussed at the Twenty-third Session for the award of "Mitchell Medal" and the "I.R.C. Medal" did not recommend any Paper for the award of either medal.

As desired by the Council at their 54th meeting held at Hyderabad on 11th January, 1959, the Executive Committee at their meeting held on the 29th August, 1959 considered the practices followed by various institutions in regard to the grant of more than one medal for a Paper jointly contributed by more than one Author and decided that if a Paper with more than one Author is awarded a medal, at least one medal and certificates for all the Authors should be awarded. In order to prepare certificates for the "I.R.C." and "Mitchell" Medals, certificates issued by other institutions were studied. Based on the information collected, draft certificates for the "I.R.C." and "Mitchell" Medals approved by the Executive Committee at their meeting held at New Delhi on the 30th and 31st August 1960, were accepted by the Council at their 57th meeting held at Bhopal on the 3rd January, 1961.

12. 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 I.S.I. Councils and Committees are:

(i) **Building Division Council:**

Principal representative —Shri K. K. Nambiar
Alternate ,, —Shri V. Kandaswamy

(ii) **Bridges Sectional Committee:**

Principal representative —Shri S. K. Ghosh
Alternate ,, —Shri R. K. Kochhar

(iii) **Cement Sectional Committee:** Dr. Bh. Subbaraju

(iv) **Bitumen & Tar Products Sectional Committee:**

Principal representative —Shri Kartik Prasad
Alternate ,, —Shri C. G. Swaminathan

(v) **Drawings Sectional Committee:**

—Shri H. P. Sinha

(vi) **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, Notations and Drawings Sectional Committee	Shri J. M. Trehan (Principal representative) 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 Equipment. Shri K. K. Nambiar continues to represent the Indian Roads Congress on this Panel.

(5) Council and Committees of 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

13. TECHNICAL ACTIVITIES

Out of 18 *Technical Committees and 10 Subcommittees of the* Indian Roads Congress, only the following *held meetings during the* period intervening 24th and 25th Sessions :

(i) Bridges Subcommittee for Section III—12th to 14th September 1960.

(ii) Do. —5th and 6th December 1960.

(iii) Road Transport Operation Cost Committee } October and November 1960.

(iv) Road Transport Development Committee } 17th and 18th August 1960.

(v) Stabilized Soil Roads Committee—7th April 1960.

(vi) Traffic Engineering Committee—22nd to 24th August 1960, 6th & 7th Septr. 1960.

In order to increase standard and output of the Technical Committees, it is very desirable that they should hold as many meetings as possible, in any case not less than two meetings during the period intervening the Sessions should be held. Given below is the position relating to each Technical Committee :

(1) Specifications and Standards Committee

The last meeting of the Committee was held at Bangalore on the 28th January and 1st February, 1960. The following subjects were discussed :

(i) Design of Highway Kilometre Stones ;

(ii) Recommended Practice for Location and Layout of *Motor Fuel Filling-Cum-*Service Stations.

Type Design of kilometre stones was approved by the Council at their 56th meeting held at Bangalore on the 2nd February, 1960. The standard has since been printed in Vol. XXV-Part I of the Journal and separate printed copies are available for sale.

Draft Recommended *Practice for Location* and Layout of Road-side Motor Fuel Filling-*Cum*-Service Stations was discussed clause by clause and amended in light of discussion. However, before its submission to Executive Committee and the Council,

some changes were considered necessary. The draft Recommended Practice including these changes were circulated again to the members of the Committee. The final draft revised in light of the comments received has been considered by the Council at their 57th meeting.

The Recommended Practice for the Design and Layout of Cycle Tracks revised in light of comments of Municipalities and various technical institutions in India and abroad was circulated to the members of the Committee and will be considered by them in the next meeting.

As desired by the Committee, the space standards for urban roads framed by the Town Planning Organization for Greater Delhi were circulated to the Chief Engineers of States for their comments. Comments received have been passed on to the Committee to finalise standards for roads within urban areas.

The Committee agreed to proceed with the work of metricization in matters concerning road design, etc., in consultation with the Indian Standards Institution and is likely to take up this subject shortly.

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

A 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 question of publication of the form for recording the test values of stone metal and type designs for village or place name sign 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 Standards 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 matter is under consideration of the Committee.

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 matter is still under consideration with the Ministry of Transport and Communications.

The Council at their meeting held in August, 1959, discussed the draft standard form for recording traffic census on non-urban roads. Forms finalised in the light of comments of the Council have been published in Volume XXV—Part 1 of the Journal.

In order to finalise a Policy on Roadside Advertisement, a draft was circulated for comments to State P.W.Ds., various Municipalities and interested Organizations. A good number of comments were received and are under consideration of the Committee.

Draft Standards 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 Curves, (6) Vertical Curves and Shock-Free Curves at Highways and (7) Traffic Rotaries were circulated to the members of the Committee for comments. The comments received were tabulated itemwise and passed on to the Committee for their consideration and forming a drafting Subcommittee to give the final shape to the standards.

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 profile of road on curves ;

(v) Concrete pavements ;

(vi) Bituminous pavements ;

(vii) Earthwork for roads ;

(viii) Base courses ; and

(ix) Specifications for $\frac{3}{4}$ in. thick light chipping carpets.

The Committee decided to set up a Subcommittee for drafting Standards and Codes of Practice. The Water-Bound Macadam Subcommittee held a meeting during the Bangalore Session. The Arboriculture Subcommittee has not held any meeting so far. All the State P.W.Ds. have been requested to send information about the arboriculture practices in their areas to enable the Subcommittee to make recommendations on the subject.

(2) Bridges Committee

The Committee held meetings on the 28th January, 5th and 6th December, 1960.

Revised edition of Section I of Standard Specifications and Code of Practice for Road Bridges dealing with General Features of Design has been reprinted. Section II dealing with "Loads and Stresses" had already been printed. Draft of Section III dealing with Reinforced Concrete prepared by the Drafting Subcommittee has been discussed by the Committee on the 5th and 6th December, 1960. It is likely to be released as a Paper for discussion prior to finalising it as a standard of the I.R.C.

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

(i) Prestressed and Composite Concrete Construction.

(ii) Steel Structures.

The draft criteria for Prestressed Concrete Bridges was circulated to the members of the Subcommittee. Further action will be taken on receipt of comments.

(3) Test Track Committee

The Committee held its meeting on the 28th January, 1960.

The lease of Calcutta Port Commissioners land on which the Test Trak, Majherhat, was situated expired in March, 1959 and no further extension could be arranged. It was, therefore, decided by the Government of India to shift the Government Road Test Track to a permanent site of its own at Pailan, 8 miles from Alipur on Diamond Harbour Road near Calcutta so that uniterrupted research work could be conducted and the Highway Engineers interested in experimental research work may frequently visit the place and acquaint themselves with the research activites. The details of traction equipment, lighting of tracks, construction of sub-soil drain, laying of monorails, etc., were worked out by the Committee at its meeting at Bangalore. All the electrical and mechanical tools and plant and the structural parts of the traction and lighting equipments of the Test Track, Majherhat, have since been dismantled, and removed to the new site at Pailan where construction of a new test track has been started and is well advanced.

The proposal to build a diversion on Diamond Harbour Road adjacant to the new test track was approved by the Test Track Committee in their meeting at Hyderabad on 9-1-1959 ; 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 was approved by the Committee at its meeting at Bangalore.

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 reports were considered by the Committee and passed on to the Research Organisation Committee for further action.

Tests on surface dressing laid on the Delhi-Mathura road near the Central Road Research Institute (Delhi) have been under study for about 5½ years. The report of these tests is likely to be discussed by the Committee shortly.

Road Research Bulletin No. 7 containing reports of the work done at the Road Test Track, Calcutta, from 1940 to 1958 has been compiled and published.

(4) Research Organisation Committee

The Committee held its meeting on the 28th January, 1960.

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 Shilling 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 Organisation Committee, the Executive Committee, at their meeting on the 14th July, 1958, decided that laboratory experiments be carried out to examine the possibllity of using lean concrete mixes in road works, preferably leaner than those so far tried. The reports of Road Research Laboratories which were requested to carry out experiments 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 cements and mortars for masonry. U.P. and Punjab Road Research Stations have already carried out research in the matter. West Bengal and Andhra Pradesh have agreed to carry out experiments. The replies of other road research laboratories are awaited.

The Central Road Research Institute was 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 on 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, it was suggested that the problems relating to traffic engineering be referred to the State Chief Engineer for advice. The Offices of Chief Engineers should be staffed with suitable specialists in this line. The Roads Wing have invited the views of Chief Engineers on the subject prior to addressing the State Governments in the matter.

At the meetings held on the 11th August, 1958, and 6th January, 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 was made:

The Central Road Research Institute had been requested to carry out research to establish a co-relation between the compressive strength and abrasive resistance of cement concrete. The report is awaited.

In order to make a comparative study of the behaviour of flexible overlays on rigid pavements, each State P.W.D. had been requested to experiment with different thicknesses of overlays, designed to suit the subgrade conditions. Suitable control sections were also to be laid for drawing comparative conditions. The reports of State P.W.Ds. are awaited. Literature on this subject issued by Concrete Association of India has been passed on to CRRI.

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 use tracked vehicles. They promised to carry out the experiments. The report is awaited.

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 C.R.R.I. A Paper on this subject is published in Road Research Bulletin No. 6. As decided by the Committee at their meeting held on 28-1-1960, Bhakra Dam authorities were requested to supply specifications together with a report on the use of "AEA Rihand" as an air-entraining agent. This matter is being followed.

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. As silicones are not produced in India and are fairly expensive, the Committee decided that the possibilities of manufacturing the same in India should be investigated, if the material proved useful. In the meantime, the Road Research Laboratories were requested to intimate the C.R.R.I. their requirements of this material for research purposes so that the question of its import could be taken up.

At the meeting of the Specifications and Standards Committee held at Nagpur in January, 1956, it was pointed out, while discussing the development of heat-resisting bituminous pavements, that with the introduction of jet-propelled aeroplanes, the maintenance of bituminous landing grounds had become difficult and costly. Consequently, the Committee decided that the Research Organisation Committee should initiate research on this problem. This Committee considered the proposal at their meeting held in December, 1956 and as per their decision, specifications obtained from the various manufacturers of tar and bitumen were passed on to the Central Road Research Institute, for processing and evolving specifications for adoption in India. The replies received from the manufacturers, and comments thereon by the Director, Central Road Research Institute, were considered by the Committee on the 28th January, 1960, at Bangalore. As decided by them, the Army authorities and the C.R.R.I. have been requested to collect information from economic point of view on rigid as well as flexible pavements for the consideration of the Committee.

The points arising out of discussions on the Road Research Report for 1958-59 were discussed by the Committee in their meeting held on the 28th January, 1960. As a result, the following progress has been made :

The Committee suggested the setting-up of a Research Implementation Committee. The Executive Committee accepted the suggestion and recommended the necessary personnel of this Committee for the consideration of the Council at their 57th meeting at Bangalore. This Committee would select the experiments to be carried out by States and express opinion about success or otherwise of the experiments.

During the period under report, the Government of India intimated the following decisions :

(i) each State may be requested to devote 1 per cent of its provision for road development in the Third Five-Year Plan for schemes of experimental specifications and new techniques ;

(ii) a sum of Rs 75 lakhs be set apart as a sort of 'Risk Fund' in the Central sector of the road programme in the Third Plan for covering risk of losses or extra expenditure on approved experimental works ; and

(iii) a Central Assessment Committee be formed under the aegis of the I.R.C.

The Planning Commission have already started explaining to the State Governments' representatives during the course of discussions of their Third Five-Year Plans that it has been decided to set apart 1 per cent of their allocation under the Third Plans for the research schemes which might be selected for execution.

Out of Rs 75 lakhs mentioned in para 1 (ii) above a sum of Rs 33 lakhs is intended for the purchase of machinery which will be placed under the control of the C.R.R.I., who will distribute and direct the machinery from time to time to places where experimental trials are to be conducted. The hire charges involved will be debitable to the estimate of construction of the road concerned with suitable adjustment for travel time and haulage charges. The balance of Rs 42 lakhs will be retained by the Ministry of Transport and Communications (Departments of Transport), Roads Wing, to encourage field trials in road construction with the help of the Central Assessment Committee.

The Central Assessment Committee will include as permanent members, the Consulting Engineer (Road Development), the Director, C.R.R.I., some Directors of State Road Research Laboratories and Chief Engineers from Highway Departments of a few States. Representatives of bitumen and concrete industries or any other suitable person may also be included.

While examining the road projects of a particular State and while recommending suitable new techniques for replacing conventional ones, the Committee shall co-opt the Chief Engineer and the

head of the Road Research Institute, if any, of that State if they are not already in the Committee.

To avoid delays, the estimates and reports will preferably be prepared in the Central Road Research Institute in consultation with the Chief Engineers concerned. The Central Road Research Institute may also process various proposals and prepare technical notes for the use of the Committee.

The Central Assessment Committee will examine the road projects of each State and determine the site, length, etc., of roads wherein normal methods of construction can be replaced by a suitable new technique evolved by Road Research Laboratories in the country. For each State, the Committee will recommend such replacement to the extent of 1 per cent of the State's allocation for road development schemes. In selecting new techniques, as far as possible, the Committee will confine itself to those which have reasonable chanches of competing with existing methods of construction as regards cost in the particular area.

In the event of any loss occurring as a result of failure of the road constructed according to the new technique, or in case the total cost of construction according to the new technique exceeds that of the conventional method, the Ministry of Transport and Communications will make good the loss or extra expenditure, as the case may be, from the "Risk Fund".

The Committee referred to above is being formed by the I.R.C. as already indicated above.

The Committee agreed that it is desirable to prescribe standards and tests to assess the suitability of surkhi for use in the construction of road pavements.

The Committee agreed that research stations could take up for independent study any research problems on which research might be in progress in any other research laboratory in the country. The Committee also accepted, in principle, the suggestion that its meetings should be held, in turn, at different State Research Stations.

The points arising out of the discussion on the last Road Research Report discussed at Bangalore in January, 1960, will be considered by the Committee at Bhopal.

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, 1960. The annual reports were studied and a general report has been published in Volume XXV—Part 3 of the I.R.C. Journal for discussion at Bhopal.

(5) Soil Research Committee

The Committee held a meeting on the 1st February, 1960.

It had been decided that as soon as specifications for stabilizing black cotton soil were ready, the Chief Engineers of States should be requested to lay experimental stretches of sufficient length to those specifications. The specifications are awaited from the Central Road Research Institute.

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 pulverisation for stabilization with lime should be investigated first and for stabilization with cement later on.

At the last meeting of the Committee at Bangalore, it was explained that the C.R.R.I. were preparing detailed specifications for the stabilization of black cotton soil with lime. These specifications, when received, will be placed before the Committee. The question of trying them on sizable lengths of road in black cotton soil areas would also be taken up.

The Committee at their meeting held on the 9th January, 1959, decided that the degree of pulverisation 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. Modification 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. The reports are awaited.

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 were considered by the Committee at their last meeting held at Bangalore. As decided, the Chief Engineer (Highways), Andhra Pradesh, was requested to supply the analysis of the cost of soil-cement blocks. This information has since been received and passed on to the Committee for the information of its members.

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 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.

As desired by the Committee at their meeting held on the 9th January, 1959, the State P.W.Ds. were requested to try the suggested subdivision 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 C.R.R.I. was also forwarded to them. The matter is being pursued with the State P.W.Ds.

As decided by the Committee at their meeting held on the 1st February, 1960, the State Road Research Laboratories have been requested to send to I.R.C. samples of specific cases (accompanied by actual data) where the Indian Standard for Classification and Identification of Soils for General Engineering Purposes is found wanting as compared to other systems already followed by the laboratories.

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 C.R.R.I. have since taken up the work of preparing draft specifications.

The Central Road Research Institute have been requested to finalise the specifications for stabilized soil-base courses and wearing courses for areas having moderate rainfall and for areas having heavy rainfall for circulation to members of the Committee. The specifications and practices for stabilized soil-base courses and wearing

courses received from various State P.W.Ds. had already been passed on to them. The specifications are awaited.

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 the Central and State Governments 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 November, 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.

As decided by the Committee at its meeting held at Bangalore, the detailed specification of the clay-sand mixture to replace double brick soling in the base of road pavements, as practised in West Bengal, was obtained by the I.R.C. and sent to the Committee.

(6) Education Committee

The Committee held its meeting on the 28th January, 1960.

The Ministry of Education had intimated that the All-India Board of Technical Studies in Engineering and Metallurgy had noted the views of the Indian Roads Congress about the introduction in the B.E. Course of the Education Committee's syllabus for Highway Engineering of 60 hours' duration and suggested 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 in the various Universities for subject of Highway Engineering is adequate and no special request need be made to the Universities at the stage, for a uniform provision of 60 hours throughout the course. The views of the Indian Roads Congress regarding the standard syllabus for Highway Engineering will, however, be brought to the notice of its Syllabus Committee at the next meeting which has not been held so far.

A syllabus in Highway Engineering for inclusion in the diploma courses for overseers and supervisors for forwarding to the All-India Council for Technical Education is being finalised.

The syllabii for Post-Graduate courses in Highway Engineering of Indian universities was under examination along with the syllabii of Post-Graduate courses in Highway Engineering in foreign countries. The Committee at their last meeting decided that a general outline of syllabus should be prepared to form a basis for preparation

of detailed syllabus by different universities, according to the facilities available without curtailing the minimum coverage required. A general outline of syllabus is likely to be discussed at the next meeting of the Committee.

The views of the Education Committee on the institution of Refresher Courses for Highway Engineering at Universities and Colleges, were accepted by the Executive Committee. The Education Committee was requested to finalise the syllabus for refresher courses. 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 last 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 from these institutions as well as from a number of foreign technical institutions were passed on to the Committee for further action. The Committee at their meeting held at Bangalore in January, 1960, decided that the syllabus approved by them in June, 1955, should be taken as final. The matter was placed before the Executive Committee at their meeting held in August, 1960 and, as decided by them, the draft syllabus has been circulated to members of the Council.

It was understood at the last meeting of the Committee that the C.R.R.I. were considering the question of organising a Refresher Course at the C.R.R.I. under the auspices of ECAFE. They have been requested to intimate the progress made.

(7) Provincialisation of Local Bodies Engineering Services Committee

The Committee held a meeting on the 31st January, 1960.

The minutes of this meeting were considered by the Executive Committee at their meeting held on the 30th and 31st August, 1960. As decided by them, the resolution of the Committee suggesting that Highways Departments should also look after buildings, water supply and to a small degree irrigation works, was referred back to the Committee for reconsideration as it was felt that if Highways Departments were entrusted with all sorts of work they might not be able to devote as much time and attention to the roads as was necessary.

Further, as decided by the Executive Committee, all States have been requested to intimate the progress about the provincialisation of the engineering services of local bodies.

(8) Manufacture of Road Making Machinery and Mechanisation Committee

The Committee held a meeting on the 31st January 1960.

The minutes of the meeting were considered by the Executive Committee at their meeting held in August, 1960. As decided by them, it has been recommended to the Government of India that for ensuring proper quality of work and quick road construction, mechanised methods should be adopted in road construction and for this purpose, necessary machinery should be manufactured in India as early as possible. Such items of machinery as could not be manufactured in India at present, should be imported from abroad and for which necessary exchange be released.

The Committee had agreed that the manufacture of motor graders, bituminous mixers and bitumen distributors should be taken up in India and decided the size and type of the machines considered suitable for manufacture in this country. The forecast of the requirements of these items received so far from the States was considered by the Committee and it was decided that further action would be taken after all the States have supplied information.

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), information about likely total requirements of the various items of road making machinery during the 3rd and 4th Plan periods 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. Most of the State P.W.Ds. have furnished information. As soon as the remaining State P.W.Ds. have furnished the information, it will be passed on to the Government of India.

The compilation of a list of the machinery manufacturers, suppliers and dealers in different parts of India along with their addresses and the types of machinery handled by them has been prepared and will be published in the Journal shortly.

(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 at Bangalore on the 28th January, 1960, considered the revised interim analysis of the cost of operation.

As decided by the Committee, the U.P. State Transport Undertaking was requested to extend the experiments on hill roads in that State so that a comprehensive picture of the cost of operation of motor vehicles on hill roads is available.

The members of the Committee met thrice during the period under report and made on the spot inspections of the routes and the experimental vehicles. The factual details regarding various basic documents, tachograph, etc., were explained to the members by the State Transport Undertakings.

It was clear from the experimental results that with the improvement of the road surfaces, there is a saving in the cost of operation.

Actual savings under different heads of running cost have been evaluated by the Committee from the experimental results so far received. In their study, the Committee have noted that there should be sufficient number of vehicles so that the savings in the cost of operation may off-set the initial cost of construction and maintenance of better type of roads.

In their final report, the Committee are prescribing various traffic intensity ranges suiting different types of surfaces.

The report of the Committee about the cost of operation on the various types of roads in plains has since been finalised.

(10) Cement Concrete Road Surfacing Committee

The Committee held its meeting in January, 1960 and submitted their recommendations.

The Executive Committee at their meeting held in August, 1960, examined the recommendations regarding the selection of thicknesses of concrete roads for Indian conditions prepared by the Committee and as decided by them, the Committee has been requested to reconsider their recommendations in the light of the following comments:

> " Keeping in view the alround development in India, the roads now being built would develop heavy traffic and heavier types of vehicles would operate on them with the result that the thinner slabs of concrete roads would not be able to stand them. It is, therefore, desirable that for concrete roads having traffic less than 750 tons per day, the minimum thickness of the slab should be 4 in. and for traffic ranging between 750 and 5,000 tons, it should not be less than 7 in. thick and for over 5,000 tons, the thickness should be 8 in."

(11) Road Transport Development Committee

The Committee held its meetings on the 1st February, 17th and 18th August, 1960.

The Committee felt that on account of meagre foreign exchange allotted so far, the target of the production of 40,000 commercial vehicles by 1960–61 intimated by the Planning Commission is not likely to be achieved and the actual production will be much less. The Committee recommended that steps should be taken immediately to step up the production of automobiles and that in the Third Five-Year Plan, provision should be made not only to increase the tempo of production of automobiles to meet the increasing demand of traffic but also to cover the back-lag of the Second Five-Year Plan. The foreign exchange required for this purpose should be released on top priority basis in the interests of overall development of the country's economy.

The Committee at its last meeting in August, 1960 also expressed the view that during the Second Five-Year Plan, the production of automobiles had not been properly phased. It is necessary that phased production of vehicles is arranged in the Third Five-Year Plan.

The Committee recommended that in order to carry goods by road economically and to utilise roads to the extent of their load-bearing capacities, all National Highways and 50 per cent of State Highways in the country, except hill roads, should be upgraded by 1965–66 in respect of foundation, surfacing and bridges to carry vehicles of 27,000 lb of laden weight on two axles. As a result of this, truck-trailer combination upto an axle-load of 18,000 lb and other modernised heavy vehicles would be able to ply on these roads without difficulty. In this connection, the Committee endorsed the recommendation of the Road and Inland Water Transport Advisory Committee to permit articulated vehicles and truck-trailer combination.

The Committee agreed that the present bridges and culverts on many of these routes had to be improved and in order to find out which of these should be improved, static load tests were necessary. They, however, clarified that wherever the Chief Engineer of a State was satisfied about the strength of a bridge on the basis of design data, it need not be tested. Further, whenever it was felt that static load test might hold up traffic for a considerable time, it was suggested that heavy army vehicles should be employed to test the strength of bridges.

In this connection, the Committee recommended to the Govt. of India that if State Governments specified which particular bridges on fairly long stretches of National Highways required reconstruc-

tion to permit heavy traffic, they should give priority to that work. And if a bridge collapsed while conducting the static load test on bridges on National Highways, the Govt. of India should bear the cost. The States should, however, make arrangements for temporary bridges, like a Bailey or Hamilton bridge for use in the case of emergency.

The reaction of State Govts. to the recommendation relating to the use of heavier vehicles and truck-trailer combination and strengthening (or reconstructing) of highways to make them fit for heavy modern vehicles has been encouraging. The Govts. of Bihar, Bombay and Madras have sent specific proposals for strengthening some of their bridges so that truck-trailer combination may be allowed on some of the National Highways passing through their respective States. As regards National Highway route between Amritsar and Agra, the Govts. of U.P. and Punjab are taking necessary steps for allowing truck-trailer combination to use the route.

In regard to the decision of Chief Engineers last year to survey at least two National Highways for weak bridges, the Committee expressed the view that instead of various States surveying different National Highways, the Consulting Engineer (Road Development) should select the two National Highways on which such surveys should be carried out, the programme being so arranged that the entire length of two particular National Highways is surveyed at a time by the States covered by that highway. The Govt. of India have been addressed in the matter.

In order to encourage the development of road transport, the Committee suggested that State Govts. and/or Municipalities should provide shelters, booking facilities, terminal stations and sanitary arrangements and levy an appropriate charge on transport operators to recover the cost over a period of years. The operators in turn should group themselves into viable units to utilise these facilities.

The Committee recommended that uniformity on the limit of permissible laden weight of motor vehicles was essential on inter-State routes. It was suggested that where necessary, roads should be improved but it was essential that the laden weight limits should be 27,000 lb on two axle truck, with axle load not to exceed 18,000 lb on all National and State Highways and 19,000 lb on two axle truck on all Major District Roads.

The Committee at its last meeting in August, 1960, noted that due to shortage of transport capacity and foreign exchange restriction, the Govt. of India had already recommended that registered laden weight of 25 per cent above the certified gross vehicle weight could be justified in case of vehicles manufactured from 1953 onwards. The major district roads were already required to carry

such heavy vehicles. In order, therefore, to facilitate full utilisation of national investment both in roads and road transport, the Committee recommended that the laden weight limits on major district roads as decided at Bangalore Session in February, 1960, be raised from 19,000 lb (on 2 axles) to 22,500 lb.

The Committee discussed the question of negotiating with the Govt. of India to increase allocation for roads, and road transport in the Third Five-Year Plan. It was emphasised that allocation of Rs 250 crores for roads in the Third Five-Year Plan was not at all sufficient and, therefore, the Govt. of India should be requested to reconsider the matter with a view to increase the allocation. The Committee will consider the matter further in detail.

The Government of India have, however, been once addressed in the matter as per decision of the Executive Committee meeting held in August, 1960, arising out of the consideration of the points brought out in the Presidential Address at the 24th Session.

Keeping in view the limited resources made available for road development, the Committee decided that the following priorities may be kept in view for road works in the Third Five-Year Plan.

National Highways :

(1) Construction of missing bridges, major and minor, and missing links.

(2) Strengthening of the structures and improvement of geometrics of roads where the traffic intensity so necessitates.

State Highways:

The same order of priority for State Highways (depending on the availability of funds, improvements and upgrading of road surface).

These recommendations have been forwarded to the Government of India for necessary action.

The Executive Committee at their meeting held in August, 1960, considered the recommendations about the popularising of I.R.C. cart wheel and as decided by them, the Government of India were requested to concentrate their efforts in the first instance in Gujerat State only. It was suggested that maximum facilities by the authorities should be provided for adoption of the I.R.C. cart wheel. It would be desirable if the State Government would kindly manufacture the wheels themselves for supply to villagers. If there was any difference in the cost of the present and the I.R.C. design wheel ,the Indian Roads Congress would appreciate if the Government of India kindly agree to pay the difference in cost.

The Government of India in their reply have intimated that a suggestion has recently been made to the various State Governments (including Gujerat State Government) that the scheme in question will be more attractive to villagers if complete wooden wheels with iron rims are supplied free to them instead of iron rims only, the expenditure on the scheme being restricted to the grant already offered by reducing the number of pairs of wheels. These State Governments have been requested to consider the desirability of adopting this suggestion in their States and send proposals to the Government of India at an early date for subsidising for the wooden frames in addition to iron rims. The Government of India have already approved this suggestion in the case of Madhya Pradesh State, who are implementing the scheme. The proposals from the Gujerat State when received, will be examined by them and necessary action taken.

The Committee in its meeting held in February, 1960, expressed the view that for roads which had developed motor traffic and yet do not have a proper authority to maintain them, suitable agency should be specified without further delay. The Executive Committee at their meeting held in August, 1960, did not consider any action necessary as they felt that roads which develop motor traffic were generally maintained by the State P.W.Ds. or other suitable agencies.

As regards the proposal for allocating to the Central Road Fund 33⅓ per cent of the tax proceeds on petrol and high speed diesel oil, the Committee reconsidered its earlier decision at Bangalore meeting and agreed that since this question was linked up with the much larger issue of getting adequate funds from general revenues for Road Development Plans, an emphasis on the Central Road Fund at this stage might not be advantageous.

Other important subjects under consideration with the Committee are: (*a*) effect of the increase in taxation on the demand pattern of automobiles and (*b*) taxation on motor transport.

(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 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, was to draft a detailed resolution on the subject to be passed by the Council. This is awaited.

The Committee held a meeting on the 7th April, 1960 and inspected the stabilized-soil roads built in the south.

The findings of the Highway Research Station, Madras, have been referred to the Soil Research Committee and to road research laboratories in the country for investigation.

As regards the construction of stabilized-soil roads, the Roads Wing has been requested to approach the Chief Engineers concerned to expediate submission of proposals in regared to the offer made by the Government of India to meet 50 per cent of the cost of 30-mile experimental lengths to be built according to Mehra's method.

The Committee noted that the specification for stabilized-soil roads to be adopted in areas having an annual rainfall of more than 60 in. are still under preparation with the C.R.R.I. On receipt, these will be circulated to members.

(13) Community Projects Road Maintenance Committee

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 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 upkeep which vary from place to place. At its meeting held on the 6th January, 1959, the Committee had finalised the "Recommended Practice for the Maintenance of Roads constructed under Community Project Administration and National Extension Block Services". The Recommended Practice which was forwarded to the Government of India, Ministry of Transport and Communications, Roads Wing, was sent by them to the Ministry of Community Development and State Governments for adhering to the standards laid therein. Till November, 1960, the States of Kerala, Assam, Andhra Pradesh and Mysore had communicated their acceptance of these recommendations. No replies had been received from other States.

(14) Traffic Engineering Committee

The Committee held meetings on the 28th January, 22nd to 24th August and 6th and 7th September, 1960.

The questionnaire on 'Parking and Loading Vehicles' finalised by the Committee, was circulated for comments to Corporations and major Municipalities.

The Committee considered road-signs. The concensus 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 and Communications, Roads Wing, for further necessary action. The question is also being dealt with by the ECAFE in connection with International Asiatic Highway and will be finalised after deliberations and decisions of the conferences on this matter.

At its 55th meeting held at Bangalore on the 28th January, 1960, the Council decided that as introduction of additional road-signs and amending existing road-signs will involve amendments of M.V. Act, fully dimensioned sketches of traffic signs as given in the Indian Motor Vehicles Act and as amplified by the late Indian Stores Department should be published in the Information Section of the I.R.C. Journal. The modified signs adopting the metric system have been publised in Vol. XXV—Part 3 of the Journal of the Indian Roads Congress.

The Committee at its meeting held in August and September, 1960, discussed nomenclature for Traffic Engineering Terms and adopted some definitions. The discussion of this subject will be continued at subsequent meetings.

A note on "Regulation of Mixed Traffic in Towns" prepared by Shri M. Meeran was discussed by the Committee at its meeting in August, 1958 and as a result of the discussion, it was suggested to the Author to incorporate in the note the steps usually taken in India and abroad to deal with the problem of mixed traffic and specific recommendations should be made in the matter. He was also requested to keep in view the suggession of the Executive Committee that location and design of traffic regulation contrivances at junctions such as traffic islands, should also be studied. At the request of Shri Meeran, the Highway Research Station, Madras, prepared another note incorporating the fresh points mentioned above. Both notes were circulated to the members of the Committee for comments. The Committee is now busy with the preparation of rules, regulations, and specifications for regulation of mixed traffic.

Draft specifications for road markings were circulated to members of the Committee for comments. These were later discussed at the meeting of the Committee in August, 1960. The draft specifications are being revised in the light of discussion that took place at that meeting.

The Committee at its meeting in August, 1960, expressed the view that at the present stage of development of the country only fixed time signals were needed at road crossings and that the standard on traffic signals should be drafted on the basis of this consideration. Shri C. L. N. Iyengar agreed to prepare the draft.

At the same meeting, the Committee discussed the subjects of Street and Highway Lighting and Draft Indian Standard Code of Practice for Design of Street Lighting Installations. The Committee expressed the view that the standardisation of road matters was appropriately the function of the I. R. C. and the Indian Standards Institution should have left this subject for the I.R.C. to deal with. However, they made some comments. Detailed comments on the draft I.S.I. standard invited from members of the Committee have been passed on to the I.S.I.

(15) Prevention of Ribbon Development Committee

The Committee held a meeting on the 28th January, 1960.

The Committee suggested that the idea or principle of Group Development should be brought to the notice of all concerned in the development of roads as that would be the best way of controlling access to roads.

The Committee desired that the Government of India, Ministry of Transport and Communications, should be requested to obtain legal opinion on the question of issuing administrative orders to freeze the land where ribbon development is likely to affect construction of roads.

The Committee expressed the view that in view of the recent trend towards urbanisation, the problem of ribbon development alongside roads in the country has assumed great and urgent importance. They, therefore, felt that immediate attention should be paid to the question of proper and planned development of roads to cater to the growing traffic and to prevent traffic hazards.

The Committee made the following further recommendations:

(a) Suitable propaganda measures should be taken through poster publicity, press articles, documentary films, etc. focussing the attention of the public to the question of ribbon development and its consequences.

(b) Special mobile Magistrates should be appointed to try

(c) Steps be taken to prepare accurate land plans duly signed by the appropriate revenue authorities. Roads Wing should be requested to take suitable action regarding National Highways and the States in respect of State Roads and in particular in respect of State Highways.

Taking into consideration the delay that is bound to take place in the enactment of Highway Bills, the Committee had also expressed the view that the Central as well as State Governments should immediately take steps to enact separate Bills to deal with the prevention of ribbon development. All the above mentioned recommendations have been recently forwarded to the Government of India for necessary action. The reply of the Government of India is awaited.

14. MISCELLANEOUS

(1) PAPERS

Twenty-one Papers were received during the year. Five were already in hand. Out of these 26 Papers, 6 were accepted for publication in the Journal, 4 were published in T.C.M.R., 10 were rejected, 1 was returned to Author for revision, and 5 are pending for consideration.

The first and foremost objective of the Society is to encourage and promote the science and practice of the building and maintenance of roads and bridges 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 would also suggest to members, especially the senior members, that they should encourage the taking of notes and photographs 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—SILVER JUBILEE SESSION

The Executive Committee at their meeting held on the 30th and 31st August, 1960, considered the various suggestions made in the Presidential Address of the Silver Jubilee Session and as decided by them, various recommendations dealing with provision of adequate funds for roads in the Third Plan, setting up of separate Highways Departments in States, employment and maintenance of mechanical equipment for road works, have been made to the Government of India.

(3) FORMATION OF A ROAD BOARD

The formation of a Road Board at the Centre has been recommended to the Government of India from time to time by the Indian Roads Congress and also by the Chief Engineers at their Conference held at Nagpur in December, 1943.

This proposal again came up before the Council at their 56th meeting held at Bangalore on the 2nd February, 1960 when they appointed a Special Committee to examine the question of establishment of a Road Board at the Centre and make suitable recommendations for its composition and functions.

The Committee at its meeting held on the 19th August, 1960, discussed the matter in detail and came to the conclusion that the establishment of a Road Board at the Centre was an urgent necessity and its formation should not be delayed any longer. The Committee also made recommendations about the composition and functions of the proposed Road Board.

The Executive Committee at their meeting held on the 7th December, 1960, and the Council at their meeting held on the 3rd January, 1961, considered the recommendations of the Special Committee and agreed with their views that a Road Board at the Centre is essential and its constitution should not be delayed. The recommendations will be forwarded to the Government of India shortly.

(4) 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 discussion and written replies were studied by the Central Road Research Institute and they have sent tentative specifications for single coat bituminous surface treatment. The specification was circulated to various binder interests whose comments have been passed on to C.R.R.I. for reconsideration of the draft specification. The revised draft specifications are awaited.

Appendix

LIST OF JOURNALS RECEIVED ON EXCHANGE BASIS

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 I'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 Vegtidss Krift (Norway).
56. Premier Automobile Journal.
57. Proceedings of the Institution of Civil Engineers, London
58. Power Engineer.
59. Public Roads.

60. Quartely Technical Bulletin (Indian). (Ministry of Railways).
61. Reinforced Concrete Review, U.K.
62. Research and 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. Stresse 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.
87. Traffic Quarterly (U. S. A.)
88. Traffic Engineering & Control (U.K.)

Minutes of the 58th Council Meeting of the INDIAN ROADS CONGRESS held at Bhopal on the 8th January, 1961.

The Council met with Shri H. P. Sinha in the Chair

PRESENT

Antia, Dr. F. P.		Khanna, G. C.
Basu, K. N.		Lall, Y. K.
Behera, S. S.		Mehra, S. R.
Barua, K.		Nambiar, K. K.
Bhagat, D. G.		Padmanabha Aiyar, C. S.
Bhatt, U. J.		Prasad, Jagdish
Chavan, J. D.		Rajwade, M. V.
Dube, S. B.		Shivdasani, P. D.
Durrani, N.		Shoba Ram
Endlaw, D. N.		Sinha, S. N.
Gupta, S. N.		Tripathi, S. N.
Iyengar, C. L. N.		Wanchoo, P. N.
Joshi, K. M.		
Hukam Singh	...	Technical Secretary
Sen, N.	...	Secretary.

The following co-opted members attended:

Bannerjee, J. K.	Nadirshah, E. A.
Dube, Major-General K. N.	Nangea, G. R.
Gandotra, H. K.	Patiyagoda, D.
Goverdhan Lal	Vagh, B. V.
Key, J. W.	Sujan Singh

The following attended by invitation:

Bhalla, R. S.	Subrahmanyam, J.
Ganguli, Dr. M. K.	Vaidya, A. G.
Hardyal	Vaidynathan, P. H.
Nagarsheth, M. P.	Vaish, V. R.

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 57th Council Meeting:

The minutes of the 57th Council meeting held at Bhopal on the 3rd January, 1961, were confirmed.

3. Office bearers :

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

President	...	K. Barua
Vice-Presidents	...	G. C. Khanna
		P. D. Shivdasani
		S. N. Tripathi
Secretary	...	N. Sen

At this stage, the newly elected President, Shi K. Barua took the Chair.

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

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

Invitations to hold the next Session of the Indian Roads Congress were recived from the Governments of Bihar, Punjab and Uttar Pradesh.

After detailed consideration, the Council decided to accept the invitation of the Government of Bihar to hold their 26th Session at Patna sometime in November or December depending upon the convenience of the host Government. The invitation of the Governments of Punjab and U.P. could not be availed of for the next Session as two Sessions had already been held in U.P. against one in Bihar and the last Session held in Bihar was earlier than in the Punjab.

The Council thanked the Governments of Punjab and Uttar Pradesh and expressed the hope that their kind invitations would be availed of sometime later.

The Council noted that the question of holding a Session in Ceylon would depend upon renewal of the invitation of that Government and the availability of the necessary foreign exchange for that purpose.

5. Committees :

The Convenors of Committees were appointed as under :

(1) Bituminous Pavements Committee	...	Shri Sujan Singh
(2) Bridges Committee	...	Shri S. L. Bazaz

(3) Cement Concrete Road Surfacing Committee	...	Shri E. A. Nadirshah
(4) Community Projects Road Maintenance Committee	...	Shri K. K. Nambiar
(5) Education Committee	...	Shri E. A. Nadirshah
(6) Local Committee of the Test Track Committee to Supervise Delhi-Mathura Road Tests	...	Director, C.R.R.I.
(7) Manufacture of Road Making Machinery and Mechanization Committee	...	Shri R. S. Bhalla
(8) Papers Committee	...	Shri H. P. Sinha
(9) Prevention of Ribbon Development Committee	...	Shri H. P. Sinha
(10) Provincialization of Local Bodies Engineering Services Committee	...	Shri N. Durrani
(11) Research Organization Committee	...	Shri H. P. Sinha
(12) Road Operation Cost Committee	...	Shri Jagdish Prasad
(13) Road Transport Development Committee	...	Dr. F. P. Antia
(14) Specifications & Standards Committee	...	Shri Goverdhan Lal
(15) Soil Research Committee	...	Director, C.R.R.I.
(16) Stabilized Soil Roads Committee	...	Shri K. K. Nambiar
(17) Test Track Committee	...	Chief Engineer, Road Development, West Bengal
(18) Traffic Engineering Committee	...	Shri D. G. Bhagat

The Council decided to wind up the Organization Committee which had no work at present. The Council also decided that the Bituminous Pavements Subcommittee should henceforth be a full-fledged Committee.

6. Resolution of Bridges Committee :

The Council considered a resolution of the Bridges Committee suggesting preparation of joint codes with the Indian Standards Institution where parallel Committees were working in both institutions.

It was brought out during the discussions that where learned technical bodies were working through their Committees on specific problems and specifications covering their fields of knowledge, the Indian Standards Institution need not have parallel Committees to deal with the same subjects as it would lead to duplication. The Council felt that so far the standardisation in regard to the design and structural aspects of roads and bridges was concerned, it should appropriately be done by the Indian Roads Congress.

After detailed discussion, it was agreed that the Consulting Engineer (Road Development) would explain the position to the Bridges Committee.

7. Selection of the personnel of the Research Implementation Committee:

The Council selected the following personnel of the Research Implementation Committee:

(1) Consulting Engineer to the Government of India (Road Development)		Convenor
(2) President, Indian Roads Congress		
(3) Director, Central Road Research Institute		
(4) Two Chief Engineers of States	...	1. Shri J. K. Bannerjee, Chief Engineer, W. & B., W. Bengal, Calcutta. 2. Shri U. J. Bhatt, Chief Engineer, Buildings & Communications, Gujerat, Ahmedabad.
(5) Two Directors of State Road Research Laboratories		1. Director, Highway Research Station, Madras. 2. Director, P.W.D., B. & R., Research Laboratory, Chandigarh.
(6) Two co-opted members from the State concerned (one Chief Engineer and the other representative of the State Road Research Laboratory)in case none of these persons is already in the Committee.		

(7) One member from Non-Government Organizations	...	Shri B. V. Vagh
(8) Three experts to be co-opted who have special knowledge of the subject under consideration:		The President, Indian Roads Congress, was authorised to select the names of persons to be co-opted.
(9) Secretary	...	The Director, Central Road Research Institute, was requested to nominate a suitable officer to act as Secretary.

It was agreed that the personnel selected would hold office for three years. There would, however, be no objection to their re-appointment.

8. Finance for roads in the Third Five-Year Plan:

The Council while discussing the question of obtaining more finance for road development in the Third Five-Year Plan stressed the need of exploring all avenues for this purpose. After detailed discussion, the Council passed the following resolution for forwarding to the Government of India:

> "In view of the increasing demand for road transport on main roads, which is bound to increase with the beginning of the Third Five-Year Plan onwards, the Council of the Indian Roads Congress is strongly of the opinion that the deficiencies in our present system of arterial roads, particularly of National Highways covering 15,000 miles, should be corrected by the year 1965 in all respects, viz., missing links, missing bridges, strengthening of road crusts, improving geometric layout and the provision of two-lane carriageways and that, if necessary, the assistance of bodies like the International Development Association should be enlisted for the purpose."

9. Miscellaneous:

(1) Major-General K. N. Dube, Director General of Border Roads, desired to know as to how best the Committees of the Indian Roads Congress could be of assistance to his Organization in their work. It was explained to him that the Committees of the Indian Roads Congress

are entrusted with certain specific subjects. If any information was needed, the matter should be referred to the Secretary, Indian Roads Congress, who would supply the information, if available with him or obtain it from the Convenors of the Committees concerned.

(2) The Council after detailed discussion agreed that whenever any subject becomes big enough or required a specialised study, it should be entrusted to a separate Committee in order to expedite its finalization. The Specifications and Standards Committee should, however, process the draft standards if that was necessary as a result of the deliberations of those Committees.

(3) The Council agreed that all Committees should henceforth follow the metric system is their work as in this way only it would be possible to act according to the schedule laid down by the Government of India. It was, however, decided that the present denominations, viz., inches, feet, etc., should also be mentioned in parenthesis against the metric figures for some years to come until the metric symbols become familiar to every one.

Discussion on Paper No. 223*

"An Investigation for Evaluating an Airfield Pavement"

By

Dr. H. L. UPPAL & H. S. BHATIA

Wednesday, January 4, 1961.

Shri E. A. Nadirshah (Chairman) called upon **Dr. H. L. Uppal**, Joint Author, to introduce the Paper for discussion.

Dr. H. L. Uppal (Co-Author) in his introductory remarks stated that the Paper dealt with the investigation of a civilian airfield. The method used for evaluation was the Load Classification Number abbreviated as L.C.N. This method was selected due to the fact that it is more or less non-destructive method of testing, and takes into consideration different combinations of load contact area and tyre pressure. The method was developed by the Air Ministry, England, as a result of large scale field testing. From the load contact area curve, it was possible to work out the L.C.N. of the airfield and, similarly, from the load-tyre pressure curve, the L.C.N. of the aircraft could be calculated. It should then be possible to say which of the aircrafts could be safely accepted, the principle being that an airfield of a certain L.C.N. should not frequently accept aircraft of a higher L.C.N.

This technique had not so far been applied to the evaluation of Indian civilian airfields, but it was also not certain if the Army had tried it on some of the runways, but no published information was available.

From the various tests carried out both on the poor and sound lengths on the airfield investigated, it would be seen that the L.C.N. of the lengths which were showing signs of distress was 4 as against L.C.N. of 10 of the aircraft and for the same reasons, it was unable to take up the traffic satisfactorily. On the other hand, the L.C.N. of a sound length was above 10, and that was why it was standing well under the traffic of an aircraft with L.C.N. 10.

The thickness of the rigid pavement both for the present and future traffic had been worked out. The thickness for flexible pavement had also been worked out, and the choice was left to the

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construction engineer depending upon the economics and facilities available at site.

As the air traffic was fast increasing, more and more of these old runways were likely to be used. In the case of international and major runways, it was not only the frequency of landing, but also the higher intensities of loading due to some of the modern aircrafts, to which the runways would be subjected to. It was, therefore, very necessary that each runway should be checked up for its load-bearing capacity and labelled on the basis of its L.C.N. so that aircrafts of a certain capacity could safely use it.

It was true that the existing runways were being maintained to pull on with traffic, but it was very necessary that such maintenance should be brought on to a certain scientific level.

From the details of the L.C.N. system, it would appear that there were two variables—the load and the contact area. By finding out the failure of a certain pavement with plates of different sizes, a curve could be drawn which could be read off at all combinations of load and contact area. In the case of runways, it had been found that for a contact area of 200—700 sq. in., the failure load/contact area curves had the same general form irrespective of the type of pavement.

It was also suggested that a general form of curve should, however, be possible for contact areas of less than 200 sq. in. In that case, a curve could be developed to accommodate contact areas ranging from that of bullock-cart with different tyre-widths to 3-ton lorries and to even heavier vehicles so as to suit the design for mixed traffic in countries like India.

A number of modifications would have to be made in the existing system, e.g., the limit of repetition of loading might have to be fixed at about a million as against 10,000 for the runway on account of greater frequency of traffic. The permissible limits of settlement for flexible pavement would also have to be increased for lower categories of road. It would, however, require extensive testing work to evolve a curve.

Shri K. K. Nambiar stated that from a review of the Paper it was apparent that the investigations had been done under some limitations of equipment and possibly also of time.

In para 1.1 of the Paper, it had been stated that the original construction was brick concrete pavement of 5 to 6 in. thickness covered with premixed bituminous carpet of ¾ in. thickness.

Experiments had shown that the temperature of a bitumen-covered concrete surface was considerably higher than that of an

unprotected concrete surface, due to the increased absorption caused by the dark colour. Thus the warping of such a slab would be very much greater. That increase in temperature could be offset by increasing the thickness or the bituminous surface, owing to the greater insulation properties of thicker layers. Tests at the Road Research Laboratory in Harmondsworth (U.K.), had shown that for cancelling out the effects of the increased absorption due to dark colour (so that the temperature effects in the concrete might be the same as for a plain unsurfaced slab), the minimum thickness of bituminous surfacing should be about 2 in. It was a matter of speculation to what extent, in the present instance, the increased warping in the concrete, caused by the thin bituminous covering, contributed to the rapid deterioration of the pavement.

In para 2.2, it had been mentioned that despite covering with a 2 to 3-in. carpet, there was a large scale settlement of the slabs within a couple of months. It would be interesting to know whether any attempt had been made to properly treat the cracks by sealing or whether the additional carpet thickness was supposed to provide cover to much cracks. From what was described in the Paper, it was not unlikely that moisture could have found access to the subgrade through the unsealed cracks, weakening it thereby and leading to accelerated settlement of the pavement.

Referring to Section 5 under the heading "Investigation", there was no indication anywhere in the Paper about the ground water conditions. Data regarding ground water level, its variations, etc., were of vital importance in evaluating the performance of a pavement and making recommendations for its improvement. The failure of a pavement could be caused as much by changes in sub-soil water level over the site or change in moisture content of the subgrade soil resulting from broken or ineffective drains, as by general overloading.

From Table 1, it would be seen that the soil in the subgrade was silty sand belonging to Group A-2-4(0) U.S. P.R.A. classification system. Soils of this group generally constituted excellent subgrade material, when properly drained and compacted. They have good compaction characteristics with densities ranging between 1.81 to 1.92 g. per c.c. (i.e., 113 to 120 lb per cu. ft.). Soaked specimens of such a soil, compacted to its maximum density, would have a C.B.R. value between 8 and 30.

The average density of the soil in the field was found to be 1.62 g. per c.c. (or 101 lb per cu. ft.) in the berms and 1.69 g. per c.c. (or 106 lb per cu. ft.) under the pavement, indicating that the compaction of the subgrade was inadequate. Considering that the construction was carried out under conditions of an emergency and at a time when the modern principles of compaction were not widely

known, it would not be surprising, if no special attempts were made then to compact the subgrade. Despite this, it would be observed that the soil had a higher density under the pavement than in the berms. It could be deduced from this that after the pavement had been constructed, some compaction of the subgrade had taken place due to the vibratory and repetitional traffic loads. The non-uniform support for the slab resulting from such compaction could, at least in part, account for the damage caused to the pavement.

In para 6.9.1, reference was made to the number of landings at one single place considered for design of airfield pavement. Usually, the life of the pavement was expressed in terms of coverages, i.e., one coverage resulted when each point in the traffic area was traversed once by a wheel and number of operations for each coverage might vary from about 4 operations of a heavy type aircraft to nearly 25 of a light type aircraft, and usually most airfields were designed for 30,000 to 40,000 coverages. Therefore, the figure of 10,000 to 15,000 landings given in the Paper as a basis for airfield design was extremely low.

It was stated in para 8.1.1 that the load which caused a deflection of 0.2 in. was taken as the failure load. For a rigid pavement, such as the one being investigated, that was not the right criterion. Concrete slabs would fail under load by pronounced cracking at deflections of the order of 0.10 to 0.15 in. The load at which such cracking occurs was the failure load.

The load/deflection curves for concrete pavements would show an abrupt change of slope at cracking. The curves in Figs. 4 and 5 did not exhibit the distinct cracking of the typical rigid pavement failure at 0.10—0.15 in. deflection; on the contrary, they showed that the load/deflection ratios were fairly constant upto a deflection of 0.30 in. That was more in keeping with the behaviour of a flexible than a rigid pavement. It was, therefore, felt that the deformations measured were those of the bituminous surfacing. He would like the Authors to throw more light on this subject.

In para 9.2, the Authors had suggested that proper drainage should be provided to keep the water-table below the capillary fringe. It was not clear what was meant by this as the water-table would always be below the capillary fringe, which was only the zone formed by the rising capillary moisture. Perhaps what the Authors intended to convey was that the capillary frings should not encroach into the subgrade. For this, he would rather suggest that the drainage system should be such as to maintain the water-table at a depth not less than 4 ft below the top of the subgrade.

Referring to Section 11, it was not clear whether the loading test on the subgrade was made beneath the location of the loading

test on the pavement. If this was the procedure followed it was probable that the deflections that occurred were lower than would have been observed, had the subgrade not been preloaded.

In calculating the thickness of concrete pavement in paras 12.3 and 12.4, the value of $E = 5 \times 10^6$ psi and permissible flexural stress of 500 psi at the corner had been assumed. It was not clear as to whether this would be for construction in concrete with brick aggregates or stone aggregates. However, the figure of 500 psi for calculating the flexural stress would correspond to a modulus of rupture of concrete of 750 psi if used on the runways with a factor of safety of 1.5 or 1000 psi if used with a factor of safety of 2 as in the case of runway ends and taxiways. This figure was much too high for normal 1 : 2 : 4 concrete used in the construction of runways.

From para 14.3, it was seen that the C.B.R. of the subgrade soil had been determined as 3, after compacting the soil to a density of 1.55 g. per c.c. (i.e., 97 lb per cu. ft.). It should be remembered that the soil had a density *in situ* of 1.62 g. per c.c. (101 lb per cu. ft.) in the berms and 1.69 g. per c.c. (106 lb per cu. ft.) under the pavement. Therefore, it was not clear why this density of 1.55 g. per c.c. had been chosen for the specimens for C.B.R. test. In present-day practice, for pavement constructions, it was invariably the rule to compact the subgrade to its maximum density. The specimens for the C.B.R. test should, therefore, have been compacted to the maximum density of the soil and not to any arbitrarily chosen value. This would have resulted in a higher value of C.B.R. and a reduced thickness of pavement.

In para 14.4, the Authors had, after careful study, selected a crushed stone base having a C.B.R. of only 80—90 for the pavement. It was surprising that, having drawn so much from the Paper by Maclean and Robinson (Ref. 13), they could have overlooked an important recommendation therein for base materials. It was suggested there that a suitable criterion for base materials used in pavement built to carry wheels exerting high contact pressures (such as in modern aircraft) would be a C.B.R. of 150 per cent under a surfacing 6 in. thick. This requirement of a higher C.B.R. for the base had been emphasised by other authorities as well.

The design for the flexible pavement had been worked out by applying the L.C.N. system to the standard C.B.R. curves. He would point out that in this system the minimum thickness of surfacing contemplated was 5 in., laid in two courses, viz., a 3-in. wearing course and 2 in. base course, as against the 3 in. surfacing provided by the Authors. In fact, the whole calculation was based on that. This base course of the surfacing (as distinct from the base of the pavement) was intended to absorb the irregula-

rities in the top of the base and thus provide smooth riding surface. Such surface was essential for modern runways to give aircraft a good ride at high operating speeds on very hard tyres.

Moreover, because of the high tyre pressures there was need for high stability in the upper layers of the pavement in order to deal with the very high shear stresses. It should be noted that this degree of stability was not attempted or achieved in the case of ordinary highway surfacings.

Thus it would be seen from the foregoing that the flexible pavement designed by the Authors fell short of the minimum requirements. A properly designed pavement with crushed stone base and a high grade bituminous surfacing, 5 in. thick, would cost more than Rs 200 per 100 sq. ft. which was reported to be the cost of a suitable concrete pavement.

It was further felt that it would be unreasonable to scrap the existing pavement altogether. If, instead, a concrete overlay had been designed, even accounting for the very poor condition of the concrete as in the case of the taxiways, a reduction of at least one inch in thickness would have been possible in the new concrete layer, effecting some economy in construction thereby.

Further, he would not advocate a crushed stone base on top of a soil cement sub-base, especially when the required degree of strength and stability can be readily obtained by the use of a soil-cement base itself. Adoption of a soil-cement base would permit a reduction of 30 to 40 per cent in the total thickness of pavement. In the present instance, for example, if a flexible pavement was preferred, he would recommend a pavement comprising a 5-in. thick two course hot-rolled asphalt surfacing and a 7-in. thick soil-cement base, the total thickness being 12 in. as against the 16 in. suggested by the learned Authors. The soil-cement would contain a somewhat higher cement content than 5 per cent (say, 8 to 10 per cent), the exact percentage being chosen so as to give a minimum field strength of:

(i) 250 lb per sq. in. at 7 days, if used for carrying aircraft with tyre pressures not exceeding 100 lb per sq. in., and

(ii) 450 lb per sq. in. at 7 days, if used for carrying aircraft with tyre pressures higher than 100 lb per sq. in.

If a flexible pavement was to be preferred, he would strongly recommend the use of cement in the sub-base and base layers to stabilise the locally occurring or imported soils, for, by adopting cement-treated soils beneath bituminous surfacing, economic and

strong pavements could be built which would have a uniformity of support and a stability not so easily or cheaply obtained with uncemented bases and sub-bases.

In regard to Section 16, page 54, the idea of the Authors to extend the L.C.N. method for road pavement design appeared to be very far-fetched and should not have been included without adequate experience in the application of the principles to actual highway loads. Since the basis of the L.C.N. method was the plate bearing test, which was more cumbersome than other tests like C.B.R., even in U.K. where that method was first evolved, they had not considered this possibility and they followed the C.B.R. method at present.

The suggestion of the Authors to have different permissible settlement for National Highways, Provincial Highways, District Board Roads or Rural Roads did not seem to be very sound, as permissible settlement was better related to traffic intensity rather than the classification of the roads.

Brig. S. K. Bose stated that the Authors had tried to find out the load in failure of a brick concrete pavement used in taxi-tracks and runways of a certain airfield already badly affected by the sulphate action and then tried to find the L.C. number. The taxi-tracks and the runways were of same thickness, i.e., 5½ in., both built according to same specification. Soil samples taken from the taxi-tracks and the runways were classified similar since the strength of the pavement being based on the same thickness of specification are the same. Theoretically, L.C.N. for the taxi tracks and the runways at the time of construction should have been the same. On the other hand, the Authors had found the L.C.N. for the taxi-track of an average value of 4 and that of the runway varying from 11 to 24. There could, therefore, be two possible explanations for this. First, that the strength of concrete and the subgrade was not the same in the taxi-track and in the runway, or the L.C.N. merely gives the extent of deterioration that had taken place in the taxi-track and in the runway because of the sulphate action.

The Authors had taken 12 in. plate bearing test of pavement badly affected by sulphate action. From this, they worked out the load at failure for 18 in. diameter plate because 18 in. was the equivalent area of contact for the total loading. They then gave an L.C.N. value of less than 4 for taxi-track and, therefore, concluded that the pavement failed because the L.C.N. of Dakota was 10 and L.C.N. of taxi-track was 4.

According to the Authors, the pavement was subjected to Dakota load and it stood up for a couple of years. The Authors however, had not mentioned in the Paper when the airfield was

first constructed. Presumably it was constructed some time in 1945. According to the Authors, the first aircraft landed in 1960, i.e., after 15 years of its construction. Naturally, the sulphate action was responsible for the deterioration during these years. The Authors then carried out tests to investigate the causes of failure, but the Authors had not revealed the dates of test carried out by them, it must have been after 1957. It had been stated that they tried to repair the track by putting in a thicker carpet and the lorry traffic caused more damage. And since the L.C.N. of the taxi-track was low, a new pavement was required. The L.C.N. of runway was about 14 according to Table 2 and the Dakota load had been specified. The Authors presumed that the traffic over the runway was just adequate, but the central portion of the runway was strong enough for the existing traffic and the ends on the border line were likely to give way with further rise in the water table. On the other hand, it was stated in para 3.1.2 that either end of the runway, where mostly the take off and landings took place, were badly cracked, some of the cracks being as wide as $\frac{1}{2}$ in. and could allow entry of water to the subgrade. The Authors then stated vide para 8.2.6 that the difference in the L.C.N. at the ends and centre of the runway could be partly attributed to the difference in the degree of saturation of the subgrade. In Table 1, higher saturation values of the subgrade were given and they attributed failure at the ends of the runway to capillary action. The point at issue was that capillary action was bound to be there because according to the Authors there had been cracks as wide as $\frac{1}{4}$ in. to permit water under the surface. Since the Authors did not carry out investigation of subgrade immediately at the time of failure, but had gone there years after, by that time lots of moisture had gone from the top down to subgrade. Any investigation about moisture content carried out so late would not give the condition of the subgrade at the time of failure. The point at issue was why the pavement failed and for that purpose it was necessary to get hold of data at the time of failure. Taking the L.C.N. value years after the pavement had failed, when more water had gone down the subgrade, more sulphate action had taken place, was of no value.

In suggesting the design of the pavement, the Authors had made use of modified Teller and Sutherland formulae. He would like to know the advantage thereof.

Dr. Bh. Subbaraju stated that it appeared that there was confusion of ideas in the minds of the Authors regarding critical deflection to which the concrete slabs had to be loaded in order to assess their L.C.N. It appeared to be their idea that load tests should be carried out on a concrete pavement slab to the limit of 0.2 in. deflection irrespective of failure and to take that load for determining L.C.N. That was at variance with the experience of

the British Engineers who developed this method. Generally, rigid pavements failed by cracking under load much before 0. 2 in. deflection was reached. Keeping this in view, it was considered that in most cases it would be adequate if loading was continued upto 0.2 in. deflection implying that in any case where failure did not occur at 0.2 in. deflection, loading should continue till failure occurred.

Even though the slab cracked earlier, the test should be continued to 0.2 in. deflection, and if cracking did not occur at 0.2 in. deflection the test should be continued till cracking occurred.

That very important aspect of load testing rigid pavements for evaluating their L.C.N. had been ignored by the Authors.

On Fig. 5, page 39, the load at 0.2 in. deformation was obtained by extrapolating the load deformation curve for which experimental values were available for values of deformation below 0. 2 in. It was not correct to extrapolate the curve in the manner it was done as it could not be stated for certain—at what stage a rigid slab would have cracked. The breaking load could be determined only after actual testing and not through extrapolation of a curve with limited data.

On page 54, para 16.1, the Authors had stated that the L.C.N. system was the only system of design which took into consideration the aircrafts of different loads, contact areas and tyre pressure. That was not correct as several other methods took into consideration the above mentioned factors in designing pavements.

Finally, the suggestion of the Authors to extend the LCN system of design to road pavements with bullock-cart and truck traffic did not appear to be rational (see page 54, para 16.1). As could be seen from Fig. 6, page 40, there were limits of application for the average curve of L.C.N. system between contact areas of 200 sq. in. to 700 sq. in. Hence the suggestion to stretch this relationship to so small a contact area of the bullock-cart wheel in the range of 2 to 3 sq. in. seemed to be far fetched and not realistic.

Shri S. Koteswara Rao, referring to para 12.1 of the Paper, pointed out that it was not correct to assume that, at the corner, there would be no stress due to temperature variations. The corners of a pavement were not free to warp, due to subgrade friction and self weight of the pavement in which case the temperature differential between the top and bottom surfaces of the slab, as well as the daily variation in the mean temperature of the slab, were sure to induce stresses. Besides the maximum load stress at the corner occurred at a point considerably away from the corner, depending on the size of the loaded area, modulus of subgrade reaction and the thickness of the pavement; the thicker the pavement, the greater

would be the distance. According to Westergaard, for the corner load case, the maximum stress occurred at a distance $\sqrt[3]{a_1 l}$ from the corner where $a_1 = \sqrt{2}$ the notation given in the Paper. This distance for the case under consideration worked out to 31 in. It was not justified to ignore the temperature stresses at a distance which was more than $2\frac{1}{2}$ ft from the corner.

Secondly, if the Authors considered, that temperature stresses were important only at the centre and edges of the slab, and negligible at the corner, then it would be wrong to say that the corner was the weakest point of the slab, for the combined stresses of load and temperature at the edge would far exceed the load stresses at the corner.

Shri V. V. Subba Rao stated that the Authors seemed to depend completely upon static loading tests for evaluation, thus neglecting the forces that were actually acting on the pavements. In an airfield due to the high speeds mainly dynamic forces would be induced. It had been proved beyond doubt that when the plane started taking off, the major portion of the weight of the vehicle would be taken up by wings, thus reducing the static weight coming on wheels. Also, it was essential for the load to be stationary at a point for at least 60 seconds to induce maximum stresses in the pavement. In the present case, however, the plane would be moving at high speeds on the pavement except at the centre portion of the runway. Hence the failure due to static load did not arise.

Further, when a vehicle moved at a high speed over a pavement, vibrations would be induced in the pavement structure. Those might also cause the failure of pavements.

In the present case, as well as in the case mentioned in Brig. Bose's Paper last year, it was only the end portions of the runway that had failed. The failure pattern of the slabs as shown in the Photos in the Paper indicated that the failure was mainly due to fatigue induced by the heavy vibrations in a runway.

In the investigation, no consideration had been given to the effect of inflation pressure. In the experiments conducted by Whiffin at Road Research Laboratory, London, it had been observed that the stresses in the surface increased considerably with the increase in inflation pressure of the vehicles.

In view of the above factors, he felt that it was better to conduct the evaluation by vibration methods like sustained vibrations rather than solely depending upon static tests.

In this investigation, no consideration had been given to the effect of temperature variation. Photo 5 showed that the failure had occurred very near the corner, indicating that the slab had failed

just under the load, due to shear stresses and not due to high tensile stresses. In some of the tests conducted by him on cretoway slabs under bullock-cart loading, the corner failed just under the load, though the tensile stresses induced were not high. That failure occurred in the morning when the slab corner had warped up. When there was no warping, however, the other corners took even higher loads. That indicated that the failure of corner as shown in the Photo must be due to temperature warping the effect of which had been neglected in the present investigation.

In considering L.C.N. system, the subgrade was considered to be similar to a liquid. The deflection tests on subgrade, however, indicated that the subgrade was behaving like an elastic solid. So, the evaluation ought to have been carried out using Pickett's or Reissner's analysis, also.

He would like the Authors to throw some light on the above factors.

Shri Z. S. Shah stated that the Authors had stressed the effect of sulphate action on cement concrete a little more. He happened to see that airfield and he could say that the deterioration of the concrete was due to salt. The Irrigation and Power Research Institute at Amritsar had carried out various tests on precautions to be taken for salt conditions and it might have been informative if the Authors had included some of the precautions which they had suggested, particularly in the Punjab.

Shri Satinder Singh requested the Authors to clarify as to how dowelled pavements distributed load from one slab to the other and what suitable modification, as referred to by the Authors on page 56, could be adopted for undowelled pavements.

Shri Jagdish Prasad stated that, on page 44 of the Paper, the maximum load per main wheel had been taken as 13,000 lb and L.C.N. as 10 with 60 lb per sq. in. contact pressure. He would like to know whether it was not necessary to add impact allowance to the wheel load of 13,000 lb.

The aircraft struck the runway generally at a speed of about 80—90 miles per hour and the two main wheels did not always strike the runway at the same time. When one wheel struck the runway first, that happened particularly when there was cross wind, the entire load of the aircraft was transmitted at the point of contact of one main wheel. That point should be considered by the Authors.

He would also like to know what horizontal force, if any, would be imparted to the pavement at the time when main wheels

of the aircraft moving at a speed of 80—90 miles per hour came in contact with the pavement; and in case there was such a force, how should it be allowed for in the design of flexible pavement so as to prevent deformation or creep.

Shri P. L. De stated that the classification of the subgrade soil as given in para 5.1.2 was somewhat confusing.

In the unified classification system as given under Reference 1, (i.e., A.S.T.M Tech. Pub. No. 113) there was no group symbol as SF. The symbol of "Sands, poorly graded" in that classification was SP. Now, looking into Table 1 it was found that none of the samples could be classified as either SP or SF as the primary requirement of a soil falling under that group was that the material retained on 200 mesh should be more than 50 per cent. Hence, as per the classification referred to, the samples were mostly ML (inorganic silts and very fine sands).

Again in the Textural Classification as described in Reference 2 (viz., Soil Mechanics for Road Engineers—H.M.S.O., London), there was no class as "silty sands". The samples might probably fall under "silty loam", but in absence of information about the silt and clay contents of the samples these could not be definitely classified according to Textural Classification.

In this connection, he wondered why the Indian Standards Classification and Identification of Soils for General Engineering purposes (IS : 1498—1959) had not been adopted and neither the P.R.A. nor the Casagrande system had been adopted. According to the Indian Standard, most of the samples might be classified as ML and as per P.R.A. A-4.

Coming to para 14.4, the total requirement of 16 in. of flexible pavement thickness had been made up of (i) 8 in. soil-cement with 5 per cent cement, (ii) 5 in. consolidated stone metal and (iii) 3 in. asphalt concrete. As soil-cement was considered as a semi-rigid pavement, a reduction in the thickness by about 25 to 30 per cent was generally recommended. The Authors were requested to say whether this point had been taken into account in the present case.

In the same paragraph, it had been suggested that the subgrade should be dug up to a depth of 9 in. and compacted so as to attain a density of 1.75 gm/c.c. with a view to increase the C.B.R. value. The Authors might indicate whether it would be still necessary to have 16 in. of flexible pavement which had been arrived at on the assumption of 3 per cent C.B.R. value.

The design of rigid pavement had been based on the 'K' values of the subgrade. No provision of a 'sub-base' below the concrete had been suggested. He would like to enquire if the thickness of the concrete could be reduced by the provision of a suitable sub-base.

Shri C. L. N. Iyengar referred to Photo 1 where from it appeared that the deflections had been measured from average of dial gauges set on the plate. According to the standard L.C.N. method, the dial gauges should be set along the bisector of the corner angle, one at the corner and the others at intervals of 9 in. up to 2 ft 6 in. from the edge of the plate. The load at failure was not only measured by the behaviour of the load deflection characteristics of the corner but also by the relative values of the deflection characteristics of the other dial gauges.

In the conclusions while discussing the selection of alternative designs, the Author had given too much weightage to the initial cost of reconstruction. However, in making a decision on this question, particularly with a view to long range solution, other factors would have to be taken into account. For example, just as this airfield had been handed over to the civil authorities at the conclusion of the last war, there had been every likelihood of the same airfield being turned over to the military authorities for operations of military aircrafts in emergency. For this reason and also for the fact that the trends in the new type of aircrafts were more for jet operation than for the piston-engined aircraft, the preference in favour of rigid pavements became very obvious.

Shri N. Mohan Rao mentioned that the L.C.N. method was very useful for evaluating existing airfield pavements as well as for investigating pavement failures. But in his opinion in designing new pavement it did not have any added advantages over other popular methods of design like C.B.R. and Westergaard's method. As a matter of fact, as the Authors had also mentioned for a new design L.C.N. had to be used in conjunction with C.B.R. testing for flexible pavements and Westergaard's analysis for rigid pavements.

It was true that L.C.N. method took into account aircraft load, contact area and tyre pressures. But that was not the only method for taking these factors into consideration. In the case of C.B.R., the original C.B.R. relation had been extended based on theoretical deflection to other tyre pressures. The more general relationship for C.B.R. is:

$$t = \sqrt{P\left(D - \frac{1}{p\pi}\right)}$$

Where t = thickness

P = wheel load

D = constant depending on C.B.R. $= \frac{1}{8.1\,C.B.R.}$

$$\therefore t = \sqrt{P\left(\frac{1}{8.1\,C.B.R.} - \frac{1}{p\pi}\right)}$$

$$\text{Also } t = \sqrt{\frac{P}{8.1\,C.B.R.} - \frac{A}{\pi}}$$

Where A = tyre contact area.

Referring to Table 2 on page 37, the L.C.N. of the broken taxiway was worked out as 4 compared to L.C.N. of 10 for the Dakota. This value would no doubt indicate the existing condition of the taxiway but did not throw any light on the cause of failure of the pavement. All other conditions remaining the same, it could be assumed that the load-carrying capacity of the runway and taxiway had been equal just after construction. The reason for the failure of the taxiway might be greater channelisation of traffic on the taxiway. That meant that a few years back when the taxiway was still serviceable, the failure load on an 18 in. diameter plate would have been of the order of 34,000 lb just as was the case for runway sections 11 and 14.

According to L.C.N. system, a factor of safety of 2 should be allowed for taxiway design. That would bring safe allowable load to 17,000 lb which in turn would correspond to an L.C.N. of 16 or more. Since the L.C.N. for the Dakota was only 10, the investigation if conducted earlier would have indicated that the taxiway had been safe for Dakotas. However, experience had shown it was not.

This brings us to the pertinent question whether the factor of safety of 2 allowed in L.C.N. method was adequate for taxiway design. Though it was too early to jump to any conclusions, that aspect should be kept in mind by all those who might be employing this method for evaluating airfield pavements.

The Authors had pointed out that one of the probable causes of failure of runway ends earlier than middle sections was the greater degree of subgrade saturation at the ends. In his opinion, the cracking was mainly due to increased stresses at the runway ends on account of landing and take off. It was very likely that the excess moisture at the runway end was more a result of failure than a cause.

Referring to the Authors' suggestion of extension of L.C.N. system for evaluation and design of roads in India on account of its mixed traffic, **Shri S. R. Pillai** quoted Norman W. MacLeod, Engineering Consultant to the Goverment of Canada, who had published another report under the title "Economic Flexible Pavement Desing Developed from Canadian Runway Study" in the "Engineering News Record" wherein he had stated as follows:

"1. The contact areas of highways wheel loads vary greatly and this difference is even more pronounced between the tyres of a very small aeroplane and those of the huge aircraft weighing from 100 to 200 tons. It is impracticable to have to measure the supporting values of the subgrade for each of these sizes of contact area when working out design problems involving different wheel loads and tyre pressures.

2. Plate-bearing tests are costly and time consuming and the equipment is cumbersome to move from one project to another. Simple tests like cone-bearing test, Housel Penetrometer test, C.B.R. test and Triaxial Compression test for evaluating the subgrade bearing capacity were correlated with the bearing plate test values and on the basis of these overall averages it had been found that the best relationship occurs for the triaxial test followed in turn by the C.B.R., the cone-bearing and Housel Penetrometer tests. The Triaxial Compression test gives over 96 per cent of the value obtained by the plate-bearing test."

Hence it appeared that L.C.N. system should not be extended for designing roads in India and that the Triaxial Compression test method should be sufficient and economical in designing airfield pavements also.

Dr. H. L. Uppal and **Shri H. S. Bhatia** (Authors) while replying to **Shri K. K. Nambiar,** stated that they agreed with him that the warping stresses in the concrete slabs covered with thin bituminous carpet were higher than those in the uncovered slabs. But the main conclusions of the Authors were that the failure of concrete slabs took place due to inadequate thickness, meaning thereby that the warping and load stresses combined together were greater than what the existing slabs could resist. Even though the same thickness was used both in taxiway and runway, the taxiway gave way earlier because of the poorer supporting power of the subgrade brought about as a result of rise of water table combined with the increased traffic, as compared to the runway.

Replying to Shri Nambiar's enquiry on the sealing of cracks before laying the bituminous carpet, the Authors explained that as a result of verbal discussion with the officials of the C.P.W.D. at site, it was learnt that the cracks were sealed as best as they could, with sand-bitumen mixes before laying the renewal coat of the carpet. In the opinion of the Authors, the cause of the failure of the pavement was due to progressive failure on account of inadequate thickness of the pavement.

Referring to the enquiries made about the position of the water table, the Authors stated that the information had already been given in terms of the degree of saturation. Since the tests were conducted immediately on the recession of monsoon, the subgrade was supposed to be at its worst moisture condition.

The Authors agreed with Shri Nambiar that the type of subgrade soil was such that it was capable of being compacted to a higher density, but they differed from the learned speaker that the non-uniform support of the subgrade was responsible for the damage caused to the pavement, as it would be seen from Table 1 that the dry bulk density *in situ* of the subgrade at different places was fairly uniform and, therefore, there was no reason to believe that the subgrade support was uneven.

Regarding the number of landings at one single place, the Authors invited Shri Nambiar's attention to the Air Ministry's Publication No. 109/59 of the U.K., where the term " 10,000 landings at one single place " had been used. Since the landing was never at one particular place, the width of the landing track increases by 3 to 4 times and, therefore, the total number of passes on that particular track would be about 30,000 to 40,000 as pointed out by Shri Nambiar, but the landings at one particular place still remained at 10,000, as provided in the design.

Regarding the deflection of 0.2 in. as taken for failure load, the attention of the learned speaker was drawn to the Air Ministry's Technical Publication No. 109/59 entitled " Airfield Design and Evaluation " which read, " Test loads are then applied in successive increments of about 5,000 pounds and the deflection measured at each load. The loading is continued until the concrete has deflected at least 0.2 inch. By this time the concrete will usually have cracked." Accordingly the plate was loaded to get a deflection of 0.2 in. of the concrete slab. This did not include deflection within the bituminous course as the same had been removed before test.

Regarding the slope of the curve in Figs. 4 and 5, which related to field strength, it would appear that the tests at the surface and the subgrade gave almost identical results showing thereby that the concrete pavement had been badly cracked and was behaving almost like a flexible pavement. The curves in Fig. 5, however, did not exhibit the same trend as the concrete pavement had some flexural strength, the exact value of which could not be obtained for want of heavy loading required for bringing about the desired deflection. The load settlement curves of subgrade in this case, were, therefore, distinctly different from the pavement.

The Authors stated that in para 9.2, there was a printing mistake and it should read as " the proper drainage be provided to keep the water table low enough to break the capillary influence ".

In so far as the location of the tests was concerned, the Authors stated that the tests on the subgrade and the pavement had been performed at some distance from each other, and not at the same place, to avoid preloading of the subgrade.

Regarding Shri Nambiar's reference to paras 12.3 and 12.4, assuming a flexural strength of 500 lb/sq. in., it was stated that by properly designing the mix, a flexural strength of 500 lb/sq. in. could be easily achieved even with 1 : 2 : 4 mix.

Regarding Shri Nambiar's point about subgrade density, it was pointed out by the Authors that from Table 1, it would appear that the subgrade had as low a dry bulk density as 1.57 to 1.59 gm./c.c. The required thickness had, therefore, been calculated by carrying out the tests at the lowest density which was assumed, after making an allowance on the side of safety to be 1.55 gm./c.c.

Shri Nambiar referred to the Paper by Maclean and Robinson where it was mentioned that the material with a C.B.R. of 150 per cent under 6 in. surfacing was recommended to be used for heavy duty airfield pavement. On page 454, in the last paragraph of the Paper referred to by the speaker, recommendations were made for a contact pressure of 250 lb per sq. in. The contact pressure of 250 lb per sq. in. would no doubt need 6 in. of surfaced carpet, but such high contact pressures were not in any way close to the contact pressures which were likely to come upon the airfield under reference.

The Authors disagreed with the learned speaker and drew his attention to the accelerated traffic tests at Berksdale in U.S.A. where Hansen * had pointed out that the base having a C.B.R. of 80 per cent gave satisfactory performance with bituminous surface of 3 inches when subjected to wheel loads of 50,000 lb and a contact pressure of 80 to 90 lb per sq. in. The loadings on the airfield under discussion were much less than the above loadings (wheel load of 13,000 lb and contact pressure of 60 lb/sq. in.). In fact, the Authors would like to point out that there were many important international airfields constructed with natural gravel (having C.B.R. 80 to 90 per cent) and covered with surface carpet much less than 5 inches. Some of the airfields which were designed for a load of 50,000 lb on a base coat having 80 to 90 C.B.R. are given

* **Hansen R.**—" Service behaviour tests, Berksdale field, Shreveport, La ". Symposium on the development of C.B.R. flexible pavement design methods for airfields. Proc. Amer. Soc. Civ. Engrs., Vol. 75, p. 45.

below:

Location	*Nature of base*	*C. B. R. per cent*	*Surface carpet thinkness in inches*
Washington (U.S.A.)	Gravel	80—90	3
Yarmouth (Canada)	,,	,,	3
Lisbon (Portugal)	Crushed stone	,,	2
Rabat (Morocco)	Gravel	,,	2¼
Albuquerque N. Mexico (U.S.A.)	Caliche	,,	2
Accra (Ghana)	Gravel	,,	3½
Kingston (Jamaica)	,,	,,	3

In addition to the above, there were many airfields in the United Kingdom, where on a bitumen sand base (C.B.R. not more than 80—90 per cent), surface carpets 2-3 in. had been provided. In fact, if a recommendation of 5 in. thick carpet was made for the airfield under discussion, it would have increased the cost unnecessarily.

Regarding stability of upper layers of the pavement, the Authors stated that the modern trend was to use asphaltic concrete as wearing courses in place of the bitumen macadam. By a proper mix design, it was possible to achieve Marshall's stability values of 1,500 pounds and above. This would give the surface stability high enough to stand under severe stresses. In view of the above, the Authors felt that the estimated cost given by them for various specifications was reasonably correct.

Replying to Shri Nambiar on the possibilities of using the existing pavement by providing an overlay, it was pointed out earlier that the subgrade and even the pavement was infested with high concentrations of sulphate, and, therefore, it was not considered advisable to resort to provision of overlay. On the contrary, the Authors were of the opinion, that some capillary cut offs were necessary to resist the upward movement of salt. In the present case where the pavement was badly cracked and settled unevenly, besides having been infested with sulphate, it was considered inadvisable to use the existing pavement even as base course.

Regarding the use of stone base over soil-cement crust, the Authors explained that this was suggested to bring about least changes in the practice of construction to which the present staff was used. The object of providing cement-soil base was to replace

brick soling so that the rest of the construction could be carried out as usual. While proposing a thickness of 8 in. in soil-cement, no allowance in the reduction of thickness on account of its flexural strength had been made as enough proof of its exact flexural strength was not known.

If the cost was to be taken into consideration, it would appear that 5 in. thick rolled asphalt concrete might still work out to be more expensive than the design suggested by the Authors.

Another reason why new techniques were not suggested was that it involved some practical difficulties as most of the contractors were not used to such techniques at present, either for want of machinery or for want of technical personnel and the design might have been found to be impracticable.

Regarding extending the system to roads, it was only a suggestion that was thrown to the learned audience. Since roads in India were subjected to mixed traffic, the existing knowledge of L.C.N. could be favourably extended for designing a particular road so as to take up a heavier intensity of loading for shorter number of passes as in case of bullock-cart, in addition to loadings for bigger number of passes by vehicles with bigger area of contact thereby bringing out a compromise in the design. As already pointed out by the Authors, this required lot of work before it could be put into practical shape.

The Authors agreed with **Brig. S. K. Bose** that the pavements of both taxi-track and runway were built to the same specifications and, therefore, at the time of completion both had the same L.C.N. under similar conditions of subgrade. Since the values of L.C.N. at the time of testing were different, it only showed the amount of deterioration that had taken place in the taxi-track as compared to the runway. It was, however, not possible for the Authors to give the exact amount of traffic that had come upon the runway except that after it was passed on to the Department of Civil Aviation, it had given satisfactory service for some time.

The attention of the speaker was drawn to para 2.2 where the complete history of the airfield had been given. It had been said that after the runway had been in use for a couple of years by the Department of Civil Aviation it started showing signs of distress in 1956, but the actual test was carried out by the Institute only in 1960. The Authors further clarified that the words "badly cracked" were used in a comparative sense with respect to the central portion of the runway. In spite of a number of hair-cracks, it had been giving satisfactory service, which can be attributed to the fact that the subgrade was fairly dry. The Authors further replied that it was true that the end portions were permitting some moisture

from the surface, but the main damage was due to the fact that the water table was permanently higher at the ends as compared to that in the centre. And it was due to this poor supporting power of the subgrade that the comparative inferior behaviour of the ends could be attributed to, besides being subjected to more severe stresses due to impacts at landing.

It was regretted by the Authors that the investigation could not be carried out earlier as the aerodrome was in charge of another organization and the Institute could carry out tests only when asked to do so. The Authors further replied that the formula modified by Teller and Sutherland was used as it was supposed to give better approximation in the field as compared to Westergaard's original formula.

Regarding **Dr. Raju's** objection to the use of 0.2 in. deflection for determining the load-bearing capacity of the concrete pavement, the Authors said that they had already dealt with the same point; while replying to Shri Nambiar. It was correct that the rigid pavement cracked before 0.2 in. deflection but the test was carried to a deflection of 0.2 in., by which time the concrete would have ultimately failed. The loading had, however, to be continued further if it had not failed even at 0.2 in. deflection.

Regarding Dr. Raju's point that it was not correct to extrapolate the curve in the manner in which it had been done in the Paper, the Authors remarked that an extrapolated value of 0.2 in. deflection was obtained as not even hair-cracks appeared upto a deflection of 0.15 in. and the trend of the curve also permitted such an extrapolation.

Replying to Dr. Raju's point regarding the L.C.N. system it was stated by the Authors that the engineers dealing with the construction and maintenance of the airfields were faced with two problems:

(1) to evaluate strength of existing pavement. For this the L.C.N. system had been suggested by the Authors on account of the fact that this was a non-destructive test, since by all other methods, one had to cut a slab out of the existing pavement and then determine its load-bearing capacity;

(2) to design new airfields. The engineers having familiarity with the L.C.N. technique for evaluation, would find it easy to design new pavements also on the basis of the L.C.N. system. The Authors would, however, be naturally interested to know the other systems which according to Dr. Raju, were equally efficient and still simple enough to take into consideration the varying contact area, tyre pressure and loads.

Regarding his remarks about the extension of the system to roads, the question had already been dealt with while replying to Shri Nambiar's points.

The Authors invited **Shri Koteswara Rao's** attention to the I.C.A.O., Doc. 7791-AGA/592 2, Volume II, Aerodromes, Air Routes, and Ground Aids Division, Chapter 6, page VII-41, which dealt with the use of corner case loading for design of concrete pavements. Referring to Shri Rao's remarks that in an edge case warping plus load stresses would need a higher thickness than the one given by corner case loading, the Authors agreed that it was so in the highway pavement where the wheels were supposed to come on the unprotected edge, but the aircraft wheel was not likely to come over the unprotected edge of the pavement and that was why the I.C.A.O. recommended the use of corner case loading for the design of airfield pavements.

Regarding the dynamic testing of the airfield pavement, as suggested by **Shri V. V. S. Rao**, the Authors pointed out that some work had recently been done in France and published by the Shell International, on this aspect. The work seemed to be very interesting but since enough work had not so far been done, it could not be applied without risk. Regarding Shri V. V. S. Rao's point on the effect of warping stresses, the same had been dealt with by the Authors while replying to Shri Koteswara Rao.

The Authors while replying to the point raised by **Shri Z. S. Shah**, stated that the detailed constructional procedure had not been given in the Paper, but the same had been worked out separately and passed on to the Civil Aviation authorities for the construction of a second runway which would be in progress soon. While working out the specification, the work carried out in the Irrigation and Power Research Institute had also been taken notice of and finally it was considered that two coats of primer both on the subgrade as well as on the sides will be effective in checking up the rise of moisture and consequently the sulphate.

Referring to **Shri Satinder Singh's comments**, the Authors pointed out that a dowel was a common element between two slabs to avoid each slab acting independently of the other. When a load came on the edge of a dowelled pavement, it was partially taken up by the adjoining slab, thus not affecting the edge as severely as it would have done, in an undowelled pavement.

For undowelled and unreinforced pavements, 25 per cent increase in the pavement thickness, as arrived from the charts of Pickett and Ray, was usually made.

Replying to **Shri Jagdish Prasad**, the Authors pointed out that no impact factor was considered essential in the design of a runway. In fact, when the aircraft touched the runway, it was still partially airborne and had the minimum quantity of fuel with it. The stresses imposed on the runway were not, therefore, very high. However, to meet any additional stresses the runway ends were given 10 per cent additional thickness.

Referring to **Shri P. L. De's** comments, the Authors agreed that there was a reporting mistake on the classification of the subgrade soil. The soil belonged to 'ML' group in the Unified Soil Classification system.

Regarding the reduction in thickness of the soil-cement pavement due to its rigidity, the Authors stated that the question had already been dealt with while replying to Shri Nambiar's points.

Provision of a strong sub-base did not affect to any material extent the thickness of the concrete pavement.

Replying to **Shri C. L. N. Iyengar**, the Authors stated that only standard procedure was adopted for plate-bearing test, to determine the L.C.N. of the pavement. The Authors could not agree with Shri Iyengar that for all modern jet aircrafts the provision of a rigid pavement was the only solution. In fact, many international air-fields today were built using flexible pavements and these were giving very satisfactory service.

Referring to **Shri Mohan Rao's** comments that the pavement failure could be due to a low factor of safety, the Authors pointed out that this pavement failure was a case of under design and it was made worse due to other factors like the sulphate action, inadequate drainage, etc.

Regarding changing the existing factors of safety of 2, for the taxi-track, the Authors pointed out that the work of that nature could not be done by a couple of observations but required a comprehensive study and as such was not within the scope of the present work.

The Authors could not agree with **Shri S. R. Pillai** that the simplification of tests for the design of the pavement was possible. In fact, this was one reason why tests like cone bearing, Housel's Penetrometer, and, for that matter, even the C.B.R. *in situ* tests did not become very popular. The triaxial test was quite complicated and, therefore, could not be adopted straightaway as Shri Pillai thought.

Shri E. A. Nadirshah (Chairman) in his closing remarks stated that, according to his experience, the layer of metalled pavement should be avoided on the top of a soil stabilised by cement because metalled pavements had their own flexibility and cracks were liable to occur under loading conditions. To make up for the metalled layer, the thickness of stabilised soil could be increased, if necessary.

It should also be considered whether one of the causes of failure was not due to water getting into the base through cracks which developed in the pavement in the early stages.

He agreed with the point raised by Brig. Bose regarding sulphate action. It was a very important point and it required more detailed study and to find out whether the pavement in this particular case had failed due to sulphate action, and if so, what remedy or remedies, the Authors would suggest for preventing failures in pavements in future.

The Authors should also state what precautions one should take to prevent water table rising and affecting adversely the base of the pavement. He also felt that the Authors should have given some more details regarding the causes of failure of the pavement.

The Authors should also throw more light on the design of landing strips taking into consideration the effect of varying speed and loading on the pavement when the aircraft landed or took off.

In the end, he thanked the Authors and various speakers.

Discussion on Paper No. 224*

"A Study in Road Failures"

By

S. N. GUPTA & P. L. DE

Wednesday January 4, 1961

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 the Paper remarked that, in the pre-war days, it had been possible and conventional, too, to wait for sufficient period to allow the newly formed embankment to settle during the monsoons before construction of the pavement had been taken up. But nowadays a bank was seldom allowed to settle properly. The conventional thickness of crust was not increased and the traffic developed far too quickly than had been anticipated. All these three factors combined together in varying degrees hastened a road failure. Other factors for road failures were enumerated in the Paper.

Shri S. N. Sinha stated that the Paper had mainly touched the aspect of failure of the embankment or the subgrade.

There were methods for estimating settlement of natural ground. One such method was given below:

Estimating Settlement of Soft Clay Layer

Assuming:

1. Clay was normally loaded and fairly insensitive.
2. Clay was saturated.
3. $C_c = 0.009\ (Lw - 10)$
4. $Lw = M$ = water content per cent.
5. Soil unit weight in place = 110 p.c.f.

$$S = \text{settlement} = \frac{C_c}{1+e_o} H \log_{10} \frac{P_o + \Delta p}{P_o} = AHB$$

where $$A = \frac{C_c}{1+e_o} = \frac{0.009\ (Lw-10)}{1+e_o} = \frac{0.009\ (M-10)}{1+2.7\ M}$$

and $$B = \log_{10} \frac{P_o + \Delta p}{P_o}$$

*Published at pages 61 to 80 of Volume XXV-Part 1 of the Journal of the Indian Roads Congress, November, 1960.

H = height of clay strata in ft

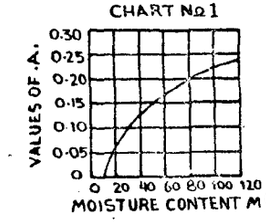
P_o = existing effective overburden pressure at mid-height of clay layer

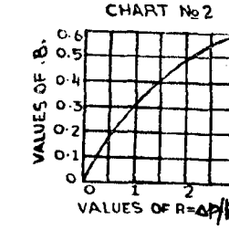
Δp = increase of pressure P

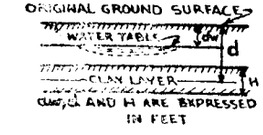
$= P - P_o$

If water table is above clay layer $P_o = 62 d_w + 48 d$.

If water table is below clay layer $P_o = 110 d$.







Coming to remedial measures, Shri Sinha suggested that it was necessary to know the present traffic intensity and the possible increase. Such a survey in every State could provide necessary data for designing the pavements adequately. The second important consideration was to adopt a design method which would be rational and suitable to our conditions even tentatively. These would have to be modified as a result of actual performance of pavement. The third important aspect was the moisture condition below the pavement and in the subgrade since this would affect the design considerably. On the basis of these assumptions, it would be possible to design the pavement, and in case of a highly clayey soil, lime appears to be able to improve the conditions very much. In the case of the soil of the Patna By-pass, the following laboratory results might be of interest:

	C.B.R. value	*O.M.C. per cent*
	3	18
Natural soil with the addition of 1 per cent lime	12.6	26.7
Natural soil with the addition of 2 per cent lime	50.8	25
Natural soil with the addition of 3 per cent lime	60.5	24

The density in each case worked to 1.7 gm. per c.c. The natural soil had a liquid limit of 58.7 and a P.I. value of 32.8.

Referring, therefore, to page 74, Table 3, paras 4.2.7 and 4.2.8 of the Paper, it was not understood why 5 per cent lime was proposed to be added. The thickness could be built up by adding different layers of stabilised soil with lime having different C.B.R. values. This would appear to be a most rational design method. As a matter of fact, it was not necessary to put in a more stronger sub-base or base in contact with the natural soil when the C.B.R. value of that soil was about 3 per cent. He would, therefore, suggest working out a more rational design irrespective whether the soil was stabilised with lime or with cement. The lime and the cement content could increase as the layer moved up.

He emphasised the necessity of adequate drainage and providing as dense a carpet as possible at top in areas where the rainfall was heavy and where the soil conditions were poor. The shoulders must also, if could not be treated cheaply, have a proper slope to drain out the rain water.

Shri N. R. Srinivasan stated that, on page 62, para 2.1, the 6 types of failures listed would be alright if the subgrade was regarded in the usual sense, viz., as the natural foundation. In that case, the types "a", "b", "c", and "d' could be taken to refer to embankments; type "e" to cuttings and type "f" to both. However, if the embankment fill was also considered a subgrade, type "e" failure had no separate existence of its own and got merged with types "c" and "d". Since the Authors had given a distinct place to type "e" failure, it appeared that they hold the view that the natural foundation was the subgrade.

However, the example of subgrade failure in para 7.2 was a case of failure due to settlement of fill material of an embankment, which suggested that they held embankment fill as subgrade. If so, he wondered how they distinguished between types "c" and "d" and type "e" failures.

In the example for shear failure of the natural ground in para 4.1, the failure of a pavement laid over a part of a pond 2 years after construction was attributed to the complete pumping out of water from the adjacent pond by its owner. The downward capillary pull in the soil, it was said, resulted in additional stress on the clayey soil that had been saturated, thus reducing the safety factor. That might be correct; but as it was generally observed in pumping tests that, even with a fairly powerful pumping set, it was rather difficult to lower the water-table to any appreciable extent beyond a distance of a few feet from the pumping point;

the following points should be made clear:

(1) the distance from the embankment to the pond that was pumped out; and

(2) the type of pumping unit employed or the rate of pumping.

Shri K. K. Nambiar referring to section 2, para 2.1 of the Paper, agreed with the Authors that shear failures and excessive settlement were two of the principal sources of difficulty relating to the engineering behaviour of soils. However, many factors tended to confuse the problem. In shear failures, it was rather difficult to estimate the existing stresses, the shearing resistance of the soil and the exact location of the surface upon which shear would occur. The determination of those factors caused most of the difficulty in the accurate estimating of soil-shear behaviour.

As regards settlement, natural soil deposits upon which a fill was placed, will tend to become more compact. In addition, within the fill itself, some added densification could be expected. The latter problem was much simpler of the two to control. The condition of the compacted soil could be specified and excessive densification eliminated. In fact, under good construction practice, little or no settlement within the compacted mass was to be anticipated. Within the natural soil beneath the fill, accurate settlement estimates were not easy to obtain. The principal sources of uncertainty were due to difficulties in determining the extent and uniformity of the in-place soil, stress conditions that existed, and the reaction of saturated soils to the stresses applied.

In regard to the application of soil mechanics as a solution of road problems, he would like to stress the need of adequately trained staff. A wider diffusion of the knowledge of the principles of soil mechanics, therefore, merited the immediate attention of engineers.

Referring to section 4, para 4.1 where Authors had explained the failure of the slope due to capillary pull in the soil below the embankment, he would like to explain that weight of the material and superimposed loads on a slope were the main forces which tended to destroy its stability. The force that resisted this tendency or tried to restore equilibrium was the shearing strength of the material. Now the shearing resistance or resistance to sliding did not depend on whether or not there was water on the outside of the slope, provided water was not permitted to flow out from the sliding wedge. On account of sudden draw down, there was an increase in the weight of the slope material, caused by the loss of

buoyancy, and, therefore, the stability of the slope was suddenly reduced, resulting in the slip.

Referring to para 4.2, Shri Nambiar stated that the embankment in question was only 6 ft high and one would not call this a high embankment. On a study of the test results, in Table 1, he found that the soil in the subgrade was a clay belonging to group A-7-6 of the P.R.A. classification system. It had a high plasticity index and was subject to high volume changes. Soils of this type constitute undesirable subgrades for flexible pavements. The provision of rubble soling over such subgrades was to be particularly deprecated. Entry of moisture through the pavement softened the subgrade and, under the action of traffic, the soft clay intruded into the soling, resulting in damage to the pavement. While building roads on soils of this type, it would be a good practice to provide a 6-in. thick blanketing layer of good quality moorum or other suitable soil, belonging to group A-1 or A-2 of the P.R.A. classification system, over the clay subgrade and then construct the pavement over it.

He did not agree with the Authors that the failure of this road was due to the inadequate compaction of the subgrade. The dry density of the subgrade was 102.5 lb per cu. ft. (Table 1) which means a fairly good degree of compaction for the type of soil used. Further, the road had been under traffic for a number of years, and in the circumstances it was only reasonable to deduce that the subgrade had reached an adequate degree of densification. There was another point which might be borne in mind with regard to soils of this type. If they are overcompacted, they would exhibit considerable swelling. Hence there was a need to limit their compaction requirements in order that the soils may not swell excessively. He felt in the present instance the provision of an impermeable surfacing would have helped in preventing the entry of moisture into the subgrade and thus maintaining its strength and stability.

Coming to the recommendation in para 4.2 3., he stated that it was neither practicable nor sound policy to insist that clay soils should not be used in embankments. From consideration of settlement and stability of the embankment, the only types of soils that should be excluded were those that contained an appreciable amount of organic materials. Whatever soil was used, the embankment should be constructed by spreading the material in relatively thin layers and compacting it to a high density. For poorer soils, the side slopes should be flatter for stability; for example, for A-7 soils, the recommended slopes would be 3 to 1 and 2 to 1, depending on whether the bank was subject to inundation or otherwise.

Ref: Para 4.2.4, Baruipur-Uttarbhag-Canning Road: Here again the pavement was a pervious one laid over a clay

subgrade. Water entered the subgrade through the pervious pavement and softened it; the softened clay then worked up into the pavement, damaging it thereby. The following measures are suitable in such a situation:

(i) provision of an impermeable base such as soil-cement, or

(ii) provision of a porous sub-base which will trap any water passing through the surface, leading to drains constructed under the berms and thus preventing the softening of the subgrade, and

(iii) provision of an impermeable surfacing.

Shri A. A. D. O. P. Saparamado stated that the main cause of damage of Berai Bridge Approach Road, was due to the settlement of the embankment itself. Hence pavement failure could not have been avoided whatever the initial thickness of the pavement might have been. Unless the embankment had reached its equilibrium it was open to doubt whether the remedy suggested by the Authors would be successful as further settlement of the layers below the compacted subgrade would eventually bring about failure in the base. It would have been more desirable and economical to bring the surface to a satisfactory condition and apply the remedy once observations had shown that no further settlement had taken place.

The failure on Baruipur-Uttarbhag-Canning Road, was due to the failure of the subgrade. It appeared that the C.B.R. value of the subgrade soil required a thickness of 14 inches of pavement which would have been alright. The necessity for stabilising the subgrade purely for the purpose of improving the C.B.R. value was not understood. That might be necessary, on account of high cost of base materials in order to reduce the thickness of base course.

For preventing road failures, the Authors had suggested construction of pavements to proper design after adequate investigation. Due to increase in the volume of traffic together with the increasing loads, the existing pavements which were constructed for low volumes of traffic were rapidly deteriorating. It would have been more useful if the Authors had suggested some practical and cheaper methods of arresting road failures with a view to prolonging their life-span till such time as these sections were taken up for reconstruction. Excepting concrete roads where failure involves complete rebuilding, it would sometimes be more economical to deliberately under-design a road at the start and keep on adding further crust as and when deformation took place. This had been mentioned by the Road Research Laboratory, England, in their

Paper "Research and its Application to Road Construction" by Fisher, Lee and Millard.

In Ceylon, it was observed that the main cause of failure in most of the roads was the inadequate thickness of the base course. They adopted the course recommended by the Road Research Laboratory in bringing up several sections by merely adding gravel to the road allowing the traffic to compact the same and putting up more crust as it deformed till stability was attained.

Shri S. Koteswara Rao stated that the Authors in para 5.6 had suggested that a proper design of the pavement thickness consistent with the expected traffic intensity and the worst subgrade condition was the essential prerequisite of a road project. This was perfectly true. But he would like to know which method of design, in the opinion of the Authors, was the proper one. The Authors had used the C.B.R. method of design which predicted failure on the basis of a limiting settlement. It was not known from the Paper whether the Authors in their design had given consideration also to the shear stresses under the pavement which would have caused shear failure of the subgrade, had it been a soil of poor shear strength.

Having considered shear failure as one of the important types of failure of pavements, he would like to know whether the Authors would still recommend C.B.R. method of design alone, without considering the shear stress in the pavement.

Shri T. K. Natarajan stated that, on page 69, a typical case of failure by spreading was given. Unfortunately, no details of the slope of the embankment or the height of the embankment, etc., were given by the Authors. Analyses of case histories tell us that such types of failures do not and cannot occur suddenly, unless there was fairly large layers of sand or silt strata underneath. The difference between the excess pore water pressure and the weight of the earth due to overburden is greater near the toe than elsewhere, and so the shear resistance in the vicinity of the toes of an embankment very often got reduced to zero, and a failure resulted. It was, therefore, very necessary to make a distinction between clay strata containing pervious seams of sand or silt and those without them. It was of course also possible that failure of an embankment could occur even in the absence of pervious seam of sand or silt, but in that case the failure should have been more gradual rather than sudden as has been reported. Some information on this point would have been instructive in this context.

Shri S. Radhakrishnan stated that in para 2, some of the causes for the different types of the road failure had been described. But the distribution of the moisture in the subgrade soils under the

pavement and its adjoining area which play an important role in the stability of the road structure, especially when clayey soils were met with, had not been taken into consideration. Sometimes, wide longitudinal cracks are developed due to the moisture gradient set up and there were many examples of road failure due to the above reason. Hence it was necessary that this aspect should also be studied particularly in determining the mode of entry of moisture into the subgrade—whether the percolation was through the road surface or by other means.

In para 3.1, it had been explained that the shear strength should be determined by conducting either the triaxial or direct shear and that the factor of safety with respect to base failure should not be less than 1.5. But when the investigation of the typical shear failure of a road was explained in para 4.1, no such details were given. It was simply stated that at the time of failure the factor of safety got lowered below unity. In all such failures, the pore-pressure developed was an important criterion and hence it was advantageous if the nature of the examination made and the details of the tests taken up and other stability diagram, etc., were furnished to confirm the mode of failure. Further, in the present case, the failure was due to sudden draw down conditions caused by the pumping of the water from the pond and to avoid such failure the best remedy would be to provide a sand blanket or a gravel filter between the fill and the base. In that case, the water would flow down into the filter and the seepage pressure would act in a downward direction instead of outward and as such the stability of the fill would not be affected. But the suggestion of the Author for driving of piles would not be of any help in preventing such failures.

The failure of the subgrade in para 4.2 on Baruipur-Uttarbhag Road was considered due to inadequate thickness of the pavement. But the examination of the subgrade soils and other aspects showed that the failure might also be due to insufficient drainage provisions. That could also be seen from the higher moisture content of the subgrade soil in the failed sections than the good portions. Generally, in all such clayey embankments, a sand blanket or other filtering medium should be provided to the full width of the road to prevent the water accumulation in the subgrade. Such medium would also prevent the soft clay working up into the base and help to prevent the disturbance of the subgrade by traffic.

Shri S. B. P. Sinha wanted the Authors to clarify whether the use of vertical and horizontal sand drains had been tried and whether digging borrow pits close to road embankments was prohibited in West Bengal.

He suggested the use of machinery for compaction of high embankments and approaches to bridges, and checking of pore-pressure during construction of such embankments. He also suggested provision and maintenance of stabilised flanks for proper protection of the subgrade below pavement.

Shri M. C. Johorey stated he had some experience of road failures particularly of miles 870 to 840 (Bulandshahr city to Ghaziabad) which showed signs of distress since 1955, but during the heavy floods of 1958 this road started sinking badly and necessary measures had to be taken to improve the surface. But he would like to point out that the advanced stage of road failure can easily be detected but the Authors should point out ways and means as to how failure in preliminary stages could be detected.

Shri S. R. Pillai stated that in every embankment there would be cross drainage works and at the joint between the masonry and the fill in the embankment, water would find its way and cause failure of the embankment. To avoid this, the masonry inner face should be made sloping. Even vertical steppings in masonry were not recommended as water would creep through the vertical faces causing failure. The other point was about the surface drainage; if water flowed along the sides of road, embankment slope would be scoured. Therefore, it was recommended that there should be berms along the road to lead the drainage water to the masonry slope drains to be provided along the slopes of the embankment.

Shri B. G. Naik stated that the data tabulated in this Paper lacked the following information which, he felt, was quite essential to ascertain the causes of failure:

(1) data of construction of the embankment,

(2) height of embankment,

(3) the nature and intensity of traffic on the road.

In para 4.1, shear failure of natural ground was described. The road had been constructed only two years back and there had been a sudden settlement of four feet. The height of embankment was not recorded and how exactly the shear failure in the natural ground had been observed was not understood. He wondered if the failure had been due to the pumping of water from the pond only. Since half of the road was originally a part of the pond, it was very likely that that might be a case of simple settlement of embankment which had probably not been constructed in layers under moisture control.

In Appendix 2, the Authors had given some very useful data of Grand Trunk Road both for damaged and undamaged sections. He

was of the view that data collected on those lines of old roads would be of more utility in ascertaining the real causes of failure and arriving at more practical and sound pavement designs, than the study of failures of new roads which were primarily due to poor compaction of embankments aided by inadequate pavement thickness.

As regards the other suggestion of the Authors, he would refer to para 5.3 wherein the compaction of embankment with specified moisture content and specified density was only necessary in cases of embankments 15 ft or more in height. For normal road embankments, between 2 to 3 ft, it was neither practicable nor necessary to adopt these measures as the construction of roads was spread over miles and was not a concentrated job like the dam embankments. All that was necessary, therefore, as stated by the Authors in para 5.4, was to lay the embankment in layers and compact it in the conventional way.

In this connection he drew the attention of the members to the subject of Proof Rolling of subgrades which had been described in a recent issue of the 'World Construction'. This was a significant development in the United States, which required the test rolling of the earth subgrade prior to acceptance as a support for the pavement. Several State Highway Departments had adopted this practice. Adding little to the cost, it had greatly improved the completeness of quality control as compared to the field laboratory control of samples only. This testing covered almost every foot of the subgrade, in the construction of which the usual construction specification pertaining to embankment and subgrade construction had been fully complied with.

Shri Satinder Singh stated that in para 2.1.5, the Authors had described the failure of subgrade on account of the combined effect of wheel load and the weight of the pavement. He would request the Authors to survey the action of the fast moving traffic on the subgrade as, in his opinion the fast moving traffic was much more responsible for the failure of the subgrade in comparison to slow moving traffic.

Shri D. C. Chaturvedi* stated that in para 4.2.2, the dry density of the soil (102.5 lb per cu. ft.) was lower than the desired dry density of 105 lb per cu. ft. He would like to know whether that small difference in dry density would lead to subgrade failure.

In para 5.3, the importance of compaction of earth in embankments had been stressed. In Agra-Mathura section of National

Highway No. 2, mechanical compaction of approaches of over-bridges had been done by use of a 1-ton roller driven by tractor or bullocks. The number of passes of that roller required to give desired density had been determined by trials. That was a simple method of achieving satisfactory compaction.

The limits of consistency of highly clayey soils which should be avoided for high embankments might be given by Authors.

In para 5.6 (iv), provision of impermeable thin film (alkathene film) had been recommended to keep off the water from the sub-grade. The Authors should indicate if this had been used by them and found satisfactory. The thickness (gauge) of sheet and pre-cautions necessary should also be stated.

Shri S. N. Gupta and P.L. De (Authors) in their reply to the comments stated that **Shri S. N. Sinha** had suggested an alterna-tive method for the estimation of settlement of natural ground. This method was generally adopted for evaluating the settlement of building foundations and might also be adopted for settlement of roads. However, the method suggested in the Paper was simpler and based on the same principles.

Shri Sinha had asked as to why 5 per cent of lime had been recommended when lesser percentages of lime might be sufficient to develop adequate C.B.R. value in the soil. In the laboratory tests adequate C. B. R. values were obtained by the use of only 2 to 3 per cent of lime but as several uncertainties were involved in actual construction, e.g., insufficient mixing, unknown quality of the lime, etc., and above all, as it was the first of its type of work to be executed, a little higher percentage of lime was recommended to be on the safer side. If the initial experiments failed, lot of discourage-ment would grow in the minds of field engineers. In later works, they had actually recommended lesser percentages of lime. The Authors agreed with the other suggestions made by Shri Sinha.

In reply to **Shri N. R. Srinivasan's** comments, the Authors mentioned that the type of failure under (e), viz., "subgrade failure" was distinctly different from the types of failures of the embankment. In the example under para 4.2.1, the road failure was due to the combined failure of the subgrade and of the embankment and hence there seemed to be no objection in describing it under "subgrade failure". In fact, the remedy suggested in this case was the improvement of the subgrade only.

As regards the questions raised on para 4.1, the Authors stated that there was practically no distance between the pond and the road and, in fact, a portion of the road was built on the pond itself and this was the portion which failed. The type of the pumping unit used or the rate of pumping could not be ascertained.

While replying to **Shri K. K. Nambiar**, the Authors appre-ciated additional information offered by Shri Nambiar in respect of paras 2.1 and 4.1.

Regarding comments about para 4.2.1, the Authors explained that the failure was due to the combined effect of subgrade and embankment failure. The density of the embankment was lower than the desired density and much lower than the 'maximum attainable density'. If the embankment was compacted upto the "desired density" (105 lb per cu. ft.) it still remained lower than the 'maximum attainable density' and the apprehension of over-compaction, as mentioned by Shri Nambiar, was ruled out. This portion of the road embankment was new and not under traffic for many years as thought by Shri Nambiar.

Regarding comments on para 4.2.4, the remedial measures suggested by Shri Nambiar might not be fool-proof, because water entered into the subgrade not only from the surface but more so from the water-table below by capillary rise.

In reply to **Shri A. A. D. O. P. Saparamado's** comments on the failure of Berai Bridge Approach Road, the Authors stated that though the settlement of the embankment had contributed to the failure, the remedial measures suggested were expected to be successful as the embankment would get naturally consolidated and stabilised with lime and further risk of failure due to settlement of embankment would not be there.

In the damaged portions of Baruipur-Uttarbhag-Canning Road stabilisation of the subgrade with lime to improve the C.B.R. value had been suggested as the provision of 14 inches thick pavement would be costlier, the cost of conventional road materials being very high in this region.

There was no denying the fact that it was not economically possible to reconstruct all the existing roads with proper design, but the Authors would recommend that proper design principles should be applied while designing new roads and improving existing ones.

In reply to **Shri S. Koteswara Rao's** comments, the Authors would like to say that the C.B.R. test conducted on the subgrade soil took care of the shear failure of the subgrade. As regards the shear failure of the embankment, however, proper embankment design had to be made considering the shear strength of the material and the effective stresses.

In reply to **Shri T. K. Natarajan's** comments, the Authors stated that no pervious layer of sand or silt existed within the zone of failures.

Shri S. Radhakrishnan had suggested the inclusion of moisture distribution in the subgrade as a cause of failure in the list in para 2. In fact, the moisture distribution might affect all the types of failures listed and as such it was considered in the Paper.

It was not clear how the provision of a sand blanket between the fill and the base could prevent the failure described in para 4.1. The failure was not due to excess of water in the base course.

The failure of the road described under para 4.2.4 was a subgrade failure and insufficient drainage was one of the causes of weakening the subgrade. As the area itself was low lying, subjected to inundation during rainy seasons, the provision of better drainage was neither easy nor economical.

In reply to **Shri S. B. P. Sinha's** query, the Authors stated that vertical and horizontal sand drains had not been tried in West Bengal. Digging of borrowpits on sides for making road embankments was not prohibited in West Bengal but a minimum distance between the toe of embankment and edge of borrowpit was prescribed. Regarding Shri Sinha's other suggestion on use of machinery for compaction of high embankments and on stabilised shoulders, the Authors pointed out that these were acceptable and were already covered by para 5, page 75 of the Paper.

In reply to **Shri M. C. Johorey's** comments, the Authors pointed out that a closer and more frequent inspection of roads would help in detecting road failures in the preliminary stages.

The Authors accepted **Shri S. R. Pillai's** suggestions as worthy of consideration.

Shri B. G. Naik thought that the failure of the road described under para 4.1 might be a case of simple settlement of embankment and not a shear failure. This, however, was apparently ruled out as a settlement of 4 ft could not take place overnight unless there was a sudden shear failure.

In cases where the subgrade was improved by stabilisation, the principle of design was such that the total thickness of the pavement plus the stabilised layer should be adequate as required by the C.B.R. value of the natural subgrade and the thickness of the pavement itself should also be adequate as required by the C.B.R. value of the stabilised layer.

The suggestion for 'proof rolling' the subgrade as adopted in U.S. deserved attention.

Shri Satinder Singh's opinion regarding greater damage caused by fast moving traffic was correct as, in addition to the weight of the vehicle, the impact also came into play. A survey of the action of fast moving traffic was worth undertaking.

In reply to **Shri D. C. Chaturvedi's** comments, the Authors stated that even a difference of 2.5 pounds per cu. ft. density in a high embankment might contribute to the settlement of the embankment as the difference between the loosest density and desired density was about 29 lb per cu. ft. (105–76) and 2.5 lb per cu. ft. was about 9 per cent of it.

The limits of consistency of highly clayey soils which should be avoided for high embankments were already given by the Authors in their previous Paper—vide para 4.1.1 of Paper No. 213 entitled "Some Studies in Soil Mechanics as applied to Roads in West Bengal" published in Vol. XXIV-Part 1 of I.R.C. Journal.

The Authors further stated that the use of thin alkathene film to keep off the water from the subgrade had not yet been tried in the field but there was a proposal to try this on a road near Calcutta.

Shri S. R. Mehra (Chairman), winding up the discussion, thanked the Authors for presenting a good Paper. He also thanked the various speakers who took keen interest in the discussion and brought out several useful points.

Discussion on Paper No. 225*

"Stresses in the Corner Region of Thin Bonded Concrete Road Slabs"

By

S. KOTESWARA RAO & VENKATASUBRAMANIAN

Thursday, January 5, 1961.

Shri K. K. Nambiar (Chairman) called upon **Shri S. Koteswara Rao** to introduce his Paper for discussion.

Shri S. Koteswara Rao (Joint Author) in his introductory remarks stated that the object of the Paper was to evaluate the stresses in concrete road slabs laid over water-bound macadam bases.

For this purpose, a 4-in. thick concrete road slab of 33 ft × 12 ft in area was laid over a water-bound macadam base constructed as per usual specifications. Stresses due to applied static loads were measured and temperature stresses were evaluated for this slab. The temperature stresses had been reported in a separate Paper. Only the load stresses were discussed here.

It was felt that the worst stress situation would occur at the corner of the pavement, when loads were applied there. So the corners of the pavement were loaded uniformly over a circular area, the strains on the surface of the slab were measured at various points on lines radiating from the corner and deflections measured in the corner region. Use was made of these deflections in the Westergaard's formula to find out the modulus of subgrade reaction. Plate-bearing test was also conducted on the base course, i.e., the water-bound macadam, to obtain the modulus of subgrade reaction.

The corner stresses in the slab were calculated by Westergaard's formula, Spangler's formula and Goldbeck's formula and these stress values were compared with the stresses obtained from strain measurements.

The conclusions arrived at were: (1) The value of the modulus of subgrade reaction 'K' calculated using Westergaard's formula from measured deflections was not the same under all points in the corner area. So the fundamental assumption for the

* Published at pages 149 to 162 of Vol. XXV-Part 2 of the Journal of the Indian Roads Congress, December 1960.

Westergaard's corner load formula, namely, that the subgrade reaction was equal to KZ, i.e., the modulus of subgrade reaction deflection, did not seem to be valid. (2) The measured stresses were in between Spangler's minimum probable stresses and maximum probable stresses and were nearer to the minimum probable stresses. That showed that Spangler's maximum probable stress which was 53 per cent more than the minimum probable stress overestimated the stress value. (3) The maximum measured stress compared very favourably with the maximum stress by Westergaard's corner load formula. (4) Goldbeck's corner stress formula gave a value of stress which was more than twice the measured maximum stress. That indicated that the main assumption involved in arriving at the formula, namely, the corner being entirely unsupported by the subgrade or base, was not correct at least in the case of bonded concrete slabs. (5) When the corners were loaded to failure, it was observed that in the vicinity of the corner bisectors, the crack was more or less straight and at right angles to the corner bisectors thereby satisfying Westergaard's assumption.

That observation, along with the close agreement between the measured maximum stress and Westergaard's maximum stress showed that to estimate the maximum load stress in the thin bonded concrete road slab, Westergaard's corner load formula was sufficiently accurate.

Shri R. P. Sikka stated that the Authors had conducted a very interesting study and it would be worth while extending it further to study the stresses with edge loading and the corner stresses when the adjoining slabs were connected by means of load transference devices such as dowel bars.

The Authors had referred in para. 2.1 of Paper to the bonding of slab with the underlying water-bound macadam by means of spreading a rich cement slurry over the cleaned base before laying the concrete. And on that basis, they had pronounced some judgment notably in paras 2.9 and 2.10. Now the extent and effect of this bonding was not clear to him. The bonding of a concrete slab with an underlying rigid pavement could well be understood; but the bonding of the slab to a flexible base was rather beyond comprehension. Moreover, if the said bonding did actually occur, then it should have added to the structural strength of the slab, with the result that actual stresses observed should not have tallied only with 4 in. thickness of the slab but rather with greater thickness, say, 5 in. or more, depending on the extent of bonding. Since the values of stresses calculated in para 2.8 did not show an increase by way of any bonding, it could only be concluded that in actual behaviour the effect of bonding was not reflected, and that it would be dangerous to make any presumptions to that effect.

In para 2.4, the Authors had remarked on page 152 that the fundamental assumption for Westergaard's corner load formula was not fulfilled in actual practice. It was well understood that there was variation in support due to the working of slab, and for that very reason Westergaard modified his original formula for interior loading to allow for the reaction of the subgrade under and immediately around the load being greater than if the reaction was assumed to be proportional to the deflection. For the corner loading also, similar modifications were effected separately to the Westergaard's formula by the Bureau of Public Roads, Mr. Pickett, and M/s. Teller and Sutherland. This naturally posed the question as to why any of these rational formulae were not used in preference to the Westergaard's formula, to calculate the stresses in para 2.8. Perhaps the Authors could throw light on this point. Anyway, it would be of interest if values of stresses calculated according to these formulae were also included in the Paper in order to indicate as to which formula was more close to Indian conditions.

In his opinion, the Authors had rather harshly condemned the Goldbeck's formula in paras 2.9 and 2.10. It was evident that as long as the corner of the slab remained supported, the stresses caused in the slab by any load would be considerably less than when the slab became unsupported at the edge due to warping, etc., and thus behaved as a cantilever. Now just because the slab had remained supported in the isolated case reported in the Paper, it did not mean that such a condition would occur in actual practice too. If the slab were subjected to actual traffic conditions, then due to pumping or other reasons, the slab might possibly have lost the support of subgrade and then the stresses would definitely be true according to Goldbeck's formula. Contrary to what had been stated by the Authors, the bonding of the slab had nothing to do with this phenomenon. Even if the slab was bonded to the underlying base, such a thing might actually happen in field. In this connection he did not understand how the Authors expected a stress of 1035 p.s.i. to actually occur when the maximum stress of concrete was only 490 p.s.i. The pavement must always fail at a stress of 490 p.s.i. but when the conditions satisfied Goldbeck's formula, then the failure would occur with a much lesser load than in the present case.

Another point which was not clear was, why the slab was laid over such a thick base comprising 6 in. soling and 4 in. water-bound macadam. It was well-known that the thickness of the base did not add to the structural strength of the slab, and that the base was used only either to form a working surface in wet weather or to prevent mud pumping on clays and silts. Such necessity did not seem to be there because the subgrade was stated to be silty sand

Nevertheless, his main point was that if the slab was laid only on 4 in. of base, then also it would behave in the same way.

He would also like to be informed about the diameter of the plate used to determine the '*k*' value.

Shri V. Venkata Subba Rao stated that the Authors had not assessed the surface contact area for the load properly. In 1945, Paxson, during his experiments on the variation in contact area due to variation in load, had observed that when the load was increased more than 4,000 lb, or over when the load was near 4,000 lb, the contact area tended to be elliptical. In some of the tests conducted by Road Research Laboratory (London) also, it was recognized that even when the load was as small as 1,000 lb, the contact area would be elliptical. In the corner region, when the contact area was elliptical, the load would not be symmetrically distributed about the corner bisector. Hence the behaviour of the corner would not be same as when the load was distributed over a circular area.

In para 2.7 on page 159, the Authors had concluded that locus of the maximum strain was similar to the corner break and they had given that corner break was just between the circular arc and a line perpendicular to the corner bisector and, therefore, the locus of the maximum strain was also the same. But in para 2.6 they had given that the maximum strain around the corner bisector did not coincide with the point where the corner failed. So, he did not know how they had assumed that the maximum locus was the same as the corner failure. He thought that as they could not get a smaller strain gauge they were not able to measure the strains between the load and 18 in. distance. Thus they had not been able to find out the locus of the maximum strain throughout the area. In some of the experiments he had conducted, which were for a 3 to 4 in. slabs, 2 ft wide, with a bullock cart loading of 1 in. diameter area and a load up to 2,000 lb, the locus of the maximum strain was a circular arc of 6 in. radius which was quite agreeing with Spangler assumption. Further, Spangler's formula for the maximum stress had assumed a circular arc as the locus of the maximum strain. The Authors had stated that their observed values were very near the minimum stress calculated according to Spangler's formula. The Spangler formula for maximum stress was for the condition when the slab had warped up and the minimum stress was when the slab had warped down. In this Paper, nowhere the temperature condition and the amount of warp or any other information was mentioned. So, it was not possible to know whether the slab had warped up or whether warping was only less. He felt that the slab had probably warped a bit down but not fully and that was why their results were very near the Spangler's minimum stress.

Some more work was necessary to find out the variation in the stress when the contact area varied. The Authors also should have discussed Pickett's formula which was supposed to be nearer to actual practice.

Shri G. C. Gupta stated that thin bonded slabs had so far been commonly laid in several parts of the country because of their economic advantage. There was no rational method of design of such slabs and specifications were adopted more by experience. A rational approach to the problem by the Authors was an important step towards analysing thin slabs.

Referring to paras 2—6 of the Paper, he stated that curves had been drawn to correlate strains and distance from corner of slabs. Strains had been observed only at 3 points, i.e., 18 in., 27 in. and 36 in. from the corner. Curves had been drawn through these 3 points and had been shown to have their maxima outside this range. Study of 3 points was obviously insufficient to draw any curve and he would request the Authors to indicate the considerations from which they inferred that the maxima would be in between 16.5 and 18.5 inches from the corner.

Later, in same para, iso-strain diagrams had been drawn in Fig. 7. The locus of maximum strain was a curved line whereas in Westergaard's analysis, maximum strain was assumed to occur along a line normal to the corner bisector. The actual failure was somewhere in between the straight line and the curved line given by strain diagrams. He would like the Authors to explain this anomaly.

The modulus of subgrade reaction had been observed to be 1,120 lb per sq. in. in dry conditions. Deflection studies gave figures of 225 and 425 lb per cu. in. The experimental determination done 9 months later outside the slab gave a figure of 405 lb per sq. in. There was a wide difference in between these observations and in order to arrive at any conclusion it would have been better if the Authors had conducted tests for subgrade reaction immediately after conducting deflection studies.

Shri P. J. Rao stated that, in the study conducted, subgrade modulus 'k' was one of the important variables. As pointed out in the study, it was allowed to be a variable modulus of subgrade reaction which varied with the moisture content of the soil. So, when the Authors conducted the tests on the subgrade, it was 1,120 lb per cu. in., but at the time of testing the concrete slab, it was much less. As mentioned by the previous speaker, there was some discrepancy in it. He believed that could have been avoided by trying to control the moisture content of the subgrade by covering

it up from below with a plastic bituminous surfacing, or alkathene cloth. That would keep the moisture content fairly controlled and give the value desired by the Authors.

He would also like to mention that in para 2.4, page 151, the Authors should have given the gauge length of the strain gauge.

Brig. S. K. Bose stated that although the Author in his opening remarks mentioned that the results tallied favourably with Westergaard, a careful reading of the Paper showed that it was not so. The measured stress tested did not tally with the computed stress by Spangler formula also. It was so because both Spangler and Westergaard had assumptions which were basically different from the experimental slab.

Elaborating his point, Brig. Bose stated that the entire concept of a rigid pavement was based on the flexural strengths of concrete and the subgrade. The value of 'l', the radius of relative stiffness, was an important factor. The concept was based on the supposition that a uniformly rigid pavement was supported on an elastic foundation.

The relationship of the modulus of elasticity of concrete and subgrade played a very important part in determining whether a rigid concrete pavement or a flexible pavement should be built. The flexible pavement was built because it had no flexural strength. Now, where the subgrade was strong and the 'K' value of the subgrade was high, the best design of a pavement was flexible; but where the 'K' value was low, the answer was rigid pavement.

The Authors for their experiments adopted a slab of 4 in. thickness over a flexible pavement consisting of 6 in. soling and 4 in. macadam. They justified this action by calling the slab a thin slab which was bonded to the macadam course by a cement slurry. It was difficult to understand the aim of this slab. Was it intended that those so-called thin slabs should work as a carpet, say, a concrete carpet instead of a bituminous carpet, for providing smooth riding quality and taking the wear and tear better? If so, why a 4-in. thickness? If no use was to be made of its flexural strength, even a thinner slab would have done and it would have been a very interesting study to find out what was the minimum thickness required to give a good riding surface and to take the wear and tear. It has become a common practice to lay under concrete slabs, stone and even dry macadam as a measure of extra precaution. He had shown in his Paper* that the base course

* Paper No 179 published at pp. 499 to 549 of Vol. XIX-3 of the Journal of the I.R.C.

under a rigid pavement was redundant. Concrete Association of America had also stated that a base course under a rigid pavement was useless unless there were conditions of frost action where the laying of a base course could be justified.

Dr. C. K. Ramesh stated that under para 2.2, mention was made of temperatures and diurnal variations of the slab at different depths. He would like the Authors to throw some light on this aspect of the temperature variation.

Under para 2.4, the Authors had stated that the modulus of subgrade reaction did not remain constant vitiating the fundamental assumption of Westergaard's corner load formula. Later on, they had stated on page 161, para 2.8, that the maximum stress calculated according to Westergaard's formula was $\sigma_c = \frac{3p}{h^2}\left[1 - \left(\frac{a_1}{l}\right)^{0.6}\right]$ and that the maximum stress of 480 lb tallied with 491 lb computed maximum stress at a distance of 18 in. from the corner. It seemed to him that the two things were not quite compatible and he would like the Authors to throw some light on this point.

Some of the other objections on the strain measurements had already been referred to by other speakers. He only wished to say that having had some experience of strain measurements, especially by the demac gauge, over 18 in. gauge length, the computation of stresses from strains was not quite reliable. It would have been quite interesting if the Authors on the other hand had taken an 8-in. gauge and used the same instrument over every inch centre and plotted out strain data more reliably and given the actual variation of the strain at 18 in., 27 in. and 36 in. as given in Table 2. He did try to make out from Table 2 at every load the variation of the strain at several defined distances, and he was sorry to find that he was really not able to get any definite evidence with regard to strain distribution. Therefore, to compute stresses on this questionable strain data and then say that the computed stresses in Table 3 were somewhere between Spangler's minimum and maximum stresses and that they tallied with Westergaard's stress, was not a logical conclusion.

The other point on which he wanted the Authors to throw some light was how exactly the line of demarcation between a thick slab and a thin slab should be drawn. He would further like to know how the Authors thought that a 4-in. slab was a thin slab.

Further, in Table 2, it was found that for 1,100 lb, the strain at 18 in. was about 32 and for 2,200 lb nearly twice, and that at 18 in.

more or less a linear distribution of strain with a little variation right upto the failure existed. But at 27 in. the linearity was not quite apparent, and more so at 36 in. He was not quite clear on that point. He should have expected the same linearity of the strain distribution at 18 in., 27 in. and at 36 in. upto a certain load, say, upto 44,000 lb or minimum 33,000 lb. The distribution which was normally expected in such conditions was not being obtained.

The other conclusion that had been drawn, purely from an approximate pattern of the failure of the slab, was the iso-strain diagram of the corner bisector which was very misleading. The fundamental value of the Paper was lost inasmuch as the Authors had not been able to explain theoretically why the basic assumptions of Westergaard's formula had not been answered. It would have been quite interesting if some more probe had been made and certain explanations offered.

Shri G. C. Khanna referred to the statement made by Brig. Bose wherein he had stated that the concrete slabs should not have been laid on a water-bound macadam. The practical experience of road engineers was that concrete slabs had been laid successfully and had been standing traffic on roads in U.P. and other parts of the country. After all, the base did add to the strength and distributed the load. But he (Brig. Bose) would recommend only the laying of the flexible pavement over a water-bound macadam. The matter, however, required investigation.

Brig. S. K. Bose again stated that it was a national waste to have soling and macadam under the concrete. In his Paper published in the Indian Roads Congress Journal he had shown that by the introduction of a base course under a concrete pavement, the reduction of the stresses on the subgrade was 2.4 per cent only.

Shri K. K. Nambiar stated that the modification on the corner case of loading in the Westergaard's formulae after experiments conducted by M/s. Teller and Sutherland at Arlington had not been taken into account. That modification would allow for the upward curling of the corners during the cool hours of the night, which condition of the slab would be more critical without load. The second omission was the reference to the modifications developed by Prof. Pickett to correct certain inconsistencies in the stress values calculated by the Westergaard's formulae for thin slabs resting on hard bases. It was found that Westergaard's formulae gave lowest stress for thinner slabs under those conditions which were rather irrational.

The Authors had not provided information on the time of loading. Since high values of loads at failure were obtained when the corners were bent downwards, as during the hot hours of the day, a check on that point would have resulted in a lower load-carrying capacity if the test was done at more unfavourable times.

The calculation of 'K' value at different points in the slab on the basis of average intensity of loading was not correct. Actually, if some pressure cells had been built into the pavement at desired points of measurement, it would have given a more realistic picture of deflection of the slab under actual pressure intensities developed.

Lastly, in the computation of the factor l, radius of relative stiffness which was a function of Poisson's ratio of concrete, no mention was made as to what value of Poisson's ratio was assumed for this work. The value assumed had to be varied depending upon the mode of application of the load. For slowly applied loads, the value was lower, whereas for impulsive loading, it was high.

Without being over critical on the value of the work done by the young Authors, he would only like to stress once again that it would be much better if studies incorporating as many of the practical aspects than just one should be made, and results brought before this Congress if useful purpose was to be served from the study and discussion of such work.

Shri D. C. Chaturvedi* stated that, in para 2.1, it had been mentioned that the subgrade modulus of the prepared subgrade was 1,120 lb per cu. in. which represented the best summer condition of the subgrade. However, the 'k' value of the base course determined in October, 1959, gave a value of 405 lb per cu. in. That difference in values of subgrade and base course gave rise to some doubt about the accuracy of results. That was further evident from the results of 'k' value, calculated from deflection measurements taken in January, 1960, when the moisture condition would be favourable than in October but the average value obtained then was less than the value of Plate test done in October. When the measurements of 'k' value had been done in different seasons, it was better to determine moisture contents of the subgrade during those seasons and value of 'k' adjusted for worst moisture conditions by consolidation test on soil samples.

In para 2.10, the warping stresses of the slab had been compared to load stresses. That might not be true as repetition of loads

* Comments received in writing.

caused deformation not only of concrete slab but also of the subgrade which might not be affected by repetition of warping stresses and hence it was not very correct to make such assumptions. He would, therefore, suggest that the study should be made taking this aspect into consideration.

It would also be desirable to see the effect of load on the strain and stress characteristics after the bond of the concrete slab had been broken with the base course as would happen after some time due to expansion and contraction of slab. Many thin slabs bonded to the water-bound macadam behaved satisfactorily at the initial stage but subsequently failed. That might be partly due to heavier loads and greater intensity of traffic but, in his opinion, it was also partly due to loss of bond between the concrete slab and base course which modified the pattern of stresses. The difference in behaviour of bonded slab and unbonded slab should, therefore, be investigated.

Shri S. Koteswara Rao (Joint Author) in his reply to comments stated that, as mentioned in the Paper, it was not his idea to suggest whether a thin concrete road slab should be laid or not. But thin concrete slabs were being laid on water-bound macadam and the Authors carried out a study in order to suggest the best solution for it.

Regarding **Shri R. P. Sikka's** suggestion for studying edge loading and interior loading, it might be pointed out that edge loading would not be the weakest situation. One or two recent Papers on the subject indicated that with temperature stresses, the longitudinal edge would be the weakest point. This needed verification.

The Authors felt that, for bonded concrete slab, the Westergaard's and Spangler's formulae were more suitable than those of Teller, Sutherland or Pickett as the warping of such slabs was considerably less. However, a comparison of the various formulae would relieve doubts entertained by some of the speakers. It could be seen in Fig. 10* that for values of a_1/l upto 0.4, Westergaard's corner stress formula (curve 1) would give very close results to those obtained by theoretical curve (curve 2) considering full subgrade support. In the like manner, Spangler's modified formula (curve 3) gave almost the same values as Pickett's formula (curve 4) for values of a_1/l upto 0.4. In fact, Pickett in his Paper titled "A Study of Stresses in Corner

* Figs. 1 to 9 are included in Paper No. 225 published at pages 149 to 162 of Vol. XXV—Part 2 of the Journal of the Indian Roads Congress, December, 1960.

Region of Concrete Pavement Slabs under Large Corner Loads" stated that his formula gave stress values within 3 per cent of those given by either Kelly's or Spangler's formula in the range

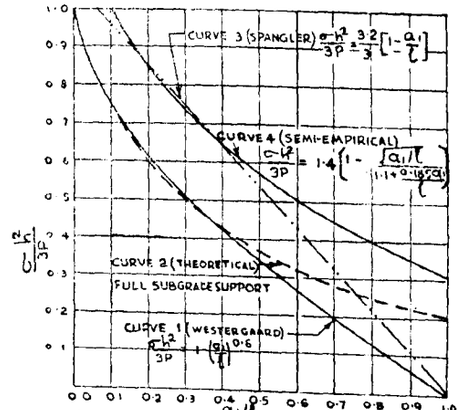


FIG. 10. COMPARISON OF VARIOUS FORMULAE FOR CORNER STRESSES IN CONCRETE PAVEMENTS

of a_1/l between 0.1 and 0.4. In the case of the slab under consideration $a_1/l = 0.354$ and hence much difference in stress values was not anticipated by the use of Pickett's formula.

The Authors disagreed with **Shri V. V. S. Rao** and stated that maximum stress and the minimum stress according to Spangler were not for the warped up and warped down conditions of the slab. Spangler had taken two limiting cases for the corner breaks, one was a line perpendicular to the corner bisector and the other was a circular arc with the corner point as the centre. He thought that a corner break could occur anywhere in between and he had found that the maximum stress was for the condition when the break was taken to be circular and the minimum stress for the condition when it was taken perpendicular to the corner bisector, but not according to warped up or warped down conditions.

In reply to **Shri G. C. Gupta**, who had stated that strains were taken only at three points and whether these were adequate, the Author stated that it would have been better to have more number of points; but it was pointed out that on account of limited number of demac gauge points being available they had to be content with three points.

Replying to **Shri P. J. Rao**, the Authors stated that their study did not cover moisture content of subgrade.

Replying to **Dr. C. K. Ramesh**, the Authors stated that a maximum difference of 18°C between the top and bottom of the slab was obtained during summer season. Regarding the discrepancy about non-linear distribution of strain at 36 in., it was pointed out that the subgrade reaction calculated from Westergaard's formula gave different values at different points in the corner region. This may account for the non-linearity of stress distribution.

Regarding **Shri K. K. Nambiar's** comment about the time of loading, it was pointed out that temperature observations were actually taken for the slab and it was found that in the morning at 8.30 temperature at various depths of the slab was same. Hence load tests had been conducted at that time. Readings were also taken just before the loads were applied and immediately after the application of the loads. So the difference in these strain readings would give the stress due to the load only.

Shri K. K. Nambiar (Chairman) in his concluding remarks stated that although the Paper was not very exhaustive, it was very useful because the Authors had tried to make a rational approach to the problem of stresses in the corner region of thin bonded concrete road slabs. During the discussion, many new points had been brought out and many shortcomings had been pointed out. These would surely help to carry out further investigations in greater detail and in a more scientific manner.

Discussion on Paper No 226*

"Study on the Stability of Well Foundations for Major Bridges"

By

A. BANERJEE & S. GANGOPADHYAY

Thursday, January 5, 1961.

Shri G. C. Khanna (Chairman) requested **Shri S. K. Samaddar** to introduce the Paper on behalf of the Authors who could not attend the Session.

Shri S. K. Samaddar, introducing the Paper, stated that the present Paper dealt with only the investigation of well foundations of major bridges embedded in sandy strata.

Terzaghi in his book "Theoretical Soil Mechanics" had deduced certain formulae considering the plastic flow of soil but his treatment was valid for weightless rigid bulkhead without consideration of the frictional forces playing at the base and on the sides of the bulkhead. Pender and Roscoe whose Paper came to the hands of the Authors after publication of this Paper had deduced formulae for stability of rigid piers and wells founded in soil, considering skin friction and friction at base but they had not considered the effects of movements due to eccentricity of the resultant vertical reaction imparted at the base due to the tilting of the well. Moreover, the equations derived by Roscoe took into account the fact that full passive resistance of the surrounding soil would be developed in resisting the movements due to external force. To allow for such conditions, the deflection at the top of the pier might become more than permissible. For this reason, Roscoe's method could not be applied in all cases.

The Authors in this Paper had endeavoured to evaluate the effects of horizontal and vertical forces on the well taking both horizontal and vertical soil reactions into consideration. Three cases had been considered, namely, (1) state of elastic equilibrium, (2) state when plastic flow just started, and (3) state when there was plastic flow upto a certain depth. In cases where the designer might find that the limit of elastic equilibrium would mean deflection of the well beyond permissible limits, he might use formulae (1) to (7)

* Published at pages 163 to 184 of Volume XXV—Part 2 of the Journal of the Indian Roads Congress, December, 1960.

for finding the effects of forces on the rigid well. In addition, the Authors had incorporated in their Paper the effects of wide surfaces on the values of horizontal and vertical subgrade reactions as discussed by K. Terzaghi in his Paper in Geotechnique, December 1955: As regards the values of subgrade reactions, though the designers might use the tables of Terzaghi given there, it would be most desirable that experiments were taken up by different research institutes for evaluating those constants for different types of soils.

The Authors regretted that there were a number of printing mistakes in the Paper which might have created confusion in the minds of the readers. The following corrections were necessary:

1. Page 167, para 5.1, Fig 3.....The arrow of reaction 'R' will be central.

2. Page 168, para 5.1
   line 19.....ρ_u should be read as ρ_1

3. Page 169, para 5.1
   line 1.....$P_1 = \int_0^{D_1} P.\,dz$ should be read as $P_1 = \int_0^{D_1} p.\,dz.$
   line 4..... $\rho = \frac{D_1 - z}{D_1}$,, ,, $\rho = \frac{D_1 - z}{D_1}\rho_1$
   line 6..... ρ^1 ,, ,, ,, ρ_1

4. Page 170, para 5.1
   lines 1 & 2.....P_1 should be read as ρ_1
   line 9..... P ,, ,, ,, ρ
   line 11.....$R = \int_0^{B_2} p dx$ should be read as $R = 2\int_0^{B_2} p.\,dx$
   line 12..... $\int_0^{B_2} K\rho_1\,dx$,, ,, ,, $2\int_0^{B_2} K\rho_4\,dx$

5. Page 171, para 5.1
   line 1..... 'X' sign should be read as x
   line 18..... $m\rho_1 = \frac{6p_1}{D^2_1}$,, ,, ,, $m\rho_1 = \frac{6P_1}{D_1^3}$

line 20..... $p = \frac{6\,\rho_1}{D^3_1}(D_1 - z)\,z$ should be read as

$$p = \frac{6\,P_1}{D_1{}^3}(D_1 - Z)\,Z$$

6. Page 172, para 5.1

line 4.....$K\rho$ should be read as KP

line 9.....$P = P_1 - P_2 = \mu R$ should be read as $P = P_1 - P_2 - \mu R$

last line $\mu R < P_1 - P_2$ should be read as $\mu R < P_1 - P$

7. Page 173, para 5.2

line 8..... $M_3 = \frac{B^3}{120}$ etc. should be read as

$$M_3 = \frac{B^3}{12D}\text{ etc.}$$

8. Page 177, para 8

Eqn. 29.....should be read as $p = m\rho z$ etc.

4th and 2nd line from bottom...

$P_z = d_1$ should be read as $p_z = d_1$

9. Pages 177, 178, 179 and 180. There are several mistakes in printing K_P as K_p.

10. Page 179, para 9

Fig. 14.....length of well should be read as 32′–0″

r ,, ,, ,, ,, Y

11. Page 180, para 9

line 11.....dimension of K should be "Kips per cu.ft." instead of "kips cu.ft."

line 12.....dimension of m should be "kips per ft^4" instead of "kips per ft."

line 19.....omit the sign $\therefore$ (therefore).

12. Page 182, para 9

line 5....." + 32" should be read as " × 32"

Eqn. (5).....1084 ,, ,, ,, ,, 1085.

Eqn. (6)....." + 16^2" ,, ,, ,, ,, × 16^2

13. Page 183, para 10.5.

line 21....." Value of μ.....from 0.45 to 0.56" should be read as " Value of μ.....from 0.45 to 0.55".

para 11.3,

line 37.....omit the word "slab".

Shri G. Venkatesulu referring to para 5.2, pages 172 and 173 and Fig. 9 regarding the forces acting on the structure, suggested examination of the forces shown on page 173. The forces acting on the structure are 'P' the external force applied, P_1 resultant resistance offered by the soil and F, force required at the base to prevent sliding. The definition of F was not very clear. When an external force P was acting from right to left, the tendency for the well would be to slide in the same direction. Hence if any force was required to prevent sliding, it would be from left to right. As such, if at all there was any force at the bottom, it should be from left to right. It was not clear whether the Authors' view that the well would tend to slide from left to right when the external force was applied from right to left was correct. With that approach in the Paper, the magnitude of P was greater than the actual force to which it was subjected to. It was not clear whether it would be wrong to assume that the magnitude of the resistance offered by the soil would be equal to the force to which it was subjected. The Authors were requested to elucidate that aspect.

In the design of a well, it was necessary to consider the bearing pressure on soil and stresses on the steining of well. The Authors had not attempted to show at what level the maximum stresses in steining would occur. Would they occur at scour level, at the bottom level of foundation or somewhere in between ?

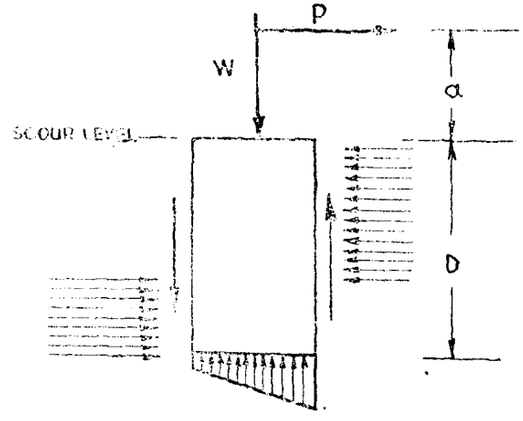
Para 5.1 and Fig. on page 167 showed that the well tilted and did not slide. They were not sure whether 'μR' would act even in case where there was only tilt and no sliding and the centre of tilt was at a higher level above the bottom of the well.

The design of well foundation was rather a very intricate one. Before attempting a theoretical approach, it would perhaps be desirable to conduct some experiments on a laboratory scale for ascertaining the behaviour of soil with reference to the magnitude of various forces.

In such Papers involving many symbols it would be better if the symbols were explained in the beginning of the Paper.

Shri M. P. Apte was of the view that in the beginning of the Paper, the Authors should have given the three basic equations of stability of the well against the active forces, to make the Paper

more instructive and complete. In case of a well foundation subjected to a vertical load " W " and a horizontal force " P " acting



at a distance of " a " above scour depth, the stability of the well against the active forces was established by the following three basic equations :

(1) $W =$ The algebraic sum of (a) the base pressure, (b) side friction induced by the tendency to tilt, and (c) frictional resistance to downward settlement, if permitted.

(2) $P =$ Passive pressure on one face at the top minus passive pressure on the other face at the bottom.

(3) $P\,(a+D)$ = Algebraic sum of the moments about the base centre caused by : (a) passive earth pressure, (b) friction on sides, and (c) by base reactions.

The passive earth pressures had been evaluated by the Authors on the basis of Terzaghi's "fictitious subgrade reactions". Terzaghi himself had stated that in the ratio $K s = \frac{p}{s}$, i.e., the ratio between the intensity 'p' of the earth pressure and corresponding settlement 's' the pressure 'p' was a fictitious figure in contrast to the real contact pressure. The error involved was, however, compensated by Terzaghi by an adequate factor of safety. The Authors had stated in para 10.2 that no factor of safety in the evaluation of factors 'k' and 'm' was necessary. The reason given by the Authors was that the error in the

evaluation of k and m would be neutralised in the ratio $\frac{k}{m}$ as the probability of error in the evaluation of the two was the same. Such an assumption did not appear to be correct.

In para 5.2 on page 172, the Authors stated that in case of heavy wells, sliding at the base could not take place as the reaction was very high. The Authors, therefore, concluded that $D_1 = D$, $P_2 = O$ and $M_2 = O$. These conclusions were questionable. When there was tendancy to tilt in a non-cohesive sandy stratum, passive horizontal reaction on the face of the well near the base would not be automatically equated to zero except under certain circumstances of loading, shape of well and area and shape of base.

It might be of interest to study the practice followed in Japan in the design of well foundations. According to the Japanese practice, the following two possibilities occurred :

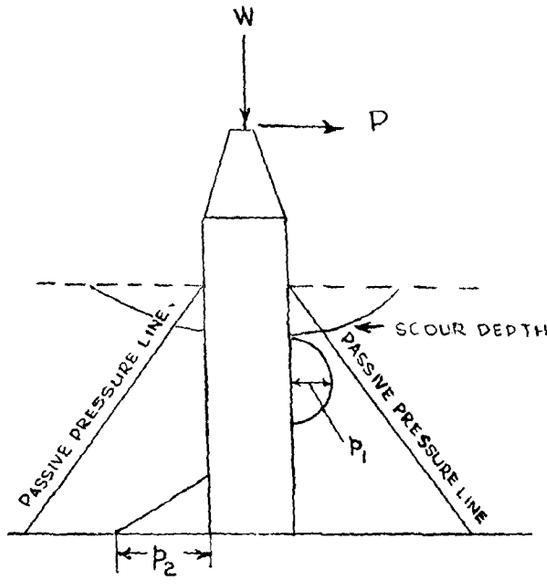
I. In case where (a) the bearing power of the ground was relatively small and (b) the well had great length but very small cross section (having small section modulus), the resistance of earth pressure on the sides was only considered for stability. In that case, the vertical force was counter-balanced by the friction and horizontal force by the horizontal resistance which might have maximum value equal to passive pressure.

II. When the cross-section of the base of the well was large and where the ground at the base could safely bear substantial loads, the resistance of the earth pressure at the sides and the bearing power at the bottom both came into play.

The method used in the first case was called Dr. Mononobe's method and that in the second case was called 'Ikehara-Yokoyama's method.

In Dr. Mononobe's method, the distribution of horizontal reaction of earth was taken parabolic (sketch) as experimented by Engels, and the criteria for safe design was that p_1 and p_2 should respectively be less than the passive resistance of the soil for the respective depths.

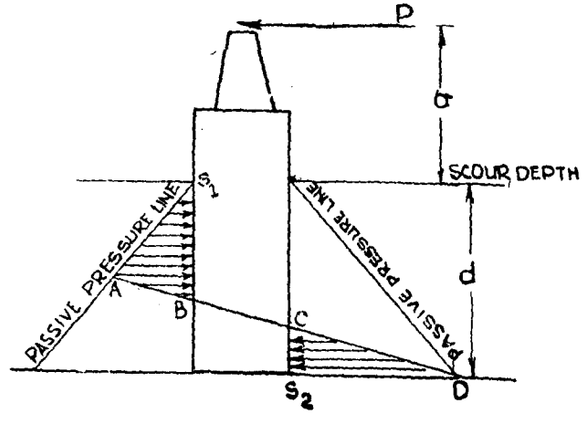
The second method was based upon the following principle : The ground reaction of the well, taken as a rigid body, caused by its rotation was calculated assuming that the foundation ground had a ground reaction coefficient proportional to the depth of the well under cover of earth. The well was considered stable if the maximum horizontal reaction working on the sides of the well and



maximum ground reaction working on bottom had a safety factor as required and did not exceed the allowable bearing power.

The Japanese Code gave elaborate equations for evaluation under both methods. The Journals of the Japanese Society for Civil Engineers could also be referred to for details of these methods.

A handy workable method used in some countries was as follows :



A straight line $ABCD$ should be drawn in such a way that the external force P minus pressure indicated by triangle S_1AB plus pressure indicated by triangle S_2CD was equal to zero. The base must withstand the vertical load and the moments on the base which were equal to $P(a+d)$ minus moment about base due to passive pressure S_1AB plus moment about base due to passive pressure S_2CD.

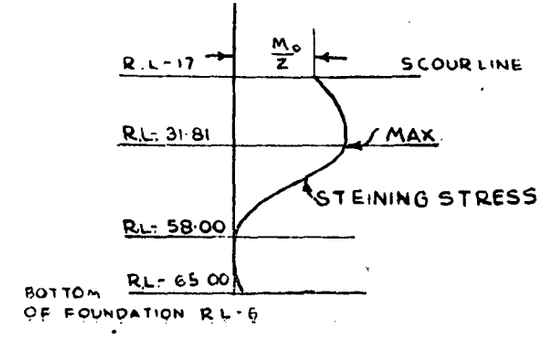
Shri S. Radhakrishnan stated that on page 166 in para 4, the first correlation that the Authors had drawn was between the pressure and the displacement of a vertical wall a – b.

What was ultimately happening at the point of failure was that as soon as the piers began to move, the passive earth pressure came into action as well as the active earth pressure on the other side. But this pressure would be proportional to the movement only upto a certain stage, i.e., upto the point of failure, and at that point the whole thrust would be in plastic equilibrium. Afterwards, whatever movement took place, the failure occurred. Then the earth pressure of horizontal movement would not have any relationship to the pressure developed. In this way, a very simple solution could be developed.

Shri B. Balwant Rao stated that in deep well foundations the problem was not so much about the base pressure and stability as the steining stresses.

The following Fig. illustrated a case where calculation of steining stresses necessitated provision of reinforcement for taking care of the steining stresses.

With reference to the Fig. below, M_o was the bending moment at the scour line. That moment went on increasing upto a point



where the resultant earth pressure upto that depth balanced all other horizontal forces. It then went on decreasing and became zero at a point as indicated in the sketch. It might be seen from the sketch that there was practically no bending stress in the steining below that point.

The Authors also had not considered the effect of shape of well. It is to be pointed out that the passive pressure obtained for a rectangular well was usually more than that for a circular well.

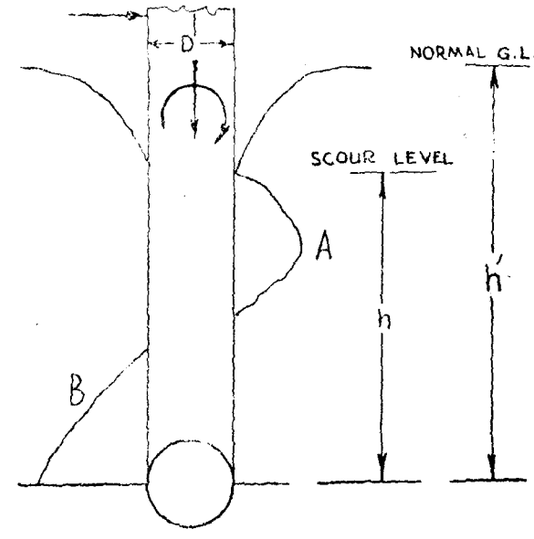
Shri S. C. Gupta commented that in para 8 page 167, m had been defined by the Authors as an empirical constant independent of depth and is given as

$$m = \frac{\gamma (K_P - K_A)}{\rho_1}$$

where ρ_1 had been defined as the displacement required to increase the value of resultant unit pressure from 0 to p_1. But the value of p_1 was given as $p_1 = \gamma z (Kp - K_A)$ which meant p_1 depended on z, the depth of any point below scour line. Consequently p_1 would depend upon depth and, therefore, m was not a constant. Hence the conclusion of the Authors in taking 'm' as an empirical constant appeared to be incorrect.

Shri R. N. Joshi stated that in the Paper and even in the discussions that followed, nobody had mentioned about the unscoured normal ground level. It was not only the scour level which was important, but the normal ground level was also important in rivers having considerable depths of flowing sand in floods. Unfortunately this factor had been ignored so far. The forces that act on a well were the vertical force, the horizontal force and the moment. As a result, there was a tendency for the well to tilt. This was resisted by the passive resistance of the surrounding soil which played a considerable part in the stability of well foundations. The unscoured normal ground level was important in the case of wells having h/I ratio more than 2. The passive resistance in the region A was more or less dependent on the depth of the point under consideration from the scour level; while the passive resistance in the region B was dependent on the depth of the point from the normal ground level. The portion of actual scour around a well was limited in expanse and the passive earth pressure at the base of the well was dependent on the height h' from the normal ground level. This was the recommendation of the Japanese Society of Civil Engineers.

It might also be noted that the actual passive resistance of the soil would be enhanced by the head of water which was causing the scour.



The practice of Japanese engineers on this issue was of special significance because Japanese engineers had done considerable work on this subject. Well foundations were quite in vogue in Japan as they were in India. Japan was largely affected by earthquakes. Japanese engineer was, therefore, very much concerned with the effect of horizontal forces on wells which in its turn called for the study of passive resistance of soil.

In the design of well foundations, the horizontal earthquake force depended upon the mass of the structure and was not to be reduced on account of effects of buoyancy, whereas the vertical loads had to be reduced for buoyancy. This naturally produced stringent conditions for the designer.

While considering seismic forces on wells and piers, it was necessary to consider the seismic impact of water for the portion of the well or pier, when the depth below the level of water was less than twice the length of the pier. In addition to the usual seismic forces, the horizontal force due to the weight of the water enclosed in the cylinder with the length of the pier as diameter, excluding the portion of the pier itself, had to be taken into consideration.

The Authors in a written reply to the discussions, referred to the remarks of **Shri G. Venkatesulu** regarding the force 'F'. In para 5.2, 'F' had been described by the Authors as the force required to prevent sliding which meant that F was the frictional

resistance at the base of the well. To understand the direction of F, it was to be considered whether the well would tend to slide at the base parallel to the direction of the applied force or whether it would tend to rotate with a fulcrum above the base. In the case of a deep well like that dealt with by the Authors, it was obvious that the well would tend to rotate with a fulcrum above the base at a force of lesser magnitude than that required to slide it along the base in the direction of P. The direction of F would, therefore, be as shown in Fig. 9. Shri Venkatesulu was right to indicate that it would be wrong to assume that $P = P_1 - P_2 = \mu R$. The Authors regretted the printing mistake in equation (15) which should be read as $P = P_1 - P_2 - \mu R$.

The formula for maximum steining stress had not been worked out by the Authors as the Paper only dealt with the "stability" of wells. For heavy wells, the resisting moment M_z in the steining at any depth 'Z' below scour level, due to passive resistance of the surrounding soil, could be found out from the fundamental equation, namely,

$$M_z = pz = \frac{m \rho_1}{D}(D - Z)\, Z^2$$

$$= \frac{\gamma (K_P - K_A)}{D}(D - Z)\, Z^2.$$

Therefore, the net moment in the steining at a depth 'Z' will be $P(H + Z) - M_z$.

Knowing M_z at different depths, it was possible for the designers to try and work out the maximum compressive or tensile stresses in the steining.

The Authors were thankful to **Shri M. P. Apte** for his advice regarding elucidation of the three basic equations of stability. The Authors still believed that no factor of safety was necessary in evaluating $\frac{k}{m}$. If, however, some designer wanted to impart different factors of safety for 'k' and 'm', there might be no objection to the same.

The conclusions made by the Authors in para 5.2 regarding $P_2 = O$ and $M_2 = O$ had not been arbitrary. These conclusions would be automatic if one considered that the well was unable to slide at the base, as in that case the force P_2 could not be generated. It was to be noted that (vide eqn. 15) sliding at the base occurred only when $\mu R < P_1 - P$ (P_2 being zero) and F, the force required at the base to prevent sliding, might have a value less than μR. The Authors expressed their thanks to Shri Apte for pointing out the Japanese methods of design of well foundations. The methods

were rational and were similar in line with the method suggested by Karl Terzaghi. The handy workable method of design mentioned by him was also in line with that suggested by Terzaghi and was already being practised by designers in West Bengal and elsewhere. But these methods had their limitations and, as already mentioned in the introduction to the discussions, were not applicable for the design of heavy wells but for the design of light wells rotating about a fulcrum above the base.

Regarding **Shri S. Radhakrishnan's** comments, the Authors liked to point out that the method of simplified design had already been dealt with under para 8 on page 176. It was important to note that further simplification would not be possible as the soil surrounding the lower part of the well and offering passive resistance would still be in elastic state even if the soil in the upper portion offering passive resistance had passed from the elastic state to the plastic state (vide Fig. 12).

Shri B. Balwant Rao had expressed more anxiety about the steining stresses than the problem of stability. On the contrary, the Authors apprehended that the problem of stability might cause more anxiety to the design engineers while designing foundations of wells in regions subjected to seismic forces. The case mentioned by Shri Rao was true only for a well having an appreciable grip length. It was essential, however, to check up the steining stresses after ensuring the stability of the wells and this could be done in the way already suggested by the Authors while replying to the comments of a previous speaker.

Shri Rao was right in pointing out the influence of shape of wells on passive resistance but such variations due to shape were small. For example, for circular wells the passive resistance might be taken as 0.92 times that of a rectangular well of the same length as the diameter.

Referring to **Shri S. C. Gupta's** remarksabout 'm', the Authors liked to elucidate that ρ_1 had been assumed to be independent of depth and as such 'm' was a constant.

Shri R. N. Joshi had referred to the consideration of "unscoured normal ground level" in evaluating passive resistances. The Authors were of opinion that the passive resistance for the depth of well below "normal scour depth" instead of "unscoured normal ground level" might be considered in particular case if the design engineer was satisfied that the likely maximum scour at the piers (twice the normal scour) would be limited in expanse. The recommendations of the Japanese Society of Civil Engineers on the above matter and also on the enhanced passive resistance due to head of water causing the scour were well worth consideration.

Shri G. C. Khanna (Chairman) in his closing remarks stated that before formulae suggested in the Paper were adopted, he would like that these should be tried on some of the bridges which had already been constructed. The old formulae which were of very simple nature and on which design of wells was based had given complete satisfaction and bridges had been in existence for decades. If sufficient grip was provided in the well below the scour level, and the diameter of the well was sufficient for bearing capacity, the design normally worked out to be safe and it was not necessary to work out such a detailed analysis. However, the subject being rather important, he would like that this matter, viz., design of wells, be considered in greater detail by the Bridges Committee who might make final recommendations in the Bridge Code. Referring to para 11.1 of the Paper where it had been stated that deduction of the formulae was based on certain assumptions, Shri Khanna stated that obviously the results of formulae would only be true if assumptions were made on the basis of reliable data.

In the end, he thanked Shri S. K. Samaddar and the various speakers for the keen interest shown in the Paper.

Discussion on Paper No. 227*

"Design and Construction of Udyavar Bridge"

By

Dr. A. S. ADKE & C. CHIDAMBARAM

Thursday, January 5, 1961.

Brig. S. K. Bose (Chairman) called upon **Dr. A. S. Adke** (one of the Authors) to introduce the Paper for discussion.

Dr. A. S. Adke (Joint Author) while introducing the Paper stated that the Udyavar Bridge was one of five typical bridges constructed on West Coast road which ran close to the sea coast in Mysore State. The rivers crossing that road were generally wide, perennial, having varied depth and were subject to tidal variation. The depth at which hard foundations were met with in that region varied from 30 to 60 ft and sometimes more. It was not, therefore, possible to have foundations other than well foundations.

Shri D. P. Ghosh stated that in para 7.1, the Authors mentioned that sinking of wells had not presented much difficulty as these were sunk through sand and clay to a depth not exceeding 45 feet. But he would like the Authors to enlighten whether the wells near right bank went down without difficulties through the 20 feet layer of soft laterite and soft granite rocks.

In para 7.3, it was not clear how the verticality of the well during sinking was maintained by checking with plumb bobs only.

As the grouting of dowel bars in the rock at the bottom of well had to be done in presence of water, there was doubt whether proper bonding could have been effected. He felt that benching or some other arrangement should have been seriously attempted though it might have been difficult.

Instead of having a few separate wells under each pier or abutment, single well would have been economical and easier for sinking. An elliptical well might have been better.

Under para 9, it was stated that the design of abutment was based on Coulomb's theory of earth pressure taking into consideration live load surcharge even after providing an approach slab

* Published at pages 235 to 292 of Volume XXV—Part 3 of the Journal of the Indian Roads Congress, December, 1960.

10 ft long. But Section II of I.R.C. Bridge Code, 1956, did not recommend any live load surcharge for design of abutment when an approach slab was provided.

In page 255, the section of the wing wall had been made 8 in. thick uniformly, although it was designed as a cantilever. It would have been economical to reduce the thickness at the free end.

On page 259, Appendix 3, in the design of roller bearing the size of the plate had been assumed as 19 in. × 12 in. but the sketch shows the width as 10 in. He would like the Authors to explain the anomaly.

Under section 13.2, the Authors had explained the reason for adoption of hollow box girder as its cost was cheaper than a bow string girder. It was not understood whether the economic aspect for the use of the balanced cantilever type of superstructure had been explored.

Shri T. Achyutta Ramayya invited attention to page 238 giving the sketch of the cutting edge and stated that at the bottom flat edge of the angle had been provided. Probably a sharp cutting edge with steel plate 9 in. × 3/8 in. would have been better because when the well passed through clay, there was a possibility of meeting with small pieces of decayed timber and in such cases, sharp cutting edges would work better.

Inviting attention to page 239, para 7.1, he stated that the depth of sinking was about 45 ft and for that depth, the pressure would be 30 to 35 lb. He was not, therefore, able to understand how the pressure of 15 lb of compressed air was sufficient for the divers for that depth. Not only that, generally for supplying air to divers, compressors of 110 or 250 cu.ft. capacity, which issue air at 80 to 100 lb per sq. in., were used when 2 cu.ft. of air per minute was required. He would, therefore, request the Authors to clarify the basis by which they got their figures.

He wished to know whether the bottom plugging was intended to take the reaction from the bottom. If so, whether tests had been conducted regarding the strength of the bottom plug to counteract that pressure.

Shri R. Thillainayagam stated that he would like to say one or two points not touched by the Authors.

One was about Ryve's formula. The Authors had taken the value of c as 1,500. Usually, for irrigation projects in the State of Madras a value of 750 was taken. However, that value was not found sufficient and they had gone upto 2,000.

As regards foundations, for a well curb, the curb diameter was generally 1 in. more than the well diameter to minimise side friction of the well.

Bottom of the capping slab had been fixed at the high tide level instead of the top of capping slab being fixed at low tide level which would have kept the cap submerged and presented a pleasing appearance.

Shri A. K. Dutta stated that the value of highest discharge as found out from Ryve's empirical formula should have been checked with some other standard formula such as Mannings or modified Inglis formula. The basis of taking the value of the constant ' c ' as 1,500 should also be explained.

Under para 7.5, it had been stated that 34 Nos. of 1 in. diameter bars had been used to anchor the well down to the rock. The basis for calculation of the numbers should be given. The bond length seemed to be on the lower side. It was doubtful whether the bond length would be adequate in case the wells tilted.

Shri M. C. Johorey stated that in this Paper, the Authors had given a section of R.C.C. curb under well foundations and had used a 4 in. × 4 in. × $\frac{1}{2}$ in. angle section. He would suggest that the Authors should have used double angle 4 in. × 4 in. × $\frac{1}{2}$ in. with a 3/8 in. plate 8 in. long rivetted to it. This would have facilitated the sinking to a great extent.

The Authors under para 7.3 had mentioned that verticality of the well during sinking had been checked with plumb bobs. That method of checking tilts would not be sufficiently accurate. The Authors should have checked up the tilt by levelling instrument. In this method, after the well curbs had been concreted with outer side truly vertical, two pairs of diametrically opposite points were fixed on the curve at one level. As the steining was concreted at stages, those points were transferred to the top of steining by equal increment of height and the verticality was checked by finding out whether the transferred points were still at level.

Under para 7.6, the Authors had given a sketch of plugging box from which it appeared that the top of lid was closed. This would result in formation of air bubbles in concrete. The Authors had not mentioned whether any percolation test was performed to see that the 1: 2: 4 bottom plug was practically watertight.

Shri C. R. Das Gupta stated that Fig. 1 in section 6 showed that the inner slope of the well curb was as flat as 45°, but for easy flow of the grab materials the usual practice was to give a slope 30° to 35°, i.e., 1 : 1.5 approximately. He would also like to know the rate per rft. for well sinking.

The abutments were of masonry for which R.C. wing walls had been cantilevered out and designed as cantilever member, considering the flexure in horizontal direction only. Vertical flexure should also have been considered.

About bearings at fixed end, the Authors had stated that the dowel bars were encased in copper tubes and the annular space filled with bitumen filler for expansion and contraction due to change of temperature. Filler would restrict movement at the time of rocking which was not desirable.

Referring to Appendix 4, Shri Das Gupta stated that the pressure of 2500 p.s.i. on mortar pad was much too high especially when there was rotation at this end, which would tend to concentrate the whole load towards the edge.

Shri R. T. Atre referring to para 7.5 mentioned that under similar condition of sloping strata at the base a 10-ft dia. well had tilted due to excessive water pressure. In this particular case the velocity being rather small, 3.68 ft per sec., the anchorage provided might perhaps be alright. But it would have been better if detailed calculations for anchorage had been given by the Authors.

On page 242, para 7.6 (b), the Authors had stated that the sand filling was consolidated thoroughly. He did not understand why that was necessary and if at all it was necessary how exactly it was done.

The Authors had stated that the concrete slabs were resting on the back of each abutment. Those were approach slabs and would definitely crack in case the fill behind the abutment sank.

Regarding the design of superstructure for a well foundation, generally a balanced cantilever design was found to be economical. Confronted with similar circumstances he would have gone for a 90-ft balanced cantilever structure with 2 or 3 beam arrangement.

Regarding the wearing coat, it was not necessary to have 1 : 1½ : 3 mix. It would have been sufficient if 3 in. wearing coat of 1 : 2 : 4 ordinary grade concrete had been provided.

Shri J. G. Bodhe opined that a balanced cantilever box girder would have proved more economical from the design point of view although the shuttering would have been slightly uneconomical. He, therefore, wanted to know whether the selection was from economical point of view or from aesthetical point of view.

Good look of a bridge structure was also a very important thing to be considered. In this respect, he would invite the

attention of the members to the discussion on the Waterloo Bridge in London.

Shri S. Seetharaman stated that the reason for assuming that the area velocity method was not applicable in this particular case could not be understood. In fact, the area velocity method was applicable even in the case of rivers with lot of spill. Calculations by this method would have given a check to the discharge calculated by catchment area method.

When the wells had been founded on firm rock, a continuous box type girder design should have been adopted more economically.

Regarding superstructure, he mentioned that it would have been more economical if a curved soffit slab was adopted. The details of the superstructure showed that only vertical stirrups had been provided as shear reinforcement. It was desirable to provide inclined stirrups to counterbalance some of the tensile forces coming in the web of the girder.

Dr. C. K. Ramesh stated that he had yet to see a design especially in these box girders where transverse distribution of load was allowed on the deck when the load was coming on to one side of the bridge. Though there was justification for assuming infinite torsional rigidity of the superstructure, he was not quite clear whether some sort of rigorous analysis would not be required when two lane loads were shifted to one side. Perhaps the top slab with the ribs might have been assumed as simply supported slab and carried out some sort of approximate analysis given by Courbon or by the distribution coefficient method. However, he would like some one to throw light on the actual analysis of a box girder under asymmetric loading.

Regarding cantilever portion of the slab, he would like some one to give details of the Swedish method. In fact, he had worked out according to I.R.C. formula given in Clause 207, Section II of Bridge Code, and found out for Class A loading 37 in. as distribution width and 5,500 lb as load per foot width. It would then be interesting to know as to how this compared with the actual results obtained by Swedish formula.

He did not consider that the design of diaphragms was satisfactory. Recommendations had beenmade in this connection in Section IV of I.R.C. Code which was being drafted. One could also apply distribution coefficient method given out recently by Morris and Little in their publication.

He would like some one to throw light as to what sort of analysis should be made for designing an R.C.C. well cap, especially when it was resting on a circular well with load at the

centre. It would be quite interesting if somebody could say what would be the exact analysis when there was a circular slab or even a rectangular slab resting on two circular wells and subjected to loading due to the weight of the pier and the rest of it.

Shri M. P. Apte stated that in the design bearings on page 257, it was mentioned that, of the three webs of the box girder, the central one would take the maximum dead weight of the deck, whereas in the calculations of shear stress in the webs on page 271, equal distribution was assumed. These too assumptions were contradictory. In the sketch of bearings on page 260, the centres of the contact curvature were wrongly shown.

From para 13.5, it was seen that the concrete mix was scientifically calculated as 1 : 1.9 : 3.7. The test results of concrete, tested after 43 days, as seen on page 250, were so poor that one would start doubting whether the scientific design of the mix was advantageous or not.

The chiselling done on the sloping side of the kerb to ensure bond between the plug and the well as mentioned in para 7.6-A appeared to him to be unnecessary and superfluous. There was no harm even if there be no bond between the two.

The maximum foundation pressure in this design was 5.97 tons per sq. ft. as stated on page 275. The foundations were taken to a depth of 45 ft to rest on hard granite rock though laterite was available at a depth of 23 ft as mentioned on page 237. The design of the foundation could have been made much cheaper by reducing the diameter of the well for hard granite foundations or by increasing the diameter of the well and allowing it to rest on laterite.

In para 7.5, it was stated that the grouting around the dowel bars was done under water. It was, therefore, presumed that dewatering was not possible or convenient during grouting of holes for dowel bars. The drilling of holes in rock also would have similarly been done under water. He, therefore, did not understand Authors' description of the drilling machine in para 7.5 where it was stated that the cutter was kept cool by water led into the hollow drilling rods. He would like to know whether the drilling of holes in rock was done after dewatering the wells whereas grouting of holes was done under water.

Shri B. Balwant Rao stated that in the case of rivers subjected to tidal action, the waterway required for a bridge should depend on two factors, namely, the tidal action and quantity of incoming fresh water. The more dominant factor would however rule.

It was seen that the size of the fixed bearing with the mortar pad was 7 in. wide. He doubted whether a 7-in. wide pad in a 90-ft span would permit any deflection of the girder.

Shri P. V. Raj stated that provision at the fixed end had been made to allow slight local movement for expansion or contraction caused by change in temperature. He thought that no such provision should be made for the fixed ends.

Appendix 4 gave design of the spirals below and above the mortar pad and it was designed as a column. But no mention was made whether pier bed block was designed as a continuous raft or not. When column action was assumed, bearing pressure on the masonry below bed block should have been checked.

In the design of the main box girder, an assumption was made that the whole live load was uniformly distributed across the width on account of the great torsional rigidity of the boxes which he felt was correct. But it would have been very useful if the Authors had taken some trouble in testing the superstructure with eccentric live load to testify their assumption.

Shri Raj also suggested testing of the cantilever deck slab beyond the web for determination of the accuracy of the so-called Swedish formula for the dispersion of the concentrated load.

Shri S. A. Balu stated that it would be of interest to know whether the size of the wells for the foundations of this bridge was decided upon based on some rational methods and whether the most economical size had been adopted considering the bearing capacity of the foundation strata and the compressive strength of the steining. The maximum pressure under the piers had been given as 5.97 tons per sq. ft. and hence the pressure under the wells might probably be much less than what hard granite could normlly take.

Another aspect which might probably have been considered already by the Authors was whether it would not have been feasible to found the wells on laterite if the pressure was within reasonable limits. From the point of view of scour, it appeared that this might not have been impossible as the scour in this river was likely to be much less as the linear waterway was more than even Lacey's regime width and, as mentioned in Appendix 6, the theoretical velocity was only 3.68 ft per sec.

At least on the Udipi side, where the laterite strata was about 20 ft deep, it appeared that the piers and abutments could have been founded in the laterite strata below the maximum depth of scour. The Authors might enlighten as to whether this alternative was considered and whether this was found impracticable and uneconomical. In para 7.5, it had been stated that 34 No. 1 in. diameter bars had been provided to prevent any lateral movement of wells, but no such dowel bars had been provided between the masonry pier and the well cap. As there was usually very little addition to the horizontal forces below the bed level, it was not understood as to why these bars were considered necessary at the bottom of the masonary pier. At least in the case of the foundation towards the

Udipi side where wells were taken about 20 ft into laterite, the dowel bars could safely have been avoided if the same were provided solely for preventing any lateral movement and not for taking any tensile stresses due to overturning moments. The method by which the number of bars required had been calculated and the details of calculation might also be given if possible.

The design calculations for the pier section were not given in the Paper and hence it would be of interest to know whether any tensile stresses were allowed in the masonry in cement morter 1 : 4 and what tensile stresses were developed under the action of the maximum longitudinal forces and forces due to water currents.

The Authors were also requested to throw some light as to whether any particular precaution in the earthfilling just below the cantilever wing walls was taken to avoid any settlement below the cantilever and consequent overturning of the same.

Dr. A. S. Adke (Author) in his replies stated that **Shri D. P. Ghosh** wanted to know the difficulties in well sinking. He would say that they had built a number of bridges in Mysore and in sinking wells they found that they were meeting the same strata as obtained in bore results everywhere without exception.

As already mentioned in the Paper, the divers available were experts. They started their operation from the centre and went towards the sides. In this way, the wells were sunk properly. Sometimes, the wells tilted but being very small they could be rectified easily.

The only difficulty encountered was rock at places. They met with rock in the case of well No. 7 and the rock was sloping at 5 : 14 (5 ft in a distance of 14 ft). Blasting was not used in order to avoid risk. Pavement breakers were used to remove the rock. In one case, 3 ft of rock was removed in that way, and about 1/3rd of the well had been properly seated. The remaining portion was anchored by means of dowel bars and it had stood very well.

Referring to the argument about single well *versus* double wells, the Authors mentioned that single well might be economical in certain cases.

The size of the plate for the roller bearing was actually 19 in. × 12 in. The width of 10 in. shown in the sketch was a mistake. The dimensions are correctly shown in Plate V.

Replying to **Shri Ramayya**, the Authors stated that as it was anticipated by the results of the borings, that only sand, clay and soft laterite would be met with, a flat edge to ensure uniform sinking of wells was provided and it worked well. However, this was changed to cutting edge of Shri Ramayya's choice in other bridge works where the strata was hard. The following Fig. will show the different types of cutting edges used.

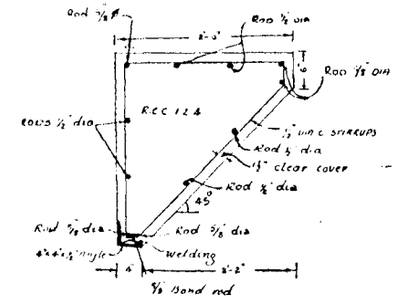


Fig. A.

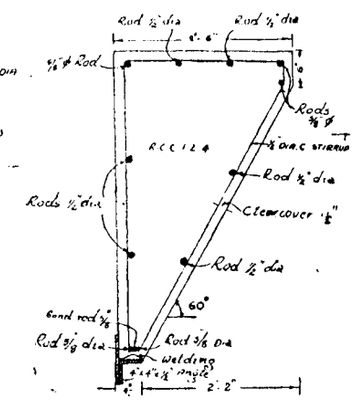


Fig. B.

In Fig. B it could be seen that the angle iron used as cutting edge was further reinforced by welding a steel plate on the outside. The angle of inclination on the inside was changed from 45° to 30°.

Regarding air pressure for divers, the Authors said that 15 lb per sq. in. was required for the average depth of 30 ft. It had to be increased at greater depth.

The decision to fix the bottom of the capping slabs at the high side level was taken in order to keep the capping slabs above saline water and also for obtaining easy working condition.

Percolation tests were conducted by pumping out water. When it was found that percolation was about 1 to 1½ in. per day, plugging was considered satisfactory.

Replying to **Shri Das Gupta**, the Authors told that they too have 30° slope for inner side of the well curb in some cases.

Brig. S. K. Bose (Chairman) in his concluding remarks stated that there were many aspects which had been discussed, such as lack of proper design, construction procedure, aesthetics, and other things which were all very important. He was also glad to note the important role the I.R.C. Bridge Code was playing.

The Authors had used welded joints for reinforcement bars. Many structures had failed where reinforcements were put without adequate space for the concrete to cover the reinforcement and develop proper bond. One very prominent structure had failed only recently. He would, therefore, like engineers to be very careful about spacing reinforcement.

Discussion on Paper No. 228*

"Study of Parking Problems—Connaught Place and Connaught Circus Area—New Delhi"

By

JOGINDER LAL

Friday, January 6, 1961.

Shri S. N. Gupta (Chairman) called upon **Shri T. S. Khanna** to introduce the Paper on behalf of the Author who was unable to present himself at the Session.

Shri T. S. Khanna while introducing the Paper stated that it was desirable to discuss a new philosophy that had been brought in, that short-time parkers park their vehicles nearer the destination and long-time parkers farther away, and all-day parkers farthest away from the point of their destination in busy areas. In the core areas of the city only, short-time parkers might be permitted, but the question was how to ensure that people did park only for a short time. This could be done in two ways:

(i) by introducing parking meters, and

(ii) by manual enforcement.

In manual enforcement, a policeman went on putting mark on the tyres with his chalkstick and after certain specified intervals, he came round and those cars which were parked longer than the prescribed time were noted. That method was not so much accurate and required a big number of police personnel. In the beginning, there would be opposition from traders who felt that such restriction on time might affect their trade. But soon they would find that, that was not correct.

Some of the advantages of parking meters were that (i) they provided an accurate time check by simplifying the detection of overtime parking, (ii) they aided traders in metered areas by increasing the turnover, (iii) only a small number of policemen were required to enforce time restriction, and (iv) they financed the enforcement themselves.

The next point he mentioned was about the meter charges proposed in the Paper. The main idea of the meters was not to raise

* Published at pages 293 to 321 of Vol. XXV—Part 3 of the Journal of the Indian Roads Congress, December, 1960.

money but to ensure the type of the turnover desired. At present, in Connaught Place and Connaught Circus areas of New Delhi, available parking space near large number of automobile repair shops was misused by vehicles coming for repairs and waiting long hours. That was not a very healthy practice in busy areas like Connaught Circus.

Shri R. Thillainayagam stated that the Author had mentioned that the parking survey was preceded by a traffic survey. It would have been of interest if the Author had also given the traffic accumulation at different hours along with the parking demands in different hours.

He presumed that the survey was conducted manually or by means of people travelling in a car. The curve given did not indicate whether the survey was conducted on a week day, or a Saturday. That should also be given. Normally only during week days, the traffic was at its peak at morning and evening hours and also during lunch hour to a certain extent. The traffic survey indicated that the parking demand was maximum between 11.00 to 12.00 hours in some cases and between 18.00 to 19.00 in other cases.

Various parking regulations had been proposed such as less than 2 hours, between 2 to 4 hours, also all-day parking, but the details of duration of parking of vehicles had not been given.

Mention was made of the physical inventory in the Paper, but the Author had not given the various kerb lengths, i.e., the spaces used for various things such as bus loading, no parking, alleyways, driveways, etc. Generally, it was found that only about 38 to 40 per cent space was available for parking, whereas other length was taken up by bus stops, taxi stands and other driveways for private property, etc.

In the Paper, no mention was made regarding the various parking stall dimensions, etc., but he assumed it as between 8 to 20 ft. At most of the places, the Author had suggested angle parking, i.e., 45° or 90° parking. Generally, all big cities go in for parallel parking because it interferes less with the movement of other traffic using the road. Actually, parking regulations in Western countries specified that unless otherwise indicated on the pavement, the vehicles should be parked about 18 in. from the kerb side. In this case, especially because the parking area was more or less circular, it would not be possible to mark the parking stalls in a rectangular way although he would favour rectangular parking spaces.

The speaker also wanted to know as to how the various stall numbers were fixed for different categories of parkers, e.g., for all-day, short time, etc.

He was of the opinion that before installation of parking meters, enforcement of the regulation should be first tried by policemen, and if proved successful, meters could be installed.

Another important point left out in the Paper was the provision for private parking. Provision to park customers' vehicles near theatres, hotels, cinemas and other public buildings like post offices was also necessary.

He would further suggest enforcing zonal ordinances giving the various requirements for buildings, and that when any new buildings were put up, they should be in a position to insist on the owner to provide for the minimum parking requirement specified, even if it might not be immediately required.

The Madras Motor Vehicle Traffic Code did not make any provision regarding parking of vehicles on pavements or parallel parking of vehicles or the method of parking. He would suggest this point should also be incorporated in Draft Traffic Code so that it was possible to enforce such a traffic regulation more rigorously.

He was also of the view that wherever parking restriction was imposed, it was necessary to mark it by means of signs or by means of line markings, etc. At present they had probably only one sign for parking, i.e., "No Parking". To that a definition plate indicating direction, duration, etc., could be added. He would suggest that new signs should be proposed to cater for our needs specifying where parking was permitted, or not permitted, its duration, etc. Besides, strict enforcement was also necessary.

All State Highway Departments should create traffic cells. He was glad to say that, in Madras, they had recently created a separate Traffic Engineering cell to deal with the traffic problems of Madras City.

Shri A. A. D. O. P. Saparamado wanted to know whether the demand for parking had been obtained by counting vehicles actually parked in the parking area. He would also like to know how in the absence of a cordon count survey, the Author based his suggestion as to the extra parking spaces given in Fig. 4. It might be that he had taken certain data from a previous survey and, if so, the incorporation of that data in the Paper would have been useful.

The Author had indicated that the purpose of parking meter was not for raising additional revenue but for obtaining better turnover of the vehicles. Where certain restricted amount of space was available for parking, and all drivers were to be given the same opportunity to park vehicles, it was necessary to use parking meters. In working out the rates, certain concessions should be allowed to drivers who park away from the business areas. If long-

time parking areas could be provided farther away from the congested area, it might not be necessary to charge anything. So an all-day parker would be induced to park his car there.

For short-time parking, the rates charged should not be fixed on *pro-rata* basis but should be progressively reduced depending upon the duration of parking, e.g., if rate charged for one hour parking is 10 nP., then for two-hour parking it ought not to be simply doubled to 20 nP. but should be fixed at less than that, say, 15 nP. This will encourage people to park away from the central area thereby leading to reduced congestion.

The Author had not probed into the possibilities of finding out off-street parking spaces which, if not needed at present, were sure to be required with the increase in traffic. If provision for such parking spaces was made now, the problem at that stage would be much easier because at that stage the land values due to the development would have increased considerably.

Shri D. N. Misra stated that in para 3.1, the Author had stated that vehicles found parked at 4 a.m. were taken as all-night parkers. No census of such all-night parkers had been given anywhere in the Paper. The Author might give that information from the data collected to give an idea of the number of such parkers. It was common practice to use parking spaces as private garages and park the vehicles throughout the night besides parking them for some hours during the day also. Installation of parking meters might discourage such parkers from continuing that practice.

Shri S. R. Pillai stated that as per correct principles of traffic engineering, there should be no obstruction in the roadway and the entire trafficable width of the road should be made available to traffic. Where unavoidable, vehicles could be allowed to be parked on the roadside but that should be controlled by the highway authorities by the installation of meters. Parking lots where cars could be parked in rows were either run by the Local Administration or individuals. Multi-storeyed parking stalls were allowed to be constructed mostly by private enterprise and parking spaces hired out by them. Roadside parking was intended for short duration parking only while parking lots and parking stalls were intended for long duration parkings. In this Paper, the Author had suggested installation of parking meters for short and long duration parkings. That did not appear to be necessary.

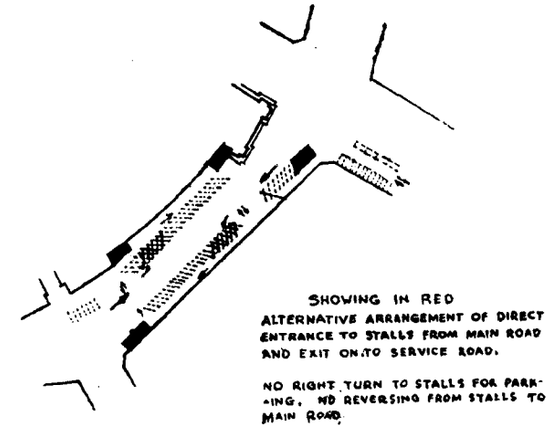
Shri Pillai did not fully agree with the Author in his suggestion to allow vehicles to park on the sides of all roads. Parking should not be allowed even on payment of tax on the sides of very important roads, important from the point of view of traffic, both vehicular and pedestrian.

Coming to parking meter rates suggested by the Author, he felt parking meter rates as suggested were too low and might defeat the purpose intended. The charges should be according to the importance of the area. 50 nP. for all-day parking, in an unimportant locality might be all-right. But he felt that the same rate of 50 nP. should be charged for medium duration parking, say, 4 hours, in a more important place and 50 nP. for one hour parking on an important roadside. Review of the rates and of the importance of the locality should also be made periodically.

Shri C. L. N. Iyengar stated that though a scientific survey had been carried out, the ultimate conclusion that had been drawn was that the available areas were adequate not only to meet the immediate needs but also for considerable time in the future. And only a process of reorganization of the parking area and prudent behaviour of all those people using those spaces would result in substantial improvements.

Further, it had to be noted in measuring the parking demand, that, same as speed, it was a variable which was very difficult to measure. It was not possible to express the demand in terms of the number of stalls required, merely because time requirement of each parking varied. Some people might require it for a short time, for purposes like shopping and some might require for a whole day. So, in between, there was quite a wide range of variation by way of time and also in the number of parking spaces. So, in measuring parking demand, two or three methods were commonly employed, one was the cordon count and the other a site interview at the parked vehicle. Both were time consuming and the time taken in conducting the investigation of either type defeated the very accuracy needed in measuring the parking demand. The time interval of cordon count adopted in the case under discussion for assessing the accumulation of vehicles, viz., 2 hours, seemed to be much too large. In fact, the cordon should also be so small as to eliminate the problem of moving vehicles to a great degree, so that the accumulation in each cordon was precisely known. He suggested that not more than 15 minutes' interval should be taken for assessing the accumulation of vehicles in each cordon. Even after that, the cordon count should be corrected for moving vehicles to properly assess the actual number of stall spaces required.

In regard to the question of preventing interference to the movement of vehicles while parking and leaving the parking stall, he suggested an alternative arrangement as shown in the sketch. It would be seen that, if it was possible to give access to the parking stall directly from the main road with exit only on to the service road, the question of extra manoeuvre for parking or leaving the stall both from the main road and the service road could be totally avoided.



At this stage when it had been definitely established that the demand had not outstripped the available space, it was too early or premature to introduce parking meters. Whenever parking meters were used, it should be out of necessity and the people should support such a move; but if there was no such justification, the move would become totally unpopular. Even if it was desired that because of close accessibility to some of the places like theatres, etc., the turnover of the parking should be increased, then he would suggest that use of meters should be restricted to areas which were very popularly used for such purposes.

Regarding the availability of parking meters, Shri Iyengar stated that he had an opportunity to discuss the problem at Bombay, where a real problem of parking existed. A British firm offered to instal and maintain all the parking meters in a locality at their own expense and maintain it over a period till they were able to realise the cost plus the interest on investment, and subsequently would hand over the assets to the local authorities. He thought that would be workable if it was possible to overcome the foreign exchange barrier. Possibly, there would be a number of firms from abroad interested in this investment. Also, parking meter was not such an intricate device which would not permit its manufacture in this country. He felt if some prototypes were copied by some firms, it was quite easy to manufacture these in this country.

The undue restriction on speed whether it was a service road or main road, for a man who was driving a motor vehicle was rather unreasonable. To expect him to keep to a very low limit of 5 m.p.h. was almost impracticable. Even a suggestion to restrict

speed upto 10 m.p.h. in very congested area was very difficult to enforce. As a matter of fact, the measurements of speed within an accuracy of about 10 m.p.h. even in the range of about 30 to 40 m.p.h. were found to be so inaccurate that enforcement authorities left a margin of about 10 m.p.h. before they prosecuted vehicles which had outstepped the speed limit. To enforce a speed limit of 5 m.p.h. was, therefore, something impossible for any agency. Under many conditions of congestion, the difficulty of movement would itself dictate the speed limit. If there were some reckless drivers under those conditions, they would only get involved in accidents and penalised. Putting a low speed limit was, therefore, both impracticable and inadvisable.

Shri R. P. Sikka stated that para 2.1 showed that field survey was carried out in June, 1959. There was no further indication that any other counts were also taken in some other month. In his opinion, a count taken only for one month, and that too particularly a summer month, did not truly reflect the correct amount of parking needs. It was well known that traffic requirements vary from season to season and from personal observations he felt that parking need in Delhi was far more acute in winter than in summer.

Again, to calculate the all-day parkers, it was stated in second sub-para on page 295 of the Paper that vehicles found parked at 9.00 a.m. as well as at 4.00 p.m. were taken to be all-day parkers. Now, while examining the curve given in Fig. 1, it was clear that the number of the parked vehicles increased rapidly between 10 and 11 a.m. The reason was obvious because so many persons coming to work to this area reached there about that time only. Therefore, proper time assumed for this purpose ought to have been between 10 to 11 a.m. Perhaps the Author would throw some light as to why 9 a.m. was the time chosen.

Again, in Fig. 4, it was not clearly indicated what was the procedure adopted to assess the future needs of traffic.

Second point was in regard to the parking meters. He felt that instead of suggesting the use of parking meters straightaway, there was need for proper education and for proper police enforcement.

The Author had overlooked the point that metering would amount to refusal to trade in areas where parking meters were employed if meter-free areas were also available nearby.

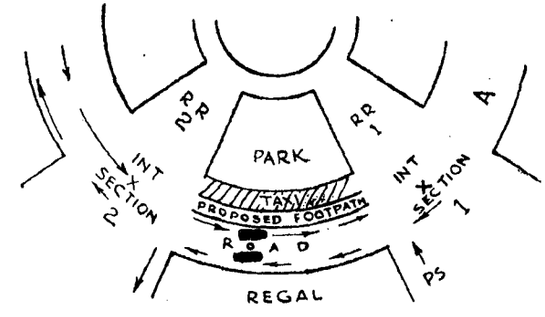
He found that in Connaught Place, parking spaces were not at all marked except faint lime-wash marks which were obliterated very soon. It would be better if parking lots were demarcated by painted lines or with studs. No parking zones

should also be marked on the pavements so that drivers knew fully well as to where they were required to park. The Author had suggested 45° angle of parking. They should also consider 60° parking. From studies, it was known that 60° parking would require about 9.2 ft of the kerb space whereas 45° parking required 11.3 ft space. 45° was better because it would require less manoeuverability, but where the roads were wide particularly in Cannaught Place, say, 55 ft wide, then 60° parking would require only 36 ft of manoeuverability while still leaving 19 ft of space for traffic. Further, where traffic was one-way only, 60° parking should be considered. By that, the space for parking would increase by another 20 per cent.

Shri Sikka also desired that the Author should clarify the first suggestion made in para 4.6.2 as he felt that it had no connection with the parking problem at all. He would also like to know the object of Plate II.

In the end, he suggested that all slow vehicles should be excluded from the Connaught Place and Connaught Circus areas altogether and that for tongas and motor cycle rickshaws, parking spaces should be provided outside the central area. Secondly, all the heavy vehicles should be banned from the area from 8 a.m. to 8 p.m.

Shri P. J. Rao referring to para 3.1., page 295, requested the Author to throw light on whether Monday through Friday counts were taken at a stretch or scattered over a longer period to get an overall picture of the problem.



Coming to page 307, para 4.6.2, sub-para (2), he stated that the stretch of road opposite Regal was very short in length and was controlled at both ends by automatically controlled intersections. Major fraction of traffic from Parliament Street and from

portion (A) travels on the road opposite Regal, only a little fraction going to the Radial Road No. 1.

If that traffic was not cleared before the traffic from subsequent cycle reached this road, cycle failure would result and such failures on that stretch of road were not uncommon.

Shri T. S. Khanna replying on behalf of the Author to the comments made by **Shri Thillainayagam** stated that no traffic volume survey was carried out and that it was also not necessary. What had been pointed out was that the Origin and Destination survey carried out a year earlier showed that the area had the heaviest parking demand, and from that they chose that area for a sample study.

His second point was that curves did not show whether it was for week days or for Saturdays. Curves were for week days and it had been pointed out in the body of the Paper that for Saturdays counts were not taken in the morning but in the evening when the rush was the heaviest.

The information about the duration of parking which the speaker had not been able to find out was available in Plate III printed in the Paper but that might not be very clear.

Referring to the question of curb lengths, Shri Khanna stated that the main idea of the Paper was not to give the kerb length but to introduce a new philosophy that short-time parkers park nearer their destination and long-time parkers farther away. Detail of parking spaces were worked out on a bigger scale but had not been included in the Paper as they would be too voluminous.

On the question of zoning ordinance, he felt that it was alright in areas which were to be built yet, but in already built-up areas zoning ordinance could hardly do anything. However, it was good advice which should be incorporated for future buildings.

He agreed that parking meters were not manufactured in India at present but some start was necessary. Some firms from abroad were likely to come forward to instal meters. It is, however expected that firms in India would be ready to manufacture the parking meters whenever there was demand for them.

He appreciated the point of the speaker that whenever parking restriction was imposed, it was necessary to mark it by means signs or by means of line markings, etc., and they had already taken care of it by suggesting putting in of yellow colour on the kerb indicate no-parking zone. That meant that as long as there was yellow colour, no one should park his vehicle within that area.

Shri Saparamado from Ceylon had made some comments as to how Fig. 4 showed the parking demand. The parking demand had been shown by the survey that had been carried out. They were not showing an estimate of the future demand but were indicating the present demand. They were taking care of the future, by providing about 25 per cent more.

Regarding rates for feeding the parking meters, Shri Khanna appreciated the suggestion made by the speaker and thought it would be worthwhile considering them and revising the rates, if necessary. He would, however, point out that a person could go back and again put in some money and use that parking meter for 4 hours instead of 2 hours. But that should not be expected from busy people. Moreover, that was illegal.

Regarding utilization of off-street spaces for parking, Shri Khanna stated that they had already explored the possibilities of finding suitable sites and a number of off-street parking sites had been made use of.

The speed limit of 5 miles per hour had been misunderstood. It was only intended for off-street parking lots available in Connaught Place and Connaught Circus areas and not on the main roads and he felt it was fairly reasonable because when people came out after parking, they came out of blind spots and the vehicles moving at a higher speed were likely to hurt the so converted pedestrians. **Shri Iyengar** had pointed out that 10 m.p.h. relaxation was given while enforcing speed restriction. It was not 10 m.p.h. relaxation given in all areas, in urban areas 5 m.p.h., in rural areas 10 m.p.h. and in parking lots no relaxation.

Shri Pillai had suggested multi-storeyed parking buildings. He thought it was too premature to start thinking of that, particularly in the area under consideration.

He had pointed out that vehicles should not be parked on all roads. Care had been taken to see that vehicles were not parked on congested roads, but it was felt that there were not many roads which were so congested in that area not permitting parking at all. Accordingly, on some roads it was only one side parking and on other roads it was two-side parking. But as the demand for traffic volume would increase, parking might have to be prohibited completely on both sides. That would be a very severe restriction; but it might be alright during particular hours.

Then he had pointed out that rates of parking were too low, whereas another school of thought might say that there should be no further fees charged from the motorists as they were already heavily taxed.

Shri Iyenggr had pointed out that no parking problem existed in the areas as pointed out by the study. It was not that there were only 30,000 vehicles and there was so much more space to park them that there was no problem. It was the concentration of vehicles wanting to go to a particular place that had created the problem and not the total space or the total volume of vehicles. From that point of view he could assure Shri Iyengar that the problem did exist as people normally wanted to clog on to a few places which were very busy.

Service road parking idea was good as pointed out by him. That had been taken care of as the parking lots were right along the main roads.

He also pointed out that meters should be used only in areas which were popularly used for parking. It was not possible to use 10 or 15 parking meters; it was necessary to cover a particular area and that area should be a sort of integrated one. If only 20 parking meters were used, nobody would park on the parking meters and they could find spaces elsewhere. Either the barest minimum of meters should be installed or they need not be introduced at all and they had found that the barest minimum number came to about 1,000 meters.

Shri Khanna agreed with **Shri Sikka** that there was seasonal variations of parking. But as he had already explained it was not necessary to be very exact in this matter.

Shri Sikka had pointed out that on page 295, second sub-para, vehicles parked on the road from 9 a.m. to 4 p.m. were taken all-day parkers. It was not true. The third sentence was only a misprint.

Shri Sikka had suggested 60° angle parking. That had been taken care of too. It had been examined as to which would fit in best in certain areas and give the maximum capacity for parking.

Shri Sikka had further suggested a ban on slow moving vehicles and a ban on heavy vehicles. Slow moving vehicles had to some extent already been banned—bullock-carts were not allowed in Connaught Place area, but there was no ban on tongas. There was no severe restriction on heavy motor vehicles. Shri Khanna said that lot of problems could be solved by introducing restrictions but the main approach should be to solve the problem with minimum of restrictions.

Referring to **Shri Rao's** query as to whether counts were completed in one week or scattered over a longer period, Shri Khanna mentioned that the idea was to take the count on typical days not necessarily confined in a week. The survey was not completed within one week. The particular survey took about 45 days, one reason being the shortage of trained personnel. Besides, it was considered that if more men were employed, more mistakes would creep in.

Shri Joginder Lal (Author) in his written reply stated that the suggestion regarding parallel parking on the road-side, given by **Shri R. Thillainayagam** was all right. But it might be pointed out that, in the layout suggested, the question of parallel parking did not arise as parking on the trafficable width of the roads had been prohibited except on wide roads carrying one-way traffic.

As desired by **Shri D. N. Misra**, the Author mentioned that all night parkers were 215 out of which 181 were car parkers.

Regarding the clarification of suggestion made in para 4.6.2, desired by **Shri Sikka**, the Author stated that the two openings were being used as entrances and exit from the parking area to the intersections, which was totally undesirable as such entrances or exits decreased the efficiency of the main intersections.

The Author further stated that Plate II showed the parking demand and parking spaces proposed in each of the block and one could at a glance find that the distance from the parking places to the places of visit was not more than one block.

Shri S. N. Gupta (Chairman) in his concluding remarks stated that the Author had focussed the attention of the highway engineers to a very important problem. Knowledge in traffic engineering was very much essential for proper highway planning and Madras had definitely given a very good lead by creating a Traffic Engineering cell in the Highway Department. He believed that that would be followed by other States also. At present, the city police do not have adequate knowledge in traffic engineering and act as the traffic engineer. That is not a very happy arrangement.

A very interesting discussion had taken place on the Paper and Shri Khanna had given very lucid replies to various comments raised by members. The Chairman thanked the various speakers, particularly Shri Saparamado from Ceylon who took keen interest in the discussion.

Discussion on

" General Report on Road Research in India, 1959-1960* "

Friday and Saturday, January 6 and 7, 1961.

Shri U. J. Bhatt (Chairman) in his opening remarks explained that discussions on General Report on Road Research have been very stimulating and useful. It had now become an important feature of every Annual Session of the Indian Roads Congress. He hoped that all road research laboratories in the country would ensure that their reports were sent to the Indian Roads Congress in time so that it was possible to present to the Highway Engineers complete information about the road research work done in the country This would also help the laboratories in avoiding duplication of work.

RIGID PAVEMENTS

Shri S. N. Sinha stated that, in Bihar, they were very much interested in the matter of partial replacement of cement by soil and would have liked very fine sand such as taken from the River Ganges being used in the cement mortar. The availability of good sand had been a problem in large tracts of Bihar, especially in the area north of Ganges where all the rivers carried fine sand and in some places it was micaceous too. The necessity for utilizing this sand in cement mortar was manifest in view of the fact that the cement required had to be transported from distances of 150 miles or even 200 miles south of the Ganges in several important works Some work was undertaken in the laboratory at Patna on the use of fine sand. Although they had not been able to formulate any conclusive results, but it was seen that there was deterioration in the strength of the cement mortar by the total replacement of good sand by local sand. They had been trying to attempt the use of mixture of fine sand and coarse sand to get good results. Shri Sinha added that they were particularly interested in the report from Madras Research Station stating that there had not only been increase in the workability but also in the strength of the mortar, by partial replacement of sand by loamy soil and would like to know the chemical and physical properties of the loamy soil which resulted in giving good strength or similar strength or improved strength for the cement mortar by partial replacement, i.e., upto 30 per cent and the results that they could get by the variation thereof as their own experience unfortunately did not warrant the use of very fine sand in cement mortar and cement concrete works.

*Published at pages 323—353 of Volume XXV-Part 3 of the Journal of the Indian Roads Congress, December 1960.

Dr. M. L. Puri pointed out a printing error in the first salient point on page 331 where instead of 'sand' 'cement' had been printed in the report. The results reported by the Madras Highways Research Station on the effect of partial replacement of sand by soil were very interesting. He requested some one from the Research Station to explain the results fully as the information available in their report was not enough. As the use of soil would increase the fines in the mortar, he expected that the mortar would be more susceptible to shrinkage than the ordinary ones. It would be interesting, therefore, to see how the results were obtained.

Referring to the second point for discussion regarding the advisability of using weigh batching instead of volume batching for cement concrete road construction, Dr. Puri said that the C.R.R.I. had carried out quality control in the field for the construction of experimental stretches on the Delhi-Mathura road and also for the construction of roads for the Heavy Electricals Ltd., Bhopal. In the former case, volume batching was used while at Bhopal weigh batching was resorted to. It was felt that exercise of any quality control when volume batching was used was well nigh impossible because of bulking of sand and due to the amount of bulking changing with the varying quantities of moisture from time to time on the same day. In the case of weigh batching, there was a preliminary objection that the speed of construction would be reduced. By proper organization of the work it was proved beyond doubt that there cannot be any handicap due to loss of speed. It would be interesting to know that the coefficient of variation for flexural strength beams cast at both the works was 8.4 per cent in the case of weigh batching and 17 per cent in the case of volume batching.

Now that small weigh batchers were being manufactured in India and were readily available, there was absolutely no reason why they should not make use of weigh batching compulsory for the construction of future concrete roads.

Dr. Puri stated that most of the concrete roads in the country which were constructed some 10 to 15 years back with thicknesses ranging from 3 to 4 inches were showing signs of distress due to the enormous increase in the number and the weight of vehicles. The problem was how to strengthen the existing pavements to keep them in serviceable condition to cater to the present as well as the future needs of traffic. The solution lay in overlaying new concrete slabs over the existing roads. This technique was tried in U.S.A as early as 1930 and still had wide application. For determining the thickness of overlays, the Portland Cement Association and Corps of Engineers of U.S.A. Army had recommended the empirical formulae. The slabs could either be bonded with the existing slabs or laid separate. The Americans were, however, more in favour of

bonded overlays because the thickness of unbonded overlays worked out to be much higher. Laboratory experiments carried out at the C.R.R.I. had shown that washing the old surface with dilute hydrochloric acid and the use of neat cement grout as the bonding media could create very satisfactory bond. In order to study the field performance of bonded concrete overlays, a short length on Hapur-Garhmukteswar road, with 3 in. thick pavement, was selected. The actual construction of 4 in. thick overlays on that road would be started shortly. The results of such experiments would show whether this technique could be applied for strengthening the existing thin pavements and also whether the concrete roads were amenable to stage construction.

Dr. Puri informed that several laboratories were requested by the Indian Roads Congress to conduct some laboratory experiments with air-entrained concrete. He wanted to know if such experiments were conducted and what were the results of such experiments.

Dr. I. S. Uppal stated that some time back they also carried out some experiments to replace sand completely with soil in connection with the plastering of mud houses in the Punjab and found that if a soil containing 50 per cent sand was used, it did increase the strength. But later on when they carried on the study after every 3 months it was found that after 9 months the compressive strength deteriorated. The addition of soil does improve not only the workability but also the permeability. When this plaster was applied to the pucca buildings they did not develop any cracks but their life was not very long.

Shri G. C. Gupta speaking on the question of partial replacement of sand by soil, stated that they carried out some work with lean cement concrete mixes. Actually this concrete was not designed for a cement concrete road but for the foundations of buildings. The sand used was local Gomti sand which had a fineness modulus of about 0.75. This was replaced by a non-cohesive soil, which was non-plastic and the material retained on 200 mesh sieve was about 45.5 per cent; the P.R.A. classification was A-4 and sieve analysis showed that the fraction (0.5 to 0.005 m.m.) was 23.4 and of clay a little less.

The results showed that if the soil was 20 to 30 per cent, there was an increase both in the compressive and flexural strength, besides increase in the workability.

Shri G. De (C.M.E. Kirkee) stated that they did some work on soil cement guniting with replacement of sand completely with soil and found that guniting, where sand was replaced in the proportion of 1 : 10 sand : cement gave very good results.

Shri C. L. N. Iyengar wanted to seek clarification on a few points.

On page 328, para 1.3.2, in regard to the efficiency of the various methods of mix design, he felt the scope of objective of the experiments was not fairly understood by the wording. He did not know what was the actual criteria for determining the efficiency of various mix designs. As far as he understood, the various data were based on ideal density curve, surface area method, workability, etc. All these methods were more or less empirical and lend themselves to comparison. The workability of any mix designed by any method in the field was more important than merely making a comparison of the mix in the office or in the laboratory.

Shri Iyengar stated that in regard to the treatment of soil by calcination to protect concrete from sulphate attack, the temperature was mentioned as 1000° C. which, he felt, would be difficult in actual practice. He wanted to know whether any alternatives like membrane, asphalt coating, etc., which were equally effective, were tried side by side and economy of these methods explored.

About the question of overlays, the report dealt mostly with the work on bonded overlays. He felt it was too premature to conclude under a certain set of conditions whether bonded overlay would be more efficient or unbonded and the two schools of thought were widely divided about this point. For example, on a very highly fractured pavement by bonding, as calculated by formulae, certain amount of thickness might be assessed, the tendency for cracking when the pavement was reconstructed might be more when it was bonded than when it was not. Probably on that very score alone some separation layer just like sheet-asphalt might be interposed between the bottom layer and the top layer.

Shri K. Ramaswamy Reddy informed that they did some work on replacing sand by soil at the instance of the Ministry of Transport but the same had not yet been completed.

In reply to one of the speakers who wanted to know the properties of the soil used, Shri Reddy stated that it was a sandy loam with about 4 per cent of clay, about 21 per cent silt and about 75 per cent sand. He also stated that with the details available now they did not recommend this for concrete work or for places where it was subjected to varying conditions of moisture or wetting.

Shri N. R. Srinivasan was glad to have the clarification from Shri Ramaswamy Reddy for it raised some of the basic questions, for instance, as per the I.S.I. specification for sand, the amount passing 200 sieve was something limited and by purposely putting a loamy soil up to the extent of 30 per cent they considerably exceeded the particular limit. He was, therefore, interested to know how in spite of this they could have good amount of workability, strength, etc. He felt more experimentation was needed to settle the question.

Regarding quality control, he said that this was often misunderstood as merely testing of the strength of the mix. It was not so. The operation started right from setting of the formwork up to the final completion of the finished surface with every operation properly controlled.

In regard to mechanization, Shri Srinivasan stated that it was very often misunderstood that it would always bring about considerable reduction in the labour. He would put it rather the other way. Actually, mechanization would help laying more roads per day and the notable change would be only that the percentage of the skilled labour to the unskilled labour would be diminished. Further, he did not recommend adoption of mehanized methods overnight, but to go about it gradually. As a matter of fact, mechanization was difficult with the type of equipment presently available in the country.

About the pavement design, which was a chronic problem, Brig. Bose brought out an interesting point regarding concrete pavement being laid over waterbound macadam, while Shri Nambiar suggested a compromise that only in places where waterbound macadam was not already existing, this method should be tried. It was not a very correct picture. As a matter of fact, even some of the present day specifications did provide 6 to 9. in. waterbound macadam even before putting a cement concrete surface. He thought that the time had come to seriously consider this problem. It had been very well proved, as stated by Brig. Bose, that in all experiments done in other countries also, the base just served the purpose of working surface only, provided a uniformity of bearing capacity, etc., was attained and did not help in the matter of additional strength to the concrete pavement.

Lastly, Shri Srinivasan stated that addition of calcined clay was not the only method of improving the resistance to sulphate action. As a matter of fact, the very basic thing was the production of good concrete and preventing the ground water from rising up and coming in contact with the concrete. For this, various methods had been suggested, for example, coating with bitumen membrane and then having a good dense concrete. All these things might be alright. But in this particular case use of burnt clay had been suggested for sulphate attack requirements, as it was something different from general pozzolanas and required slightly higher temperature of burning which gives increased resistance to the concrete against sulphate attack.

Dr. Bh. Subbaraju replying to various queries raised by Shri S. N. Saiha, informed him that the P.I. of the soil used in the Madras experiment was 15.9.

To the information given by Dr. Puri regarding the overlays, he wanted to add that in the C.R.R.I. they were also planning

flexible overlays over rigid pavements on Hapur-Garhmukteswar road. There the thickness arrived at according to the empirical formulae given by the Corps of Engineers, U.S.A., was rather on the high side, but if the thickness was calculated according to the design proposed by Brig. Bose in his Paper presented at Srinagar in 1955, there was considerable reduction in the thickness of the flexible overlays. Their interest was to find out which was the more reliable method.

Regarding the bonded and unbonded overlays, Shri C.L.N. Iyengar had raised a point worth considering. He would like to add for the information of the house that in the C.R.R.I. experiments were in progress on bonded and unbonded overlays and the criteria used for evaluating the strength of bonded and unbonded overlays was the flexural and the shear strength. The results of experiments indicated that in the case of unbonded overlays the flexural strength was as much as 50 per cent of the monolithic slabs, whereas in the case of bonded overlays with cement grout, the flexural strength was as much as 90 to 100 per cent of the monolithic slab.

Shri P. D. Shivdasani, referring to the experiments on flexible overlays on the Hapur-Garhmukteswar road being done by the C.R.R.I., stated that a lot of work had been done in other countries. Brig. Bose also said that flexible pavements had decided advantages over the concrete pavements. But most of the flexible pavements were of the premixed type using asphaltic concrete. He felt that flexible pavement of the penetration macadam type perhaps would give a better performance and reduce the reflection cracks which was a common feature in flexible overlays on rigid pavements. He suggested doing field experiments on one stretch with full grout and observe its performance.

Dr. Bh. Subbaraju, replying to Shri Shivdasani's suggestion of adopting the usual type of premixed as overlay over Garkmukteswar-Hapur road and to have full grout penetration, stated that it was not possible to go in for premixed method because it was impossible to mould a specimen with that open graded mix material. Actually, the overlay being laid was a dense carpet and they were going to determine the E value of the asphalt concrete being designed and the thickness was going to be controlled by the relative E value of the cement concrete and asphalt concrete.

Shri M. S. Venkatesan replying to the point raised by Shri C. L. N. Iyengar, stated that the object of the study of efficiency of various methods of mix design was to find out a design procedure which would not be cumbersome for the designer in the field when designing his concrete mixes and also it would give economical cement content. Later on, if no such method was possible, he should be able to evolve a new method of mix design embodying the various principles of other methods.

FLEXIBLE PAVEMENTS

Shri C. J. Fielder referred to para 2.1.2, on Surface Dressings describing some results obtained with the use of primer and RT-3 and stated that it was not clear what was meant by experimental test track, whether it was actually a test under road traffic conditions or whether it was a test track of the Majherhat type. The question of use of primer with tar was raised some time ago by Mr. Murrell who carried out some work in Bihar with primers and was enthusiastic about it. They tried to reproduce his results and included it in the programme of Majherhat Test Track. Under the climatic conditions there, he thought, the results recorded showed that the primed surface did not show any advantage and actually appeared to be less effective than the one without primer.

Referring to para 2.1.3. (ii), Road Tars, he stated that it was quite correct that the Germans have produced a specification for road tars having certain features different from those adopted in U.S.A., U.K. and India, and were mainly concerned with the heavy oil or anthracene oil content and pitch ratio. Shri Fielder had already written to the Railway Research Institute regarding the figures given in their report because he did not agree with the ratio which they had determined as he felt it required checking. He had not seen any recent reports as to why the anthracene oil content was given so much importance in Germany. It would be very interesting to know about it. The added advantages which might accrue on account of durability, he thought, might create difficulties over the setting time of the carpet or the surface dressing, in which case the structure might break up before the durability was able to come into effect. He suggested carrying out of actual experiments with the German type of road tar for comparison with those adopted in India under actual traffic conditions, so that they could get some idea of the relative effectiveness of the different road tars.

Regarding Low Temperature Tar, he was of opinion that in nc other country efforts have been made with success to turn low temperature tar into road tar. The fundamental difficulty was that low temperature tar due to its chemical nature was entirely different from the high temperature tars as the former was predominantly paraffinic in type and did not show the same durability under weathering conditions. He was not sure if the paraffinic base could be turned into an aromatic base by any simple means, as the fluxing of the pitch with high temperature tar oils was not going to improve the oil section of the tar. Low temperature tars with bitumen were tried in some of the experimental work done in the U.K. where they found that some of the rolled asphalt surfaces developed a very high degree of polish and became slippery. They incorporated the low temperature tar into the rolled asphalt with the object of encourag-

ing certain amount of oxidization on the surface to give them non-skid properties so that if the low temperature pitch was used without any bitumen, the whole thing would tend to oxidize and not just the skin.

Shri Sujan Singh referring to page 332, Design of Dense-graded Mixtures, wanted to know if the pavements designed by the C.R.R.I. for Heavy Electricals, Bhopal, on National Highway No. 47 and also for the Atomic Energy Commission, Bombay, had since been laid.

Regarding Surface Dressings, this subject has been dealt with at length by the I.R.C. and a series of experiments carried out at Alipore Test Track and later on National Highway near Agra. The results, as far as he understood, were that priming coat had no advantage if the metal was good. He would be interested to know if the new findings in any way over-ruled it or experiments were still to be conducted further.

Regarding Cold Fine Asphalt for Surfacing, Shri Sujan Singh stated that he had seen lot of work in other countries being done from the waste of the stone crusher quarries and strongly supported the idea of States doing more work of this type since the work done by the Madras Corporation had given good results and he understood that it was still standing very well.

In regard to the cutbacks, Shri Sujan Singh stated considerable work was done by him in Burmah-Shell to find suitable cutback, one or two for the entire country for summer and winter and that it was not found possible to have separate cutbacks for summer and winter though the cutbacks now supplied by the Oil Companies were produced after considerable experimentation. Certainly, fluxing on the site in a way was easy as one could change the percentage but it has its drawbacks. During war time, due to various reasons the suppliers suggested and also adopted fluxing of bitumen with fluxing oil on the site and found that always same results were not obtained. That was why it was preferred to have readymade stuff which was fluxed suitably in the plant where they were homogenously mixed. Besides, it was not stated in the report which is the fluxing oil the Authors had in mind. The fluxing oils normally used had more value in rupees than the bitumen and it had been the experience that whenever fluxing oil and the bitumen were supplied separately, the fluxing oil was usually pilfered from the road. So, before deciding this question, all the various points might be kept in consideration.

Regarding stripping of binder mentioned in the report, these were two entirely different types of strippings. In many countries, the agents used for the first type of stripping were not called anti-stripping agents, they were called only wetting agents because

stripping in the initial stages only happened due to lack of wetting of the aggregate by the binder. As the work had just started in India, it was better to separate and define them properly. In this report it was not clear what was the object of the experiments conducted. Shri Sujan Singh added that in other countries wherever he had been he made enquiries to find out what stripping agents they used and the advantages thereof. They all confirmed that they had yet to assess whether there was any advantage and how much. They were all using wetting agents and not anti-stripping agents. Anti-stripping agents were used only in very few cases. Regarding the use of lime, he stated that if lime was used in entirely dry aggregate and also Turkey Red oil with binder he was sure the result would not be satisfactory because of some moisture in the aggregate, as the chemical action would displace the water with lime acting as a filler and the oil staying on the top which would prevent the wetting rather than help in wetting. This was another point whether the object of using this agent was in the case of moisture or wet aggregates or for dry aggregates.

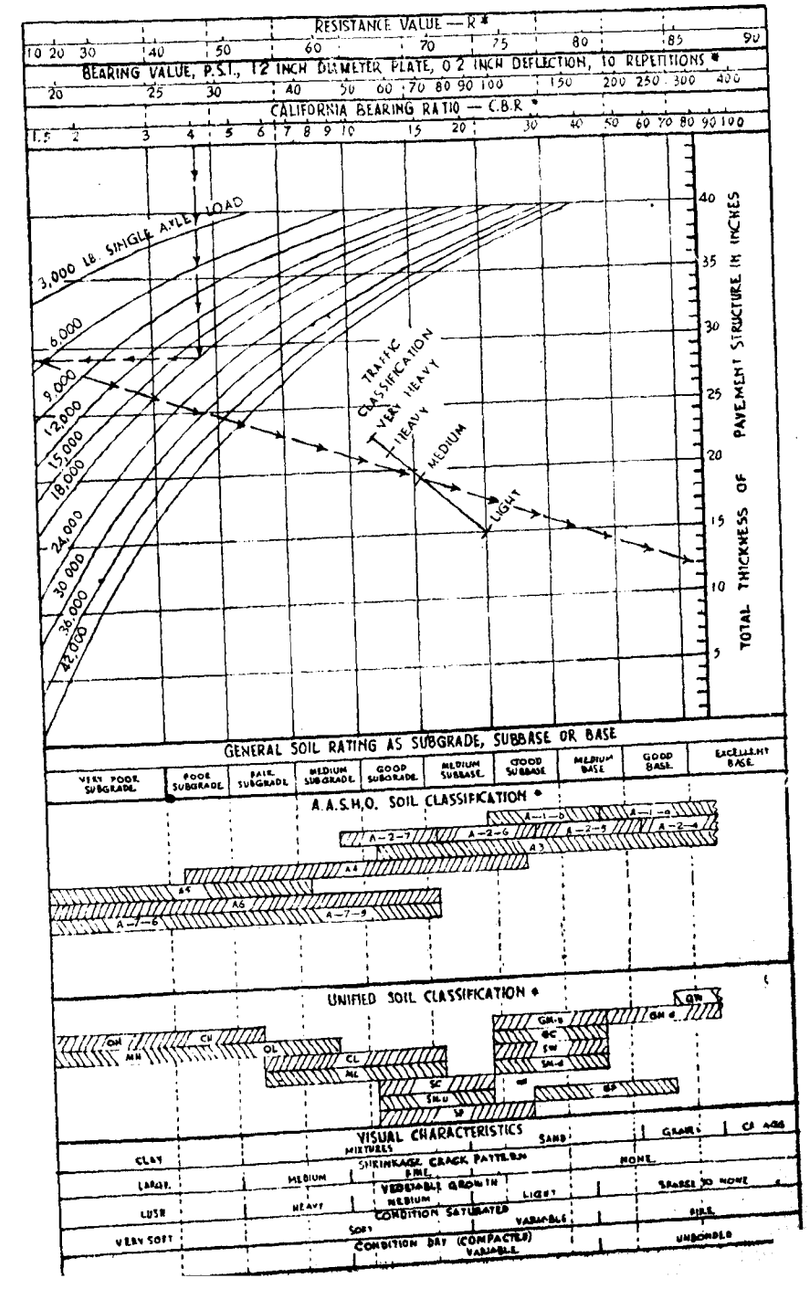
Coming to the advisability of laying dense carpets, Shri Sujan Singh stated that from experience it had been found that in some places dense carpets would definitely be of advantage and he strongly supported that these should be tried. The States had so far been rather hesitant in laying dense carpets and he was glad more and more encouragement was coming through the research notes.

Shri S. N. Sinha stated that so far as the total thickness of a flexible pavement was concerned, some work was done on the comparative study of the C.B.R. method and linear shrinkage method in the Laboratory at Patna and the results were more or less corroborative. Further work was in progress. An important school of thought had been that cohesion in the bituminous pavement was a very important requirement for a proper pavement design. The potential paths of individual particle movement would indicate the possibility of a failure of the top pavement unless it had sufficient cohesion in its constituents, especially in the case of a pavement which had to carry a heavy load.

In respect of the requirement of pavement structure, he suggested some work to be done in the light of the chart suggested by the Asphalt Institute of the United States of America in their pamphlet published in June, 1959, which was co-related not only to the traffic classification but also to the axle loading. The chart was also co-related to the A.A.S.H.O. and the unified soil classification as well as to the visual classification of the soil.

After studying some of the methods for the design of pavements in a few States in America and wherever the C.B.R. method of

Asphalt Institute Chart for Thickness Requirements for Pavement Structures



CLASSIFICATION OF TRAFFIC

Traffic Classification	Traffic Density Maximum, per lane, per day	
	Daily Volume of Passenger Cars and Light Trucks	Daily Volume of Commercial Trucks and Buses
Light	25	5
Medium	500	25
Heavy	Unlimited	250
Very Heavy	Unlimited	Unlimited

design was being used, the chart suggested by the Asphalt Institute had a more general application. It was found while calculating the thickness requirement of such a pavement that according to the Asphalt Institute chart a 13-in. thick pavement would do against 16 in. on the basis of the chart adopted by us. The rationality of the chart, suggested by the Asphalt Institute, was such that he was encouraged to suggest the application of this chart after proper investigation and correlation to our conditions.

In this connection, Shri Sinha mentioned the Paper presented by Shri Foster, Chief, Flexible Pavement Branch, and Shri Alhvein, Chief, Special Project Section, both of the Corps of Engineers, at the 37th Annual Meeting of the Highway Research Board, America which laid emphasis on field moisture studies and suggested that the thickness design procedure could be properly done if they were able to evaluate and estimate the C.B.R. which the soil would develop after it had been placed in the pavement system and the moisture content became adjusted to the weakest condition. Certain results, conducted by them, indicated that the four day soaking test was conservative for non-plastic or slightly plastic material but was about correct for plastic or very plastic materials.

Shri Sinha also referred to a Paper published in 1959 by Shri R. S. Millard on "Road Development in the Overseas Territories", to support his view that differences in moisture conditions had an enormous effect on the thickness of construction required. In Great Britain, where the water table does not vary greatly with the seasons, it could be resolved as a problem of statics. No such analysis was possible in the tropics where with

well defined wet and dry seasons, there was frequently no regular water table at all.

Dr. I. S. Uppal in reply to some of the points raised by Shri Sujan Singh, stated that actually the anti-stripping agent was not a very inappropriate word. More appropriately, they could be termed surface active agents rather than wetting agents. These anti-stripping agents were mainly recommended for the wet stones and not for dry stones, as they actually helped in coating the dry stones. Their main function, Dr. Uppal said, lies in displacing the water from the stone surface, and each molecule of these cationic chemicals had a little head which attached itself with force to the stone surface irrespective of presence of moisture on it. Elongated body of the molecule holds equally strongly to the binder, thus ensuring a solid coating with uninterrupted regular layer of binder. Dr. Uppal then described some of the anti-stripping agents used by them, viz., Adhevia-T which is known to everybody, Duomeen-T, Cationic Emulsifier. All these chemicals cost about Rs 4 to 10 per pound, which was very expensive. The main idea was to try some indigenous materials and hence Turkey Red Oil was in troduced, which could be prepared even at site.

Lime had also proved of great utility in stabilizing soils. If a cutback was not mixed in soil, generally it was not sufficient to make it water resistant which would absorb about 16 per cent of water. Even if Duomeen-T was kept in water for 10 days, it would not absorb more than 10 per cent of water.

Shri Bhupinder Singh stated that no doubt C.B.R. method had been commonly used for the design of flexible pavement, not only in India but even in the Western countries, and the limitations of this method had already been high-lighted in the Central Road Research Institute's Monograph No. 3. C.B.R. was an empirical method and often gave conservative thicknesses. Further, it gave quite unreliable results in case of silty and sandy subgrades. Therefore, he suggested that group index method might be more suitable where the subgrade was silty or sandy. Group index method gave less thickness than C.B.R. methods of design. He added that many organisations in the world had resorted to Plate Bearing Test method for designing flexible pavement, a review of which had already been given in Vol. 25, Poceedings, Highway Research Board, 1945. Plate Bearing Test was a convenient method to determine the actual bearing capacity of the subgrade on the pavement by using the plate of the same area as that of the wheel contact area. They had developed some suitable curves which gave the thickness of the pavement required over a subgrade of known bearing capacity. Some of the curves also included repetitions of loading unlike the C.B.R. curves. He also suggested that some correlation should be derived between C.B.R. in situ and Plate

Bearing Test. Of course, some correlation was worked out at C.R.R.I. when soil cement on a large scale was used as a material of construction in one of the heavy duty airfields in India. Still much work was required to be done on different types of soils which were normally met with in the subgrades of roads, though already some work in this direction was being done at the Central Road Research Institute. He hoped that other Research Organisations would do similar study.

Shri P. L. De stated that the designing of the thickness required for flexible pavement was very necessary for the durability and economy of the road. Though some standard thickness adopted for the entire length of a road in a particular region might be quite adequate for the major length of the road, there might be some portions of poor subgrade soil where the thickness provided might be inadequate, as a result of which the road might fail. Hence, the construction engineer must have some tools in his hands for the quick design of the thickness of pavement required for such bad types of subgrade soil. The well known methods of pavement design, viz., C.B.R. method, Plate load test method, Group Index method etc., which the previous speakers discussed had their advantages and limitations. But all the methods required a properly equipped laboratory for testing and wercalso time consuming. In such cases, in his opinion, the "Linear shrinkage method" was the simplest and at the same time quickest method.

Regarding the study of pavement performance, Shri De stated that, in West Bengal, this study was being made, as far as possible, wherever the roads gave signs of failure. Several such examples of the study had been described in Paper No. 224 already discussed at the current Session.

Shri Z.S. Shah referring to the statement on page 329, that the C.R.R.I. was using foundry slag, at least experimentally, for soling and water-bound macadam construction, stated that blast furnace slag was being used in U.K. and Germany for bituminous open textured constructions for some years now and perhaps the C.R.R.I. would like to undertake tests to use this material as bituminous aggregate. In his opinion, this would be useful for those areas, like Jamshedpur, where slag was available in good quantity and stone aggregate not so freely available.

In regard to the suggestion of the C.R.R.I. for adopting semi-dense carpets in cases of lack of equipment, Shri Shah observed that their own organization for the same reason had been suggesting such carpets depending on a sort of rule-of-thumb method for some years now and some carpets so laid have been standing well for the last 15 to 20 years. They were ready to give any details required by the C.R.R.I. in this connection.

As regards anti-stripping agents, there was in 1957 a Committee of the Indian Roads Congress dealing with this subject. Perhaps the work done by that Committee would be of help in future experiments.

Shri M. B. Jaywant observed that the choice of a particular type of asphaltic wearing surface depended on traffic, climate, availability of aggregates and the availability of equipment. It was an established fact that dense graded surface would give better results as compared to the present specification of open graded carpets or even "stone sand crete surfaces". For want of laboratory facilities and the hot mix plants, it had not so far been possible to adopt the dense graded mix. But strangely enough, the report suggested going in for a semi-dense surface even when all these facilities and equipment were available. The report was probably based on the findings of the Paper on this subject read in the last session, wherein the addition of a filler was not recommended. It might, however, be possible in many other locations to obtain fillers at economical rates and, in some instances, to get a dense mix even without the addition of a filler. It was, therefore, not logical to conclude that semi-dense carpets should be adopted when all the equipment, such as mix plant and the spreader finisher etc. were available. The semi-dense mixes had their own place as base courses or binder courses or even surface courses in certain climatic conditions. Further, the mix criteria given on page 336, specified a stability of less than 500 which would not be suitable except for light traffic and the flow value was a significant omission in the report.

Regarding addition of flux oils to cutbacks for surface dressing, Shri Jaywant said, this needed further clarification. The type of cutback required for surface dressing depended not only on atmospheric temperature but also the size of aggregate. With the help of the temperature viscosity chart for various cutbacks and aggregate sizes plotted on the same, the suitable viscosity of a binder could be determined under given weather conditions and aggregate sizes.

As for any binder there was an optimum viscosity for surface dressing under given weather conditions, it would, therefore, be more logical to specify viscosity of binder for given atmospheric temperatures. The desired viscosity could be achieved not only by flux oil but also by heating the cutback to the required temperature. It would be a good practice to standardize one or two grades in each of the RC, MC, and SC groups and then modify the cutback at site provided adequate mixing and testing facilities were available, and the working conditions so demanded. However, the criteria for the quantity and type of flux to be added should be more clearly defined. The grade of flux oil would also have a definite effect on the properties of the binder such as rapid curing

or medium curing and hence one flux oil could be specified for all cutbacks used for surface dressing.

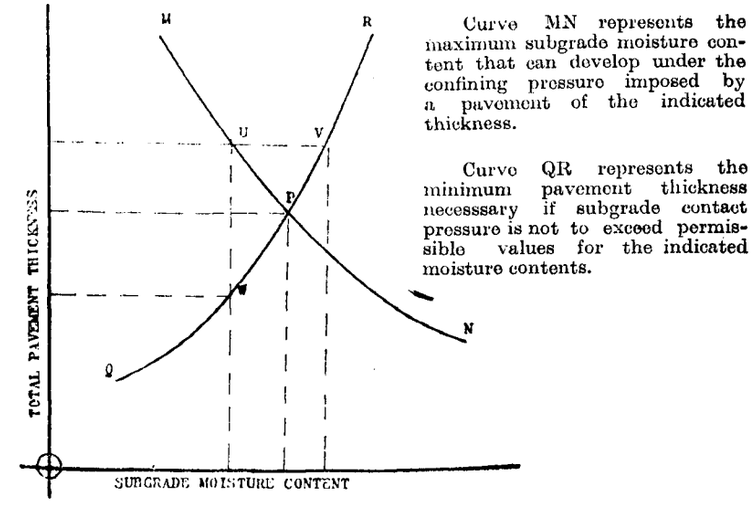
Shri G. C. Khanna, at the outset, commended the sessions of the I.R.C., where research problems were discussed, and the Highway Engineers had an opportunity for refreshing their knowledge of modern techniques in design and construction.

In order to keep the Highway Engineers interested in the subject of research, he suggested that the report on road research in India should be circulated atleast a month ahead so that members could study it in detail. Further, the booklet was very brief and some of the subjects to be discussed some time got beyond comprehension, for instance, specifications and problems regarding dense carpets. It would be a great help if this booklet was prepared in greater detail and definition given in the form of appendix, so that practical engineers could also take greater interest. Research work being primarily intended to benefit practical engineers, should be written in a language which they could understand.

Shri Khanna added that research should be carried out on subjects of practical benefit to the engineers, as he felt that too much stress had been laid on research on carpets which were beyond the means of any State Highway official. About 99 per cent of roads in the Punjab were surface dressed and this practice had been going on for the last 20 years. The specifications for surface dressing were simple and easy to adopt, but in hills where working season was limited to 3 months or so, much progress was not possible due either to heavy rains or excessive cold weather. He suggested that the Central Road Research Institute should draft specifications so that work for about 8 to 9 months during the year could be done in order to complete the road programme.

Prof. Robert G. Hennes commenting on para 2.1.1, Design of (Flexible) Pavement Thickness, stated that much of discussion here dealt with C.B.R., Linear Shrinkage, and Group Index methods for the determination of the proper thickness of flexible pavements with bituminous surfacing. It was interesting to observe that this topic was as controversial in this part of the world as it was in his homeland. Flexible pavement design practices among the Western American States had developed along different lines from those prevailing in the eastern half of the U.S.A., and invited the attention of the house to the "Stabilometer Method". He explained that in the accompanying sketch, the curve MN indicated in a general way how the swelling of the subgrade soil was controlled by the weight of the superimposed pavement structure. During the monsoon, a subgrade loaded down with twelve inches of road metal could not become as wet (and soft) as the same soil sustaining only six inches of overburden.

Curve QR, on the other hand, indicated that softer (wetter) soils theuired a greater thickness of pavement to be interposed between the tyre and the natural soil, so that the wheel load spread over a



larger area of subgrade, with consequent reduction of the induced contact pressures to values compatible with the bearing capacity of load the rain-softened soil.

If pavement thickness were to be selected solely on the criterion that the subgrade contact pressure must be reduced to some arbitrarily standardized value, as in the C.B.R. test, then the resulting pavement thickness corresponding to some point V on curve QR could be sufficient to restrain the moisture content of the subgrade (as demonstrated by point U on curve MN) from ever attaining the assumed value. Actually, at the water content compatible with the pavement thickness of point U, nearly double the thickness required (see point W on QR) could be had to adequately distribute the wheel over the confined subgrade surface.

A balanced design was to be achieved only at the intersection of the lines MN and QR. At point P, the pavement thickness was sufficient to spread the wheel load over a subgrade whose water content could not exceed the value compatible with that same thickness. In theory, at least, no other method of pavement design could result in a better combination of safety and economy, if wheel load distribution and soil swell were accepted to be the governing factors. The merits of this design procedure, he said, certainly

warranted the thoughtful consideration of highway engineers everywhere.

Continuing, Prof. Hennes remarked that, repetitional loading sometimes caused the densification of underlying soil strata whose influence was not recognised in the procedure described above. Moreover, the laboratory determination of curves MN and QR must always involve some arbitrary assumptions and decisions. However rational the basis for road design, a considerable element of empiricism must be introduced to achieve workable procedures, and these must be correlated with actual highway experience under the conditions prevailing in any specific geographic region. For this reason, as well as for lack of time, it was not possible, he said, to discuss the stabilometer and swell tests that provided the data for constructing curves QR and MN, nor the cohesiometer and exudation tests that had also been developed in California to supplement the stabilometer. These also were deserving of consideration, but it was the fundamental principle illustrated in the sketch that, he believed, warranted special emphasis, irrespective of the technical procedures employed to establish the corresponding physical relationships.

Referring to para 2.1.3. (ii) on Analysis of Road Tars, where Shri Fielder pointed out that the incorporation of anthracene oil in tars should not be given too much importance as an excess of anthracene oil would make the tar very slow-setting, **Shri P. M. Varma** stated that those who advocated the use of anthracene oil to impart a longer life to the tar did not do so without any consideration to the setting qualities of the tar. In fact, certain quantities of light and middle oils were added in addition to anthracene to control the setting of tars.

Shri Varma agreed with his suggestion to C.R.R.I., about performing field experiments with road tars of varying pitch to anthracene oil ratio, and hoped the Institute would consider the proposal favourably.

Regarding para 2.1.3. (v) Low-temperature tar, he felt that Shri Fielder seemed to be too sceptical about the possibilities of low-temperature tar being processed into a durable road binder and that probably no country in the world makes road binders from low-temperature tar. In this connection, Shri Varma liked to point out that a test track with low-temperature tar was already being planned by the C.R.R.I., and the results of this test track would show whether or not the road binders made from low-temperature tar were worthy to be used. If other countries had not gone in for this proposal, it was not because low-temperature tar gave a worthless road binder, but because their chemical industries were so advanced that the low-temperature tar found a better and more valuable use

in chemical industries. In India, the problem was somewhat different. The Government of India had planned to set up a number of low-temperature coal carbonisation units all over the country. According to an estimate, nearly 5 million tons of low-temperature tar would be produced by 1970 as a by-product, the proper utilisation of which was vital to make the soft-coke production an economic proposition. Thus in the absence of suitable chemical industries in this country, road tar could be a valuable outlet for this tar.

Dr. H. L. Uppal replying to **Shri S. N. Sinha's** comment on the design aspect of the flexible pavements with a particular subgrade moisture, stated that it was not only important for engineers to know what moisture the subgrade had when putting up a road but also the highest moisture the subgrade was likely to have during the lifetime of the road, and not for an year or two. Regarding his reference to work in progress in the R.R.L., Harmondsworth, Dr. Uppal stated that the results of the Road Research Laboratory were based only on particular type of conditions such as temperature, subgrade as well as atmospheric condition, a certain type of clay deposit and a very little fluctuation in the water table. Those conditions could not be applied to India and, therefore, the C.R.R.I. started working on this problem to provide an answer to this very serious problem. They found that conditions were still worse here because whereas in England by just finding out the laboratory test they could find out the moisture content characteristics and from the known water table in the field could calculate moisture content to which the different soils would be subjected, but it was more difficult in India. As a result of few years study it had now been decided that certain areas did get saturated during the worst part of the year and, therefore, the design had to be based on those worst conditions. But in large majority of areas, the saturation varied something between about 20 to 40 to 60 per cent for a particular fixed water table. Dr. Uppal also stated that even though in England they were able to predict the likely moisture content in the seal prevalent on the depth of water table, the same procedure was not found applicable under Indian conditions for the simple reason that continued rise and fall of water table will leave the subgrade at a higher moisture though the depth of water-table was the same. But so far as the division of India into degrees of saturation of the subgrade was concerned, Dr. Uppal stated that the information had already been sent to the Indian Roads Congress.

Shri S. Radhakrishnan observed that whereas some of the previous speakers had favoured selection of design of the flexible pavement by C.B.R. method, others had insisted on the linear shrinkage method. In this connection, he referred to a statement by Dr. Glanville, Director of Road Research Laboratory, Harmonds-

worth, who after explaning the various methods of flexible pavements had quoted that the design of flexible pavements was in a state of confusion, and stated that even though there were innumerable methods available, as already pointed out by previous speakers, some of the methods were not at all suitable as they erroneously gave either high or low values. He entirely agreed with one of the speakers that the C.B.R. was always on the conservative side. He added that on the instance of the Ministry of Transport they conducted lot of tests on the correlation between the linear shrinkage method and the C.B.R. method for the design of flexible pavements. Subgrade soil samples were taken from throughout the State, not only from the new roads but also from the existing roads, and the thickness of the pavement was designed both by the C.B.R. as well as by the linear shrinkage method. So far about 100 to 120 samples had been tested. In this connection, he stated that as far as the highly plastic soils were concerned, the C.B.R. was giving enormously high values whereas for other non-plastic soils the C.B.R. had given good values. The linear shrinkage method had not given any correlation. He would, therefore, be interested to know the details from the gentleman who also carried out lots of tests and found out a correlation between the two. This indicated that the selection of a proper method for the pavement design should not be taken as a universal criterion but it should depend upon soil subgrade properties, and also be based on the judgment and experience of the field engineer at site. So, whenever a new design was taken up they should also look upon the existing pavements and the pavements which had given satisfactory performance.

Shri D. R. Kohli observed, referring to the viewpoints put forward regarding various methods advocated by different people, that it appeared that a rational method of desiging flexible pavements had not yet been attempted very seriously. As far as the C.B.R. method was concerned, there at least one thing was certain, no matter what was the thickness designe, it would not permit increase or decrease in the thickness required as per design curves, even though the Asphalt Institute had made *ad hoc* recommendation that in the case of a bituminous base course, as against the conventional base course, certain reduction could be made. During the last 4 or 5 years, lot of work was done in Holland, France, England, and a team of research workers in France was also trying to analyse the complex equation evolved by Burmister, to possibly find a solution by electronic apparatus. Another machine was developed at the laboratory in Holland known as "The Dynamic Testing Equipment", which simulated the condition of actual behaviour of a road under moving vehicles. So, with the combination of both these machines they were able to evolve a tentative set of curves using 2-layer system evolved by Burmister, and this tentative design made it possible to draw curves only for a particular type of traffic, i.e.

to motorway standard, whereby the construction thickness could be reduced to permit the design of a road or runway on more rational methematical design basis than on empirical C.B.R. design method. The main difficulty was that they were not able to actually measure the elastic modulii of either asphaltic mixes or granular mixes. Quite a lot of development work was done towards finding the stiffness or elastic modulus first of asphaltic dense types of mixes and then of granular base courses and it was quite likely that, in about another six months to a year, another revised set of curves might be presented to give direct measurement or relationship of thickness of two layers as against their elastic modulii. The complete data about the method briefly described, he added, was available in the booklet entitled "Bituminous Base Courses".

Regrading the mention made earlier about tar and bitumen mixtures to the extent of 50 per cent tar and 50 per cent bitumen, Shri Kohli stated that in Germany they had used a large quantity of tar and bitumen mixes. But when they wanted to put higher proportion of tar or bitumen, they used a specially prepared asphalt having a certain aromatic added to it to increase the aromaticity of bitumen, as otherwise normal tar with about 20 per cent of bitumen would not be miscible.

Shri C. G. Swaminathan replying to Shri G. C. Khanna's suggestion, that the C.R.R.I. should see that greater work in the laboratory was done by which the surface dressing work became cheaper, referred him to paras 2.1.2 and 2.1.3 wherein he would find that quite a good deal of work on surface dressing was being done by the C.R.R.I. As a matter of fact, on 11 furlong stretch of Delhi-Mathura road, about 44 specifications of surface dressing were laid down about 20 months ago and the data were still being processed in the Institute and would be available to the engineers in the country shortly. In the meantime, some of the preliminary information obtained from the performance and behaviour of the surfacings was given in para 2.1.2. Agreeing that there has been controversy regarding the use of primer, Shri Swaminathan stated that many of the text books on highway engineering hold primer as a must, but in 2 or 3 reports based on actual field performance in this country, an impression was gained that primed and unprimed surfaces behaved alike. In this particular stretch, he added, the priming was done on a newly laid water-bound macadam and it was found that when spraying was done with binder, a much better spread was obtained on the primed surface than on the unprimed one. Later on, after a period of about 12 months or so, the behaviour of the primed sections as against the behaviour of the unprimed sections, was found to be quite well indeed, the quantity of binder and aggregate size being the same.

Regarding the cutbacks, perhaps he should not have used the word 'cutbacks' when referring to the fluxed bitumen. It was not their idea at all to go on adding fluxing oil to ordinary existing cutback. The main idea was to give sufficient fluidity to the straight-run bitumen by fluxing oils from 2 to 14 per cent. One of the speakers said that it was not the pavement temperature that mattered in the proper choice of the cutback or addition of fluxing oil to the cutback, but also the size of the chipping, *viz.*, 5/8 in. down to $\frac{1}{8}$ inch. Perhaps it was true that in the case of multiples of sizes in vogue in this country, most of the time they used sizes of $\frac{1}{2}$ in. and 3/8 in. It was obvious that the most important factor which should govern the choice of the binder was the pavement temperature so as to simulate field temperature corresponding to the time when it was laid, *viz.*, in October or in March. In this connection, he stated that very often the plant was dead more or less for nearly 8 months in the year. In order to lengthen the duration of construction so far as the surfacing jobs go, a series of experiments were done in the C.R.R.I. varying the pavement temperature from 60°F. (October temperature) to 140°F. which was more or less mid-summer temperature. They took the base material of 80/100 penetration at 350°F. and spread it on a pavement with temperatures varying from 60°F. to 140°F. It was found within a period of 10 minutes or so that as soon as the hot binder came into contact with the pavement, the temperature dropped down. If chippings were spread when the bitumen was at 350°F., sufficient fluidity and much better adhesion could be obtained. It was also found that by adding 20 per cent of kerosene oil, much better performance was gained.

Shri Swaminathan pointed out to a printing mistake in the data given on page 336; the Marshal stability should not be equal to or less than 500 but equal to and more than 500 and that the percentage of voids should be 7.5 and 12 per cent in the case of field samples. In this connection, he referred to the comments of a speaker that if lot of equipment was available, why not go in for the dense mix itself. Cost of filler was not the criterion at all. If the filler was not available, cement could be added. Addition of 5 per cent cement was successfully tried in one of the taxiways near Agra.

Lastly, regarding tar and bitumen mixtures, in Germany, where about 25 to 30 per cent of tar and bitumen had been incorporated in the mixture, he observed that it was in the case of high temperature tars only. The C.R.R.I. reference, as stated on page 337, related to the blending of low temperature tars and bitumen in a proportion of 50:50 and no separation was found there.

Shri U. J. Bhatt (Chairman), in winding up the discussion on the first day suggested continuing of the session as the completo

report had not been disposed of. He requested the organizers to provide sufficient time for the discussion of this very important subject.

He thanked Shri S. R. Mehra, Director, Central Road Research Institute, and his associates for the excellent compilation, and requested them to bear in mind Shri Khanna's suggestion asking the I.R.C. to send this report well in time to the members for study so that they could come prepared with their comments and suggestions. The Chairman also reiterated Shri Mehra's suggestion to the various laboratories to send in their reports sufficiently early to enable the C.R.R.I. to incorporate the same in the final report.

SOIL ROADS INCLUDING STABILIZATION

Shri L. R. Chadda wanted to make a suggestion to various Research Organisations in India for conducting field trials with lime treated clay and while carrying out these experiments they should not ignore the basic concepts of lime-soil stabilization.

Some recent laboratory experiments carried out in the Central Road Research Institute with black cotton soil had shown that the lime treatment had a fundamental limitation. It was observed that mechanical improvement produced with lime in black cotton soil could be maintained only under favourable moisture conditions. Effectiveness of lime treatment in the road sub-base or base was likely to be reduced with wetting and drying as a result of fluctuation in water table. What was true in black cotton soil should be true with other clays too, for the simple reason that the mechanism of reaction was almost similar except that with montmorillonite clays the rate of reaction was rapid and with kaolinite clays rather slow.

Shri Chadda concluded that, in making this statement, the value of lime in soil stabilization was in no way under-rated. In fact, it had proved to be an excellent stabilizer especially for black cotton soils, because with 5–10 per cent lime it was possible to harden rapidly black cotton soil giving a C.B.R. value of 25–30 at moisture content of 50–60 per cent. But this hardness could be maintained only under suitable subsoil water conditions.

Mechanical Stabilization

Shri Bhupinder Singh inviting reference to para 2.2.3 on page 340 stated that Highways Research Station, Madras, had claimed that there was no decrease in C.B.R. value when soil gravel mixtures were treated either with Rc-3, cement or lime, etc., and hence

apparently no case for the stabilization of soil gravels either with Rc-3, cement or lime which was contrary to their own statement in para 2.2.7 on page 342 under the heading of Bituminous Stabilization. Work carried out in some of the Western countries and Western African countries had shown that it was becoming a common practice with them to use cement or lime in conjunction with soil gravel for the construction of roads for higher traffic intensities. He desired to know from Highway Research Station, Madras, the consistency limits and gradation of the soil gravel mixture which they had used and what percentage of lime or cement was added to such mixtures.

Criteria for cement content

Referring to page 341, para 2.2.5, wherein Highways Research Station, Madras had suggested that a minimum compressive strength of 400 psi might be adopted instead of 250 psi which was a generally accepted procedure and recommended by A.S.T.M., he could not understand this deviation from the standard practice adopted for soil-cement mixtures. This fixing of 250 psi as minimum compressive strength, if he was not mistaken, had been fixed after an exhaustive study for almost all types of soils with an explanation that as soon as cement soil mixture after compaction attains 250 psi as minimum strength would resist the cycles of wetting and drying and loss in disintegration would not be more than 7 per cent. And it had also been claimed by S.K. Web from U.K. that high compressive strengths of soil cement mixtures, say, of the order of 400 psi and above, were detrimental because of shrinkage cracks which were likely to develop and had thus justified 250 psi as the requirement.

Shri S. Radhakrishnan referring to stabilization with cement added that if initially 5 per cent cement was added to a soil of P.I. of about 20 to 25, it gave a compressive strength value of 350. But with added plasticity of soil, i.e., 30 per cent soil, if 5 per cent cement plus 0.5 per cent of sodium hydroxide were added, the value went up to 520, whereas even with adding 10 per cent of cement it was only about 480. In some of the cases, more than twice or thrice the value of what it would be with ordinary black soil mixed with 5 per cent cement was obtained. Further, he suggested that some of the research institutions should take up more detailed work in finding a successful solution to tackle the stabilization of heavy clays. He stated that they had a programme to take this work in the Highways Research Station, Madras, also. He was interested to note that the Military Engineering College, Kirkee, had done some work in this direction.

As regards the use of lime in stabilization, one of the previous speakers mentioned about the fundamental principle in which lime had to be used. He wanted to mention that it more or less acted as surface active agent, especially with regard to bitumen stabilization.

Dr. I. S. Uppal, restricting his remarks to the work done by the Punjab Research Laboratory in the last one year and included in the report, stated that mechanical stabilization of soils was no longer new and quite big lengths at different places had already been tried. Recently, they had replaced the brick soling with stabilized soil in the base course by using lime as well as soil stabilized mechanically with sand and brick aggregate. These lengths had behaved very well—even when they used lot of water for wetting the stone metal.

With regard to chemical stabilization, he said that the work done by Karnal Laboratory had already been published by the National Building Organization about a year back.

Dr. Uppal stated that addition of about 0.25 per cent of sulphated castor oil in conjunction with 1 per cent cement gave good results. Sulphated castor oil was an indigenous product and could be very easily prepared by mixing sulphuric acid with castor oil. Some more surface active agents like Adhevia-T and Duomeen-T and Cationic Emulsion, had also been tried with success. He explained that blocks prepared by thorough mixing of soil with about 0.05 to 0.1 per cent only by weight of Duomeen-T completely cut off its capillarity. The blocks even when immersed under water for a week remained hard and intact, and no disintegration was noticed. Similarly, Adhevia-T and Cationic Emulsions also improved the resistance of the soil mass to the softening action of water, but Duomeen-T gave the best results.

It was found that a proportion of about 1 per cent of Duomeen-T in the bitumen cutback rendered the compacted soil containing only 3 per cent of such cutback almost completely resistant to the capillary rise of water when placed over wet sand. Even on immersion in water for 48 hours, the total moisture was not found to be more than 4 to 5 per cent as compared to over 16 per cent in the case of blocks containing no Duomeen-T.

In view of these observations, Dr. Uppal was of opinion that Duomeen-T offered very promising material for improving the soil and the waterproofing qualities of the bitumens used in the manufacture of cutbacks or emulsions required for making waterproof mud plasters and other things.

Coming to the other point, i.e., cement, Dr. Uppal mentioned that they had done some work on the stabilization of sand and sandy soils using sodium silicates and found that in non-cohesive soils 2.5 per cent of sodium silicate gave much better results than

what would be obtained with 10 per cent cement, which was much more economical. Bricks actually prepared out of this material had been lying in the open in the monsoon for the last one year and they had stood very well without any appreciable disintegration.

With regard to cement stabilization, Dr. Uppal invited the attention to the report on the work done by the Karnal Laboratory describing the influence of lime on the soil-cement mixtures, which had already been published in the N.B.O. Journal, Vol. V, for July 1960, and some of the results were also displayed in their stall in the Exhibition. The object of the study was that soil-cement being not recognised as a regular building material whether the quantity of cement required could be reduced to give the same strength under wet conditions by replacing it partly with lime. It was found that if only 4 per cent cement was used in the clayey soil having 10 P.I. and about 11 per cent fraction higher than 200 mesh, it gave 135 lb compression strength immediately after curing and 203 lb after 24 hours immersion in water.

But if 2 per cent cement and 1 per cent lime were used, it gave a compressive strength of 278 lb after immersion in water, which meant that 2 per cent of cement and 1 per cent of lime gave much better results than even 4 per cent cement. Similarly, when these blocks were subjected to the weathering action of six wetting and drying cycles, it was found that 3 per cent of cement and 1 or 2 per cent of lime gave much better results than even 5 per cent of cement. We could economically and profitably replace cement with lime to some extent.

With regard to stabilization of soil with lime, lot of work had been done by various laboratories. Details of work done by the Karnal Laboratory have been published in the I.R.C. Journal, Vol. XXV-1. He pointed out a correction in the Paper on page 108, under Fig. 8, where the denomination of the graph had been given wrong. The figures for higher and lower moisture should be inter-changed in the graphs.

Dr. Uppal added that lime stabilization had been tried extensively on field scale in waterlogged areas in the Punjab on very badly damaged road where the water-table during the rains was almost at the ground level. They tried about 1,000 ft length in 24 ft width. They dug it out to about 18 in. depth as it was not possible to get sufficient soil from the fields to raise the level, and later used the same soil after mixing 2 per cent of lime and recompacted that in three layers—6 in. compacted to 4 in. Over that they gave 2 to 3 in. thick layer of the aggregate obtained from the scarified portion and mixed in the soil and gave another layer; over that was laid the pavement proper consisting of brick soling and stone metal, as usual. It received the full monsoon with water

passing over this road for about a week constantly and it was reported that once even a contingent of very heavy military vehicles consisting of 400 vehicles continuously passed over it. So far they had not observed even a single hair crack over this portion. Similarly, these specifications were tried on N.H. No. 1 between Tanda and Dasuya and were also being tried on another National Highway between Hansi and Hissar. The results obtained were very good and the C. B. R. actually taken in the field after every 2 or 3 months was found to be ranging between 15 to 30 *in situ*, whereas the C.B.R. of the local subgrade was almost nil under those conditions. Even the laboratory experiments further carried out in this connection confirmed that the C.B.R. improved with ageing and the report had also been sent to the I.R.C. sometime back.

Dr. M. L. Puri did not feel very happy when Dr. I. S. Uppal used the word "surface active agent" for soap. In the particular experiment referred to by him he stated to have used a mixture of soil and cement with a certain quantity of soap solution, and found that the permeability had decreased to a considerable extent. In Dr. Puri's opinion, soap was not only a surface active agent but was also an air-entraining agent. The very fact that the permeability was reduced was due to the introduction of some air particles and these air bubbles in an inert manner furnished the capillary channels through which water could flow. He requested Dr. Uppal to measure the air content of such mixtures and then probably he might be able to explain the phenomenon better.

Shri P. L. De observed that lime brings about lot of changes in the soil, particularly the clayey soils. It reduced the P.I., thereby helping its pulverization, for example, 1 to 1½ per cent lime helped greatly in this process. In one case on N.H. No. 6 on a strip having about a mile of very bad clayey soil, they had spread 1½ per cent of lime just before the monsoon and allowed it to work into the soil for about 3 months in the monsoon. After that when the soil started drying up it was found that the soil had entirely changed, and could very easily be pulverized.

Dr. I. S. Uppal replying to a very interesting point raised by Dr. Puri, mentioned that while using soap with cement, it was not actually air-entraining reaction but the chemical reaction going on, i.e., double decomposition. The cement on hydrolysis produces calcium hydroxide that reacted with sodium stearates of the soap and forms calcium or aluminium stearates which decompose in the air and make the whole thing waterproof by actually coating the particles.

If a cement block had already set and it was coated with soap solution, it would become impermeable because of the air-entraining. But in the case where soap was used in the cement

mortars while preparing them, it was a chemical reaction and not the air-entraining action.

Coming to the point raised by Shri De about the minimum time required for lime, Dr. Uppal stated that according to his experience they should try to roll up the lime mixture as early as possible, of course, not so immediately as in the case of cement, say, after 10 to 12 hours. Actually, in his opinion, once lime acts there was instantaneous action between the soil and the lime, which was really a pozzolanic action.

Shri L. R. Chadda did not agree with Dr. Uppal's version in so for as the rate of lime-clay reaction was concerned. The reaction between lime and clay was quite slow and experiments in the laboratory had shown that reaction under controlled condition was a long-term one. The reason why lime-soil mixture when used in road construction should be immediately spread and compacted was not apparently due to rapid lime-clay reaction, but mostly to prevent the conversion of lime into calcium carbonate by coming into contact with carbon dioxide of the air in the presence of moisture.

Shri S. N. Sinha, Chairman, concluding the discussion on Soil Roads & Stabilization stated that the discussion was very illuminating and useful.

In regard to lime treatment and the possible use of the lime together with cement for clayey soils, his view on the basis of work done in this country and in other countries, notably the Iowa region of U.S.A., was that large increase in the plastic limit of clayey soils could be obtained by adding a small quantity of lime. Both the montmorillonite and kaolinite soils were effective pozzolanic reagents. They had elements within their crystalline structure which reacted with lime to produce a cementing material equal to or greater in strength producing qualities than the cementing agents produced in the reaction of lime with flyash. It was not necessary to add flyash to soil containing large amounts of montmorillonite or kaolinite when treated with lime. Such additions were even detrimental.

Percentage amount by oven dry weight of soil and calcium hydroxide which could be fixed by the given soil was the lime fixation capacity of the soil. The lime contributed to the improvement of soil workability but not to increase in strength. The amount of lime added above the lime fixation quantity caused the fixation of cementing materials within the clayey soils. Lime fixation capacity of montmorillonitic or kaolinitic clayey soils was the same as the optimum lime additive for maximum increase in the plastic limit of the soil. The idea was that if

1 or 1½ per cent of lime required to increase the workability of the soil was added, then probably if cement was used for the stabilization of soil, better results and possibly cheaper construction could be had. In regard to the criteria for soil-cement construction, based on his experience in various States of the U.S.A., Shri Sinha opined that this treatment could be divided into three categories. Category A, using about 3.5 to 6 per cent of lime where the expected compressive strength would be 650 to 850 lb per sq. in. to cope with the very heavy traffic that could be expected in a certain region. The C.B.R. value of 120, as was suggested in the Madras report, was more or less the one used at other places and might be desirable.

Category B would have the percentage of cement varying between 2½ to 3½ per cent to be adopted for light-trafficked roads to give the expected compressive strength of 300 to 400 lb, the percentage of cement being raised to achieve the particular strength, after 7 days of casting and wetting for 7 days.

The suggested category C should be used immediately after the base and might contain cement to the extent of 1½ to 2 per cent. This category would help to improve the C.B.R. value of the selected material to offset the effect of chance inclusion of adverse clay which was possible if the entire length was laid in one day and should provide a working table for the construction of additions at a later date.

BRIDGES AND STRUCTURES

Shri T. K. Natarajan suggested that some systematic work on the subject of bridge foundations should be intiated in this country by the different organizations. In this connection, he emphasized the importance of the comparison of actual earth pressures behind retaining walls with those computed on the basis of classical earth pressure theories, as well as the careful planning of the drainage system of the backfill. He added that a study on the evaluation of the residual stresses behind the abutment wall due to compaction of the backfill was being initiated in the C.R.R.I. If the requirements of the drainage system in the backfill were not specified, the wall would be acted upon by various agents and forces beyond the scope of any classical earth pressure theory. If a backfill, for instance, was loosely deposited or inadequately drained, its properties would change from season to season and during the course of each year it would pass from the state of partial or total saturation alternating with state of partial or total desiccation. All these processes involved changes which had received practically no consideration in the classical theories. On the basis of actual observations of earth pressures, various empirical or semi-empirical procedures could be developed to represent a useful body of information.

Influence of swelling type of clays as backfill on earth pressure behind retaining walls was another problem worth consideration. Another aspect of the study receiving attention at the C.R.R.I. was the creep strength of clay in the case of abutments resting on backfill with soft clay. Some bridge abutments, supported by piles without batter had advanced in the course of time until the tension members had started to buckle owing to axial compression. The problem of mechanics of shear failures on clay slopes of retaining walls had already been taken up. The results so far analysed indicated that many clays such as Bombay Express Highway clay and the Marine clay, etc., had very low creep strength, of the order of about 0.6 or 0.65 times the value of unconfined compression strength. It was possible to conclude on that basis that if the weight of the backfill exceeded about .6 of the bearing capacity of the soil, the pregressive movement of the abutment walls was likely to be excessive even if the foundation was to be provided with enough batter piles to resist the backfill pressure. Under these circumstances, it might be necessary to substitute some light weight material for ordinary types of backfill. In this connection, it seemed reasonable to expect that open type of spill-through abutments might be more useful than the solid types of abutments. There were other cases where tilt of the wall had changed the clearance between the abutments. The clearance sometimes decreased until the superstructure acted as a spacer. In some cases, the clearance had increased and even threatened to increase the span of the bridge.

The standardization of design of well foundations, the relief of earth pressure due to arching in the case of circular wells, the problem of scour, and a few other problems were awaiting to be tackled. Probably they should, in the first instance, send out a questionnaire to the various highway departments and the railway organizations and collect information on the behaviour of the existing retaining walls to study and analyse the process of failure in the case of walls which had already failed. The study should not merely include the earth pressures acting on the backfill but should also include the stability analysis in the case of failed retaining walls. He felt that progress could be made in this important field of estimating backfill pressures on some empirical basis only by observing failed retaining walls for a number of years and interpreting the results.

In the end, he hoped that research workers individually as also the organizations would come forward to undertake one or more aspects of this many-sided problem.

Shri R. Thillainayagam stated that under the section "Bridges & Structures", some details had been given regarding the evaluation of load-carrying capacity of culverts and bridges.

Actually, the problem of assessment of load-carrying capacity was important in the sense that there was growing demand from the transporters to increase the laden weight from 9 to 12 tons. In the Madras State the existing limit was 9 tons, but when bodies like the Lignite Corporation and the Electricity Board, etc., having huge projects in Madras State, approached them for the movement of very heavy loads, they had to examine all the culverts, etc. There was, therefore, considerable delay in issuing permission for the movement of such heavy traffic and to check all these things a Committee consisting of an S.E., one D.E. and one A.E. was constituted to go into the details. They personally examined various structures and evolved some criteria theoretically for construction slabs, piles for arch masonry, culverts, etc. On that basis, they were able to get the load-carrying capacity of the structures, for instance, for the construction slabs it was decided to have a minimum cushion of 1 ft and the thickness of the slab 6 inches. Generally, they did not allow construction slabs in improved surface except in katcha roads where R.C. slabs were provided. For piles also, they decided that the minimum diameter should be 2 ft 6 in. and should satisfy the Class AA loading of the I.R.C.

As regards the masonry arches, theoretically they had evolved a number of graphs and from that they were able to evaluate the load-carrying capacity of the arches. In addition to these, they found that the actual load-carrying capacity of the arches was much more than the theoretical capacity. Some work had already been done in the Building Research Institute, London, on arches varying from 20 to 40 ft and they had evolved some criteria of probable load for these. In order to correlate the results with what had been obtained in England with Indian conditions, they had done some tests on one bridge and evaluated the function of various things like cushion, parapet, haunches, etc. The results were under compilation and more or less agreed with those found in U.K. Work on some more bridges was being undertaken because the spans adopted in England were of 20 to 40 ft length whereas in India spans varied from 20 to 60 ft.

Shri R. P. Chanda stated that to improve the bearing capacity of black soils, particularly for open type of foundations or where the foundation load was not too high, they did not require deep wells. He enquired if in some type of soils which were very poor, like the highly plastic black soils, whether by driving a large number of piles it was possible to compact the soil or it just started flowing out, thereby defeating the purpose for which piles were driven for compaction. He wanted some of the research people to consider the matter and to give them their opinion after necessary trials.

Shri B. G. Naik observed that the science of prestressed bridges had developed considerably and was mostly used on high

level bridges whilst in Madhya Pradesh they mostly had small submersible bridges and only a few major ones. He requested to be enlightened if prestressed beams could be used for submersible bridges in higher spans, say, upto 30 or 40 ft, as they generally carried out work upto 25 ft spans. If prestressed beams could be used for submersible bridges as in olden days by just putting in R.S joists and some sort of arches, spacing the beams 3 ft apart on the lower flange and covering it with concrete, it would help to do away with the centering work and also quicken the work of construction.

Shri S. N. Sinha (Chairman's closing remarks on the Section) thanked all the participants and stated that the discussion had been quite useful and had brought forth the need for more work on the structures, especially on the foundations. He felt that in the case of balanced cantilever construction, the articulation joints had been a problem and there had been failures even of bridges constructed by very reliable firms, only a few years ago, say, 8 to 10 years ago, because of the fact that the articulation joints had not been properly designed. In areas where the foundations were subject to unequal settlement, balanced cantilever designs had been adopted, the only snag being these articulation joints. In the case of prestressed units for culverts of small sizes about which Shri Naik had enquired, Shri Sinha stated they could only be useful if they were precast. For precast construction, high tensile steel was necessary, and it might not, therefore, be possible at the present moment to use precast concrete for smaller size bridges whether they were high level or submersible.

TRAFFIC & TRANSPORTATION

Shri T. S. Khanna hoped that the points mentioned in the report were sufficiently clear but wanted to highlight certain points.

Roughening of roads was being tried to dissuade cyclists to use the main intersection and to avoid mixing up of cyclists with other traffic on busy intersections in Delhi, particularly where there were too many cyclists. He wondered if anybody knew anything about it, whether any experiments were tried like that and whether any useful results were obtained. The C.R.R.I. had tried couple of different types of road roughening methods, but were not quite satisfied as yet. The idea was that it should be just rough enough to dissuade the cyclists using the main road and not so bad as to disturb the motorists.

Regarding the economics, he particularly drew the attention to the fact that in many areas having rail-road crossings by following the good old system of closing down the gates when a train was expected often resulted in long queues of waiting vehicles, as it took about 15 to 20 minutes for the gates to open. As such, they should see

whether there was economic justification for building an overbridge to avoid the loss by way of traffic stoppage and how it would be balanced out by providing an overbridge. There would be slight difficulty in exactly evaluating the time of the motorists so as to put it in terms of money. This might be possible in the case of commercial vehicle drivers on the basis of what they were being paid for. But for motorists it was very difficult. Other things like congestion and slowing down and acceleration, could be easily calculated. He, therefore, invited views on the subject.

Regarding contribution of road transport to public exchequer, it was a very important study carried out by Applied Economics Research Centre in New Delhi and they had assessed how much this industry was paying to the Government. A survey of the economic benefits of road construction in under-developed regions was being carried out by the Ministry of Transport and Communications and he wished Dr. Ganguli to throw some light on it.

The cost of operation of road vehicles on different types of road surfaces was also being carried out by the Ministry of Transport. A similar study carried out by the C.R.R.I. for the operation of different types of vehicles in urban areas included all hired transport vehicles like tongas, taxis, bullock-carts and all different types of vehicles using the roads. The report was under compilation and would probably be published next year.

Regarding employment potential of road transport, being an interesting study it was essential for every citizen of the country to know what were the potentialities of road transport for the benefit of the country and how it could help its economy. The report had assessed how much more people could be employed by the road transport industry compared to any other industry, rupee by rupee spent on other industries. A comparison with the railway transport had also been made to show the difference.

Shri R. Thillainayagam stated that actually they had not done much in regard to the problem of speed limit though the study had been taken up. He opined that no one could blindly put up traffic speed limits at each place, the geometrics of the road and the travelling conditions of the traffic would have to be taken into consideration for evaluating these things.

As regards cycle traffic, they had the same problem in Madras where the cycles constituted nearly 50 per cent of the total traffic on the road. They had not tried anything like roughening of the road because it was very dangerous sometimes as well as injurious to the tyres and vehicles. Instead they had provided separate lengths on either side for cycle traffic. At intersections also, they found

it was necessary for cyclist to be separated instead of mixing them with the other traffic. They had, therefore, phased their traffic signals in such a way that the cyclists moved safely at the intersection.

As regards central control islands, he informed that now they had portable traffic islands with umbrellas, etc., and these islands were put inside the road at the time of peak traffic when it was regulated by the police. At other times, it was removed from the roadway and kept aside. They had also found that many of the rotaries had failed in Madras City during peak hours and were being replaced by signals. At places, use of traffic signals along the rotaries was also being tried.

As regards road accidents, they had just started compiling statistics and had not done much study about the geometrics of the roads. They were taking prevailing street conditions of the traffic to evalute safe speeds and posted them for the information of the public.

Regarding parking, some study was made on the Mount Road in Madras and it was found that about 72 per cent of the parkers did the parking for less than 30 minutes. So they were proposing a parking limit of 30 minutes in the busy shopping areas; for people wishing to park for more than thirty minutes, parking facilities by acquiring vehicle lengths nearby were being provided.

The taxi stands were at present located on the pavements and footpaths and it was proposed to shift them to separate places very near the bus stops and bus stands so that the passengers getting down from a bus might immediately get a taxi.

Regarding road-rail crossings, they had the same difficulty in Madras. Actually, they had prepared a programme of replacing all these rail-road crossings by means of overbridges and the Madras Research Station would be very glad to take up this study.

Shri S. R. Pillai commenting about the adoption of rotary island design, stated that these were found to be working satisfactorily where all the four roads branching from the junction carried more or less equal traffic but where the traffic on the cross roads was less than half of the traffic on the main road, rotaries gave rise to accidents and unecessarily retarded traffic, especially on the main road. If the junction was wide enough to provide at least 80 ft diameter rotary, channelising and division islands proved to be of success. In Trivandrum, he added, at an important junction a small rotary was giving rise to many accidents. When it was redesigned as a channelising island giving right-of-way to the main road with the introduction of a projecting bulbhead to the channelising island, no accidents had happened in the last 10 months.

He also suggested that the engineer must fight against the direction given by the Police authorities, who happened to be the traffic engineers in this country, to provide rotaries at all junctions irrespective of the importance of the junction.

Shri A. A. D. O. P. Saparamado narrated their own experience about the traffic rotaries in Ceylon. Before the war when traffic on their roads was not much, controlling of traffic by means of rotaries was quite satisfactary. But since the war the traffic had increased considerably. In the last 2 or 3 years it had been found that most of these rotaries developed a long queue and in some places traffic was held up for long periods. Another danger was that in places or a junction with light traffic, one being a main road and the other a minor road, there were several accidents when the motorists on the main road could not see the rotary while there was traffic on the road and they went over the rotary. At least at one place several fatal accidents happened during the last couple of years. In such places, they had to cut down the rotary so that it became more or less an oval island. After that the accidents were eliminated. It was their objective now to do away with the rotaries in all future designs and to use channelising islands. Rotaries in the U.S.A. had been designed to take up the amount of traffic from one road to other, i.e., their area was such that there was sufficient weaving length from one road to the other so that the vehicles could weave in and out across. But such islands had to be quite large and in Ceylon they could not afford to provide such a large area in the city, with the result that the method of channelisation in all designs of intersections was being introduced.

Shri S. N. Sinha (Chairman), winding up the discussion on the subject, stated in regard to the point about the crossing of railway lines by overbridges, that on the National Highways even, apart from the fact that they were necessary from consideration of traffic using them, there hardly were many overbridges in most of the States. The present trend of the railways was rather more disquieting as almost all the crossings close to a city were interconnected with the general signal system and were being operated from the cabin. In the City of Patna itself, during the last few months as many as four crossings were added on and they were being operated from the signal cabin. There the great difficulty was that the gates were not opened until the train steamed out of the station; as such, the gates remained closed for more than fifteen minutes. People would be very happy if it were for only five minutes, but in practice the closure was never less than 15 minutes. Wherever there was a shunting yard, the position was still worse.

In respect of rotary islands, he mostly agreed with the previous speakers on the subject and that as a matter of fact these islands were getting more or less more dangerous to the traffic conditions even in smaller cities than being useful, especially because the rotaries were not properly designed. His own experience in 7 or 8 States in the U.S.A. had been that the rotaries had practically disappeared. The traffic was controlled either by signals or by 'stop' signs. People getting into the main road had to stop at each intersection.

He thanked all the speakers for participting in the discussions, especially Dr. Uppal and Shri Khanna for clarifying the salient points.

WRITTEN COMMENTS

Shri V. V. Subba Rao stated that at present various Laboratories and Institutions were taking active interest in Road Research. It was essential, therefore, to have co-ordination of research work between the various laboratories so that duplication of work could be avoided. He suggested that the Centre and State Road Research laboratories, should take up mainly field investigations, while the Universities and Institutions tackled problems of academic interest.

Shri Rao explained that the Roorkee University was having regular post-graduate course in Highway Engineering. As a part of this course, students would be working for 4½ to 6 months on a certain problem for their M.E. thesis. Until now, the problems taken related to stresses in concrete creteways due to bullock-carts, frictional stresses under concrete pavements, effect of mortar on the stability of bituminous mixtures, stability of slopes of road embankments and cuttings and strength of bituminous mixtures with brick aggregates. Currently, study of behaviour of concrete pavements under dynamic loads and study of '*K*' value for concrete pavement design were on hand. He requested the Director, C.R.R.I. to try to bring co-ordination of work between various laboratories.

Panel discussion on

"The Use of Low Grade Aggregates in Road Construction"*

Bangalore, Tuesday, February 2, 1960.

Shri N. Durrani (Chairman) called upon **Dr. H. L. Uppal** to initiate discussion and invited members to give information on the questionnaire regarding "the use of low grade aggregates in road construction".

Dr. H. L. Uppal explained that the object of this panel discussion was to collect the information available on the subject in India. He, therefore, requested the various members coming from different States to give information about soft aggregates available in their States and the practices followed for their use. In view of the large programme of road construction in the country, the use of materials other than the conventional ones have to be thought of. Therefore, he would appreciate if the members could give as much information as possible, so that the Central Road Research Institute who had sponsored the panel discussion could go into further details.

Shri K. Ramaswamy Reddy stated that classification of low type aggregates merely as kankar, moorum, etc., would not be scientific. Their classification should be based on their hardness or crushing value. On page 669, it was mentioned that a particular nodular kankar had an aggregate crushing value of 15 to 20. When crushing value was high it would be appropriate to classify the material as high grade aggregate.

Some of the soft aggregates would become a cake when subjected to the impact test in wet condition. Under such a condition, the test results would not give correct value. Therefore, he felt that, for the soft aggregates, impact tests in wet condition could not be taken as a standard. Further, it was not clear how a value of about 60 or 70 had been obtained from such tests.

In Table 1 on pages 675-678, the letters L, M and K were used to indicate laterite, moorum, kankar, etc., respectively. In the report on Road Research in India, the term gravel was also used. It was desirable that clear definitions of terms like gravel or moorum, etc., were given.

Shri Reddy desired that the basis on which the four "Tentative specifications for use of low grade aggregate in road pavement were evolved" be explained.

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* Published at pages 667 to 679 of Volume XXIV - Part 4 of the Journal of the Indian Roads Congress, January, 1960.

In Madras State, generally construction of the road pavements using soft grade aggregates was by the method of "Stage construction". Subsequent improvements depended on the traffic volume. Bituminous surface treatment or cement concreting was taken up only when the crust was sufficient for the anticipated traffic, i.e., about 6 to 8 in. of waterbound macadam base and 8 to 12 in. of soft aggregate sub-base.

It was not clear whether the specifications recommended in the note would permit a stage construction

Shri D. C. Chaturvedi observed that on page 668 of the Note, kankar was said to be nodular or calcareous. How could this be distinguished? In U.P., they had two types of kankar, one was called "Silia" and the other "Bichwa". The former was obtained in large lumps in the form of boulders and the latter was obtainable in small lumps. The classification, therefore, needed modification.

Under specification of surface treated waterbound macadam, it was stated that the aggregate impact value should not be more than 35 which, he thought, was rather on the high side. Experience in U.P. after having tested about 100 samples of kankar, was that the impact value varied from 10 to 21 in dry state and from 11 to 23 per cent in wet state. If corresponding values of abrasion were taken, the values would range from 30 to 35 per cent. Therefore, if the value of 35 as aggregate impact value was adopted in the field, they might use very soft material especially if a traffic of 1,000 tons was allowed.

Referring to page 671, Note (2), Shri Chaturvedi enquired if there was any test for assessing the cementitious properties of kankar.

Shri B. K. Choksi remarked that on page 668 moorum was stated to be light or dark red colour gravel, while in Plate I on page 679, in the legend, moorum was shown different from disintegrated trap. In Bombay State, where a large area was covered by trap, disintegrated trap was known as moorum. So he was not clear whether moorum mentioned in the note was the same material known as moorum in the Bombay State. Further, moorum in Bombay State was divided into 2 or 3 varieties according to hardness; the variety known as hard moorum was used for surfacing light traffiicked roads.

Kankar was also used in some places in Gujerat, but mainly by the Local Boards. The type of kankar available there was of very small size, about $\frac{3}{4}$ in. gauge. In addition, laterite was also used on the west coast. The laterite available there was fairly hard, something intermediate between hard and soft aggregates.

Dr. H. C. Visvesvaraya wanted to know whether any low grade aggregates had been used in foreign countries and what had been their experience. In India, in certain cases where questionnaires had been issued, it was his experience that even though the questions were very sound, it was difficult for the departments to give very specific replies. He would like to know whether any information had already been collected.

Dr. Bh. Subbaraju stated that, in the south-eastern and south-western zones of U.S.A. a material similar to soft kankar known as Calichi was used for the base course. But he never came across any standards laid down in terms of strength for it.

Shri M. M. Katrak described the surfacing work for few miles with low grade aggregate of "soft white sandstone" on Mulag and Bhadrachallam roads in Warangal and Khamam Districts, of Telangana. The white sandstone if broken to chips would crush to powder under wheels of the roller.

On the Mulag road, the metal crust of 4 to 6 in. was uneven and worn out. The road had traffic intensity of about 1000 to 1500 bullock carts per day for a period of about a month and a half during the festival season. It was intended to give blacktop surface to eliminate dust and dirt.

The section of the road was to be remetalled for which $1\frac{1}{2}$ in. metal was already collected at site. Good sand was available at site at Rs 7 to Rs 10 per cu. ft.

If the conventional specification of 1 in. premix chipping carpet, both for the base and seal coat were to be adopted, it meant carting the $\frac{1}{2}$ in. and $1\frac{1}{2}$ in. metal from Warangal, a distance of 32 miles, at prohibitive cost.

He found that the best method was to consolidate the already collected $1\frac{1}{2}$ in. metal as water-bound macadam to the stage of moorum blindage but not put the moorum. After the dry and wet rolling was done, the surface was closed to traffic and the water was allowed to dry out. Care was taken not to do too much rolling so that the metal was not crushed to powder.

A tack coat of 18 to 20 lb of 80/100 penetration bitumen was given by using a 4 gall. empty kerosine tin as a pouring can. Sand was premixed with 80/100 pen. bitumen at 6 lb per cu. ft. of sand. The premixing of sand was done in half-cut bitumen drums put on slow fire and hand mixed by shovels. The premixed sand was spread on the metalled surface which had a tack coat on it, like blindage. After over 100 to 200 rft of the road was covered with the sand, the rolling was done in the usual manner. Care was taken to keep

the roller wheels clean and damp with wet gunny bags. The surface was rolled well to a finished surface.

The following observations were noted :

1. If the 1½ in. metal was according to the specifications, it took about 4 to 4½ cu. ft. per 100 sq. ft. of premix sand to seal the surface.

2. If metal was oversized, i.e., 2 in. to 2¼ in., the premixed sand used was 6 cu. ft. per 100 sq. ft.

3. If the metal was big and oversized, he found that the quantity of premix sand could be reduced to 4 to 4½ cu. ft. per 100 sq. ft. by a little extra rolling. This broke up the oversized metal and thereby reduced the voids. The advantages of this specification were :

(1) Good neat blacktop surface could be had even in areas where soft low grade aggregate was available.

(2) The blacktop surface could take up and stand to fast rubber tyre traffic and also iron tyre traffic.

(3) The cost of black topping the surface was Rs 6,500 to Rs 8,000 per mile of 12 ft wide road against Rs 11,000 to Rs 13,000 for surfacing with ½ in. chipping.

(4) The tedious and costly collection of ½ in. chippings was eliminated where hand broken ½ in. chipping as supplied was usually ¾ in. to 1 in.

(5) The finished surface was water-tight, which was not the case in 1 in. stone chipping carpet. In cases where stone chips were hand broken, the finished surface was very open.

(6) Because of the low cost, this specification later found use in Municipal areas, specially in residential areas where large areas with little or no traffic had to be covered.

The same specification adopted at Bhadrachallam road also gave good results.

Small lengths were laid using hard granite by Municipalities, where rollers, boilers, and power-driven asphalt mixers were available. At one place this specification was laid on heavy bullock-cart trafficked road. For three years, it stood the bullock-cart traffic well and the surface looked like asphaltic concrete.

He suggested that the specification should be tried on large scale where the metal was good and hard on State and National Highways and also where the metal was soft and poor. As the specification had given good results with soft low grade aggregate, it was bound to give better results with hard metal and good sand. Due to low cost per mile, greater number of miles could be covered and the work done faster as there was no problem of collection of ½ in. chippings.

He was of the view that this specification would fit well for work on Khanmamet-Rajahmundry road where work was to be taken up shortly. The examination of the quarries on this road gave a poor variety of stone for ½ in. chippings. Sand in this section was good and could be had at low cost.

Dr. H. L. Uppal replying to various speakers referred to **Shri K. Ramaswamy Reddy's** remarks as to how an aggregate impact value of 60 to 70 per cent had been obtained with soft aggregates and stated that when the aggregate impact value test was carried out on materials soaked overnight, a loss in crushing strength was of that order, after the caked material had been washed. Regarding the distinction between gravel and moorum, it had already been made clear that gravels were water-borne pebbles deposited by rivers.

Regarding his inquiry about tentative specification for use of low grade aggregate in road pavement, Dr. Uppal stated that wherever water table was low, the aggregate impact value tests were based on dry sample, and wherever the water table was high, and the aggregate was likely to get wet, the aggregate impact value under wet conditions was specified.

Replying to **Shri D. C. Chaturvedi's** point for distinguishing nodular and calcareous kankar, he pointed out that the nodular kankars were generally small in size like the one met with in U.P. and commonly called "Bichwa", whereas the calcareous ones were softer in nature like the "Silia" of U.P.

Regarding the aggregate impact value of 35 for water-bound macadam, he stated that the AASHO fixed a limit between 30 and 40 with a wearing course of about 2 inches. Since the wearing course consisted mostly of about 1 in. carpet in India, in proposing the aggregate impact value of 35, comparatively stronger material had been suggested.

Regarding Shri Chaturvedi's point for determining the cementitious properties of kankar, it was suggested that the C.B.R. determination might give a good indication of such materials.

Regarding **Shri B. K. Choksi's** remark about moorum in Bombay, he said that the word ' moorum ' had been so badly confused

that whatever was available at site was known as moorum. When they collected material from all over India, the Rajasthan P.W.D. sent samples of moorum which were nothing else but pure clay. To the overseer on the spot, moorum was material readily available at site other than local sand. Normally, the type of moorum that was found in Bombay was more of a shale rather than moorum. Moorum was a typical composition of a quartzite base and, therefore, it should not be confused with other types of soft aggregates.

Answering **Dr. H. C. Visvesvaraya,** Dr. Uppal stated that the use of ' soft aggregate ' for road construction in England was based on the C.B.R. values irrespective whether it was more clayey or gravelly, and had been used in the bases of some of the roads irrespective of its C.B.R. Dr. Uppal offered to supply complete information later on. If the material was very strong, it might be used by all means at the surface; if it was weak it could still be used as a base or sub-base.

Shri N. Durrani (Chairman) winding up the discussion, stated that the subject of the discussion was an important one. For want of time further discussion had to be deferred till the next session at Bhopal. He asked members to send their comments in writing to the Indian Roads Congress.

Panel discussion on

"The Use of Low Grade Aggregates in Road Construction"

Bhopal, Saturday, January 7, 1961 (contd. from 24th Session—Jan./Feb. 1960).

Shri E. A. Nadirshah (Chairman) opening the discussion stated that questions relating to compaction, specifications, climatic conditions, etc., were discussed at the Bangalore Session of the I.R.C. He invited members to discuss the questions relating to surfacing, the design of pavements, making use of soft aggregates, etc.

Dr. H.L. Uppal stated that a survey carried out by the C.R.R.I. revealed that there were huge deposits of inferior aggregates such as moorum, laterite, kankar, shale, etc., almost throughout India. Laboratory tests had shown that these materials could be very profitably made use of in road construction, especially in areas where hard stone was not readily available. Yet it appeared that engineers in the field were hesitant in using them extensively, probably because of lack of scientific knowledge of such materials, some failures in the past had occurred.

He requested members from the different States to give information about the soft materials available in their areas and the practices prevalent for their use.

Shri K. Ramaswamy Reddy stated that generally soft grade aggregates were not widely used in Madras for the base coat immediately below the wearing surface. They were used in the "stage construction". However, in the West Coast, where the low grade aggregate found was of very good variety and capable of yielding sufficient C.B.R. value to take up a bituminous wearing coat, it was used for the base coat. In such cases, the bituminous wearing surface was done with a tack coat at the rate of 15 to 20 lb per 100 sq. ft. Their experience showed that the performance of the surface was satisfactory.

Shri S. N. Sinha stated that soft aggregates had behaved satisfactorily only after bituminous wearing coat had been laid over the base course. For traffic of one thousand tons per day or even a little more, performance of the soft aggregates was satisfactory if thickness of the road crust was adequate, and the bituminous wearing coat had been properly done. The wearing coat with precoated chips, laid to a thickness of 3/4 in. or more, on soft aggregate base coat had given satisfactory results for traffic mentioned above. As regards question 9, Shri Sinha stated that a priming coat had proved to be of great help specially if the

wearing coat could not be laid immediately. He would recommend a priming coat with a rate of application of 25 to 28 lb per hundred sq. ft.

Dr. I. S. Uppal stated that it was the practice in the Punjab to apply a priming coat for stabilized soil roads having a base coat consisting of soil stabilized with 33 per cent brick aggregate but without stone grafting, but later on, it was found that the treatment was not advantageous and was, therefore, given up.

He mentioned that, for soil stabilized roads with brick aggregates, the addition of 1 per cent surface active agent like sulphated castor oil to the asphaltic material used for the first coat improved considerably the adhesion of the base coat with the bituminous surfacing.

No other soft aggregate had been used in the Punjab for the construction of base coat of a road.

Shri P. L. De stated that where a bituminous wearing coat was laid directly over a base coat constructed with soft aggregates like moorum, the wearing coat had a tendency of spreading out and thinning under the wheel track. There was a tendency for the surfacing to peel off due to lack of proper bond between the wearing coat and the base coat.

Shri De was of opinion that priming coat might be helpful to some extent where the peeling off tendency existed.

Shri S. R. Mehra stated that soft aggregates were not being extensively used in spite of the existence of large deposits throughout the country because facilities for their scientific testing had not been developed. Wherever materials of varying quality was obtained from a quarry, subjecting the aggregates to C.B.R. or similar test would help in the use of materials of suitable characteristics in different parts of the road structure.

The object of the panel discussion was to get information from the various States and then to finalize the recommendations. The main point to be considered was of economy. He suggested that representative samples of soft materials occurring in different areas should be sent to the C.R.R.I. or other laboratories for testing to find out about their suitability for use either as a base course or as wearing course material.

Experimental stretches should then be laid to the specifications given in the note, their behaviour kept under observation. These specifications could be modified in the light of experience gained in the field.

Dr. H. L. Uppal stated that the idea of putting this question was as to how the pavement thickness was being designed in

various States, especially when the pavement was constructed in stages.

Shri S. R. Pillai stated that, in Kerala, there were large deposits, mostly laterites, of soft aggregates which could be used in subgrade for road construction. They could be cut to any size or shape. They were used as aggregate for the sub-base mainly and as base course in minor roads. For the construction of roads in sandy soils, they were used as sub-base below the base course of water-bound macadam. In minor roads where the traffic was light, laterites were used for base course. Generally bituminous treatment was not done over the base course of such low grade aggregate. Bullock-carts of ½ ton loaded weight ply over them and the roads stand the strain. During the rainy season, wheel tracks develop quickly, on such roads. A thickness of 6 in. is generally used for sub-base. Compaction was done using stone rollers or light power rollers. Spreading of sand gave a better road surface though that was not done always. Soil-gravel mix was in practice though no proportioning the admixture was insisted. The climatic condition of the area varied very widely and the water-table was about 5 ft below the road surface. In dry weather, laterite when used on the surface formed a good road surface, but the top layer easily crumbled to dust. Wherever hard granite metal was available, soft aggregates were not used for road construction. He felt that a bituminous wearing coat laid over a priming coat on a soft aggregate base would stand well on roads of light traffic. Granite quarries were getting depleted and it was time that substitute aggregates were popularised for road construction. It was made clear by Brig. Bose that it was unnecessary to provide a hard water-bound macadam surface beneath concrete roads. If that be so, in places where granite aggregates were either costly or not available, soft aggregates could be used for base course over which concreting was to be provided.

Shri S. N. Sinha stated that there are many methods of design of pavements and described the C.B.R., U.S. Army Corps of Engineers and the Asphalt Institute, Group Index and Hveem's Stabilometer methods.

In the C.B.R. method of design for maximum economy, the different layers starting from the subgrade to the wearing coat had to be such that they had an increasing C.B.R. value. So it was clear that in that method of design, the use of soft aggregate could be scientifically done. Softer the aggregate, the lower the C.B.R. value and the greater the need of placing it closer to the subgrade according to the C.B.R. value.

After a study of the performance of the pavements under various volumes and types of traffic, it should be possible to

develop a method most suitable for the various parts of this country. He emphasised that the method had to be evolved and developed on the basis of work done in the country itself though advantage could be taken of the experience of other countries.

He mentioned that the best way of making the scientific use of low grade aggregates popular would be to design the pavement thickness in a scientific manner. It was only when a pavement thickness was designed scientifically that the use of low grade aggregates could be popularised. It was no use putting in very hard aggregates just near the subgrade when a lower grade aggregate would serve the purpose. Unless that basic concept of the design of pavement thickness was accepted and properly understood, the use of low grade aggregates could not be as popular as it should be. It was, therefore, necessary to insist on the proper design of pavement and to educate the Engineers concerned on the various aspects of a design so that soft aggregates available locally could be judiciously selected and used. It was no use claiming that the low grade aggregates could replace the hard aggregates or that the former could always be used as wearing coat. It had its place dictated by the pavement thickness design criteria. The lower layers could always be the low grade aggregate.

Shri E. A. Nadirshah (Chairman) stated that where hard materials were available at economical rates or their cartage from a distance was not expensive, the question of utilising soft materials did not arise. Use of soft materials arose only when hard materials were not available or were available at a high cost and there were plenty of soft materials in the vicinity.

He thanked various speakers for their comments.

INDIAN ROADS CONGRESS

Classified List of Papers, etc., in the Proceedings I to XXV

SUBJECT INDEX

Classification

I.	Roads in General.	VIII.	Bridges, Retaining Walls and other Structures.
II.	Road Surveys, Design, Layout and Construction.	IX.	Traffic Statistics; Regulation and Control of Traffic; Economics of Roads and Road Transport.
III.	Soil and Earthwork; Soil Science as adapted to Road Foundation, Banks and Earth Surfaces, Soil Stabilization, etc.	X.	Road Maintenance and Road Usages.
IV.	Water-Bound Macadam Roads and other Low-Cost Roads, such as Moorum, Brick and other Forms of Trackways.	XI.	Standardization, Designs, Loadings, Impact, Specifications.
V.	Tar and Bitumen Surfacing Carpets, etc.	XII.	Research and Experiments.
VI.	Concrete.	XIII.	Administration and Finance.
VII.	Miscellaneous Materials and Processes; Aggregates, Tests, Sizes, etc.	XIV.	Plant, Machinery and Apparatus.
		XV.	Miscellaneous.

I. Roads in General.

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
1	Roads and Public Health in India with special reference to Malaria, Borrowpits and Road Dust.	Raja Ram	III	33	64-73	37
2	Safe Wheel Load for Indian Roads.	K. G. Mitchell & Jagdish Prasad	IV	E	1 (e) to 32 (e)	49

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
3	Corrugations on Road Surfaces.	C. B. E. Trustcott	IV	G	1 (g) to 24 (g)	51
4*	Ribbon Development.	A. S. Trollip	V	M	1 (m) to 30 (m)	58
5	Slip and Subsidence in a Hill Road.	D. C. Datta	VI	I-39	1 (i) to 17 (i)	72
6	The Broad Classification of Traffic and Contributory Causes of Wear and Tear of Roads.	Sir Kenneth Mitchell	VIII	A-41	1 to 4 (b)	85
7	Drainage in Hill Roads.	M. Mahapatra	X-1 & 4	106	183 to 184-1 & 724 to 729-4	106
8	Cycle Tracks.	Fatch Chand	X-3 & 4	111	429 to 433-3 & 796 to 809-4	111
9	Causes of Landslips and Suggested Remedies.	Geological Survey of India	XVII-3	—	485 to 492	—
10	Road-side Development in Madras State.	K. Ramaswamy Reddi & P. C. Nambiar	XVIII-3 & 4	169	309 to 370-3 & 607 to 617-4	169
11	Adequacy Assessment of Highways.	D. G. Bhagat	XXIII-1 & 4	207	117 to 157-1 & 731 to 749-4	207
12	Crystal Pattern Formula for Integrated Highway Planning in India.	K. C. Mital	XXIV-2 & 5	218	336 to 399-2 & 917 to 931-5	218
13	Regional Concept for Highway Planning—The Web and Lattice Pattern.	D. G. Bhagat	XXIV-4 & 5	222	629 to 665-4 & 917 to 931-5	222
14	A Study in Road Failures.	S. N. Gupta & P. L. De	XXV-1	224	61 to 80	224

* *Awarded Medal.*

II. Road Surveys, Design, Layout and Construction.

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
1*	Construction of Shillong-Jaintiapur Road, Khasi Hills, Assam.	F. E. Cormack	II	30	390-397	34
2	A Method of Rapid Road Reconnaissance.	Captain W. G. Lang Anderson	II	31	398-416	35
3	Some Notes on the Layout of Rural and Suburban Roads in the Punjab.	R. Trevor Jones	III	32	10-26	36
4	Optimum Weight of Vehicles on Extra-municipal Roads.	K. G. Mitchell	III	39	92-105	43
5	Layout of Roads.	R. Trevor Jones	V	k (ii)	4 (k) to 17 (k) & 18 (k) to 43 (k 2)	56
6	Transition Curves for Roads.	W. R. Fleury	IV	C-40	15 to 47	78
7	Calculation of the Structure of Roads.	Brigadier Lang Anderson	IX-1 & 4	98	1 to 6-1 and 1 to 18-4	98
8	Basis of Road Planning.	Jagdish Bahadur	XII-5	134	267 to 282 & 448 to 455	134
9	Fundamentals of Highway Needs and Highway Planning.	D. G. Bhagat & Jagdish Bahadur	XIII-3 & 4	141	377 to 417-3 & 193 to 197-4	141
10	Some Examples of Planning Surveys.	R. P. Chanda	XV-3 & 4	153	365 to 392-3 & 648 to 650-4	153
11	Construction of Shillong-Silchar Road, Assam.	S. C. Pal & R. C. Das	XVI-2 & 4	158	151 to 204-2 & 537 to 544-4	158

* **Awarded Medal.**

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
12	Location of Roads in Hilly and Mountainous Country.	B. Chaudhury	XVIII-1 & 4	166	41 to 57-1 & 577 to 582-4	166
13	Fact Finding Survey and Highway Planing in Uttar Pradesh.	P. N. Srivastava	XX-3 & 4	186	297 to 323-3 & 578 to 583-4	186
14	Study and Investigation of Performance and Failure of Road Pavements in U.P.	H. G. Verma & D. C. Chaturvedi	XXII-3 & 4	203	347 to 393-3 & 741 to 755-4	203
15*	The Importance of Subgrade Compaction in the Economic Design of Flexible Pavemont.	S. R. Mehra & H. L. Uppal	XXII-3 & 4	205	425 to 452-3 & 775 to 783-4	205
16	Landslide Investigation and Treatment in Assam.	G. C. Sharma	XXIII-3 & 4	212	479 to 549-3 & 808 to 829-4	212

III. Soil and Earthworks; Soil Science as adapted to Road Foundation, Banks and Earth Surfaces, Soil Stabilization, etc.

1	Earth Road Construction and Maintenance by Machinery.	G. W. D. Breadon	I	3	90-105	4
2	Earth Road Development and Stabilization with Gravel.	Lt.-Col. A.V.T. Wakely	I	4	68-89	5
3	Roads in Rural Areas (village roads).	Chowdhary Lal Chand	II	23 (a)	191-194 & 227-233	25
4	Oil as Binder for Earth and Gravel Roads.	T. G. F. K. Hemsworth	II	24	205-233	28

* Awarded Medal.

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
5	Soils in relation to Roads—A Bibliological Study.	G. W. D. Breadon	V	N	1 (n) to 12 (n)	59
6	The Use of Soil Stabilization in Unmetalled and Metalled Roads in India.	S. R. Mehra	V	O	1 (o) to 21 (o)	6
7	Stabilization of Unmetalled Berms of Metalled Roads.	S. R. Mehra	VI	F-39	1 (f) to 25 (f)	69
8	The Use of Soil Stabilization in Unmetalled and Metalled Roads in India.	S. R. Mehra	VII	H-40	135-156 (g)	83
9	Some Experiments to Stabilize Moorum Roads in Chota-Nagpur.	K. Gupta	VIII	D-41	57 to 74 (b)	88
10	Fundamentals of Soil Mechanics.	F. L. D. Woolterton	VIII	L-43	211 to 298 (b)	96
11	Road Construction in Black Cotton Soils.	A. Nageswara Ayyar	X-1 & 4	104	125 to 132-1 & 697 to 712-4	104
12	A Method of Soil Stabilization for Low Cost Roads.	S. R. Mehra	X-3 & 4	110	379 to 427-3 & 790 to 795-4	110
13	Analysis of Soil Samples.	Indian Roads Congress	XIV-1	—	123 to 135	—
14	Stability of Densified Soil under Adverse Moisture Conditions.	Sachindra Nath Gupta	XIV-2 & 4	145	193 to 246-2 & 523 to 531-4	145
15	Use of Stabilized Soil in Engineering Construction—Section I.	S. R. Mehra & H. L. Uppal	XIV-3	—	293 to 310	—

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
16	Use of Stabilized Soil in Engineering Construction—Sections II & III.	S. R. Mehra & H. L. Uppal	XV-1	—	184 to 204	—
17	Do do Section IV.	Do.	XV-2	—	320 to 335	—
18	Stabilization of Gumbotil Soil for Highway Use.	O. H. Patel	XV-2	—	336 to 356	—
19	A Note on the Use of Moorum Soil for Base Course for Macadam Roads.	G. Sriranga-chary	XV-2	—	357 to 361	—
20	Use of Stabilized Soil in Engineering Construction—Section V.	S. R. Mehra & H. L. Uppal	XV-3	—	469 to 482	—
21	Do do Section VI.	S. R. Mehra, H. L. Uppal & Labhu Ram	XV-3	—	483 to 491	—
22	Waterproofing of Alkaline Soil by Linseed Oil-Cake.	B. R. Sen & Manohar Lal	XV-3	—	492 to 500	—
23	Design of Road Beds.	G. Sriranga-chary	XVI-3 & 4	160	301 to 353-3 & 556 to 563-4	160
24	Compaction of Some Alluvial Soils of India.	Central Road Research Institute, Okhla, Delhi	XVII-2	—	291 to 344	—
25	Soil Cement in Road Construction	K. F. Antia	XVII-2 & 4	163	205 to 270-2 & 594 to 601-4	163
26	Stabilization of Certain Clayey Soils in India by Heat Treatment.	S. K. Bose	XVIII-2 & 4	168	215 to 245-2 & 591 to 606-4	168

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
27*	A New Approach to the Analysis of Stability of Slopes.	P. C. Varghese	XIX-1 & 4	171	23 to 43-1 & 651 to 659-4	171
28	Stabilized Soil Construction in the Formation of Tuticorin-Tiruchendur Road.	E. C. Chandrasekharan & T. S. Chandrasekhar	XX-1 & 4	180	69 to 118-1 & 522 to 540-4	180
29	Study of a Clay Bank Failure on an Indian Railway.	U. G. K. Rao	XXI-1 & 4	190	49 to 61-1 & 645 to 657-4	190
30	Experimental Soil Stabilized Road Construction in Black Cotton Soil Area.	J. F. Mistry	XXII-2 & 4	202	261 to 296-2 & 726 to 740-4	202
31	Role of Calcium Chloride and Sodium Chloride in Soil Stabilization.	I. S. Uppal & B. P. Kapur	XXII-3	—	485 to 516	—
32	Sand-Bituminous Stabilization for Road Construction.	L. R. Chadda & H. R. Aggarwal	XXII-3	—	527 to 544	—
33	Some Studies in Soil Mechanics as Applied to Roads in West Bengal.	S. N. Gupta & P. L. De	XXIV-1 & 5	213	27 to 69-1 & 823 to 843-5	213
34	A Resume on Lime Stabilization with Particular Reference to the Effects of Lime on the Physics and Chemistry of Soils.	H. L. Uppal & R. M. Palit	XXV-2	—	203 to 212	—

IV. Water-Bound Macadam Roads and other Low-Cost Roads such as Moorum, Brick and other Forms of Trackways

1	Corrugation of Water-Bound Macadam Surface in the Bombay Presidency and a Cure.	Henry J. N. Cousins	1	10	184-189	12

* Awarded Medal.

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
2	Some Physical Aspects of Roads and Tyres.	G. L. W. Moss	I	12	190-198	12
3	Treatment with Molasses of Bangalore-Mysore Road.	N. N. Ayyangar	II	19	105-109 & 125-130	21
4	Gravel Roads.	N. N. Ayyangar	II	23 (b)	199-203 & 227-233	26
5	Vitrified Bricks for Surfacing Roads in Deltaic Districts.	Gopalacharya	II	23 (c)	111-116 & 125-130	27
6	Roads under Local Bodies and How to Maintain Them.	Fateh Chand	IV	F	1 (f)-20 (f)	50
7	Collection of Material for and Consolidation of Water-Bound Macadam.	R. Trevor Jones	V	k (i)	I(k)-5 (k) & 6 (ki)-40 (ki)	55
8	Some Notes on the Maintenance of Water-Bound Macadam.	A. L. Rao	VIII	G-48	151-155 II	91
9	Water-Bound Macadam.	G. M. McKelvie & K. S. Raghavachary	XI-2 & 4	117	177 to 284-2 & 566 to 568-4	117
10	Low Cost Roads for the East.	Col. F. L. D. Wooltorton	XII-3 & 5	125	283 to 327-3 & 412 to 424-5	125
11*	Low Cost Roads in India and Use of Soil Science for their Improvement.	G. Sriranga-chary	XIII-1 & 4	135	59 to 146-1 & 112 to 132-4	135
12	Brick Pavement in Highway Construction.	D. C. Chaturvedi & J. C. Tayal	XXIII-3 & 4	210	377 to 433-3 & 785 to 796-4	210
13	A Note for Panel Discussion — The Use of Low-grade Aggregates in Road Construction.	Central Road Research Institute	XXIV-4	—	667 to 679	—

* Awarded Medal.

V. Tar and Bitumen Surfacing Carpets, etc.

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
1	Recent Methods used for the Treatment of Roads with Bitumen and Tar in Delhi Province.	A. W. H. Dean	I	1 (a)	21 to 50 & 56 to 67	2
2	Progress made in the use of Tar and Bitumen in the Punjab since the last International Road Congress in Washington in October 1930.	S. G. Stubbs	I	5 (a)	121-134 & 168-182	6
3	Notes on the use of Tar, Bitumen and Emulsions in the Punjab.	R. Trevor Jones	I	5 (a)	135-145 & 168-182	7
4	Asphalt Roads.	G.G.C. Adami	I	6	146-182	8
5	Necessity for Surface Treatment of Important Tourist Lines and some Aspects of Economical Works in that Direction.	V. S. S. Acharya	II	18	74-83 & 93-104	20
6	The Road Problem in India with some Suggestions.	Col. C. E. Sopwith	II	20	84-104	22
7	Further Notes on the Treatment of Roads in Delhi Province, with Bitumen and Tar.	A. W. H. Dean	III	34	27-63	38
8	Some Aspects of Bituminous Road Construction in India.	Col. C. E. Sopwith & W. A. Griffiths	V	L	1 (l) to 24 (l)	57
9	Revitalisation of Tarred or Bitumened Surfaces by mix-in-place Methods using Cut-Back Asphalt.	Capt. R.C. Graham	V	P	1 (p) to 12 (p)	61

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
10	Surface Treatment of Concrete Road when Outworn.	W. A. Radice	V	Q	1 (q) to 18 (q)	62
11	A Note on "Experiments with Cutbacks of Bitumen".	P. C. Neogi	V	—	89 to 102	—
12	Present-day Methods of Bituminous Road Surfacing Work in Chota-Nagpur, Bihar.	S. A. Amir	VI	E-39	1 (e) to 15 (e)	68
13	Light Bituminous Surfacings.	Ian A. T. Shannon	VI	G-39	1 (g) to 50 (g)	70
14	An Economical Substitute for Water-Bound Macadam.	A. L. Rao	VI	N-39	1 (h) to 10 (h) & 18 (g) to 50 (g)	71
15	Primers, Their Nature and Uses.	N. Das Gupta	VII	F-40	79-86	81
16	Notes on Drag Spreading and Drag Brooming.	W. L. Murrell	VII	I-40	157 to 190 (o)	84
17*	Revised Specifications for Bitumen Roads in the Punjab.	Abdul Aziz	VIII	I-43	161-184 (j)	98
18*	Bituminous Treatment of Wet Aggregates.	C. J. Fielder	IX-1 & 4	99	7 to 54-1 & 19 to 35-4	99
19	Track Spreading.	W. J. Madden	XII-2 & 5	124	241 to 253-2 & 406 to 411-5	124
20	Bituminous Treatment of Wet Aggregates.	Indian Roads Congress	XIV-3	—	360 to 382	—
21	Behaviour of Brick Metal in Tar Carpets.	K. C. De	XV Parts 3 & 4	154	393 to 414-3 & 651 to 658-4	154

* Awarded Medal.

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
22	Treatment of Wet Aggregates with Turkey Red Oil and Slaked Lime for Bituminous Road Construction.	I. S. Uppal	XVI-1	—	144 to 147	—
23	An Examination of Black-top Surface Dressing laid for Field Tests in 1945 on the Bombay-Delhi Road, Mile 736.	E. Zipkes	XVI-2	—	223 to 245	—
24	Some Observations on Air Field Runway Surfaces.	Central Road Research Institute, Delhi	XVII-1	—	153 to 170	—
25	Bituminous Treatment of Brick Metal Water-Bound Macadam Surfaces in U.P.	D. C. Chaturvedi	XIX-1 & 4	172	45 to 89-1 & 660 to 679-4	172
26	Compressive Strength as a Design Criterion for Bituminous Mixtures.	C. G. Swaminathan	XX-2 & 4	182	141 to 149-2 & 553 to 558-4	182
27	Specifications for Surface Dressing Water-Bound Macadam Roads—Critical Notes.	K. C. De & P. N. Sen Gupta	XX-2 & 4	184	219 to 228-2 & 567 to 577-4	184
28	Surface Dressing with R.T. 4.	K. C. De	XXII-1	—	77 to 88	—
29	Asphalt Paving Mixtures—Their Design and Composition.	N. H. Taylor	XXII-2 & 4	200	135 to 194-2 & 702 to 717-4	200
30	Adhesion between Bituminous Binders and Road Stones.	C. G. Swaminathan & K. P. Nair	XXII-2	—	299 to 310	9

Serial No.	Name of Paper	Name of Author	Reference to Proceedings: Volume No.	No. of Paper in Volume	Pages	Serial No. of Paper in general index
31	Investigation of Failures of a Bituminous Road.	C. G. Swaminathan & S. A. Swami	XXIII-3 & 4	211	435 to 478-3 & 797 to 807-4	211
32	Bitumen in Road Surfacing — Development of Cold Fine Asphalt in Madras.	M. Meeran, D. R. Kohli & S. M. Mohideen	XXIV-1	—	165 to 179	—
33	Scientific Design and Laying of a Bituminous Carpet on a National Highway.	S. R. Mehra, C. G. Swaminathan & V. R. Vaish	XXIV-3 & 5	219	475 to 516-3 & 932 to 949-5	219
34	Some Preliminary Trials for the Improvement of Wood Tar for Use in Low Cost Road Construction.	H. L. Uppal & L. R. Chadda	XXV-2	—	187 to 192	—
35	Some Field Experiments on Bituminous Road Construction.	D. C. Chaturvedi & J. C. Tayal	XXV-2	—	213 to 232	—

VI. Concrete.

1	The Use of Cement Concrete for the Construction of Roads in the Bombay Presidency.	L. E. Greenings	I	7	214-216 & 236-252	9
2*	Cement Concrete Roads.	W. J. Turnbull	I	8	217-230 & 136-258	10
3	Concrete Roads in Hyderabad (Deccan).	M. A. Zaman	I	9	231-252	11
4	Cement Bound Roads.	W. J. Turnbull	II	25	117-130	20
5	Economy and Development of Bonded Brick Concrete Roads, Plain and Reinforced.	A. K. Datta	III	35	106-146	39

* Awarded Medal.

Serial No.	Name of Paper	Name of Author	Reference to Proceedings: Volume No.	No. of Paper in Volume	Pages	Serial No. of Paper in general index
6*	Evolution of the thin Concrete Road in the United Provinces.	W. F. Walker	VI	A-39	1 (a) to 31 (a)	64
7	Repair and Maintenance of Cement Concrete Roads.	A. C. Mukerji	VI	B-30	1 (b) to 34 (b)	65
8	Trackways for Rural Road Development.	Sir K. G. Mitchell	VII	D-40	49-65 (j)	79
9	Cement Concreting the Bombay-Poona Road.	W. H. E. Garrod	VIII	K-43	203 to 216 (h)	95
10	Bonding a Thin Wearing Coat of Cement Concrete to an old Cement Concrete Road Surface.	H. M. Surati	XI-2 & 4	115	153 to 159-2 & 510 to 552-4	115
11	Standard Form for Recording Data on Cement Concrete Surfaces.	Specifications & Standards Committee	XII-1 & 5	122	87 to 97-1 & 382 to 392-5	122
12	A Study of Cement Concrete Roads with Special Reference to Bombay Province.	L. T. Aminbhavi	XIII-1 & 4	136	147 to 168-1 & 133 to 157-4	136
13	A Review on "Modern Road Construction in Concrete."	Lt.-Col. W. P. Andrews	XIII-1	—	169 to 173	—
14	Cement Concrete Trackways.	Central Roads Organisation	XIII-3	—	419 to 430	—
15	Grouted Concrete Roads.	E. A. Nadirshah	XVI-1 & 4	157	77 to 130-1 & 517 to 536-4	157
16	Cement - Aggregate Reaction in Concrete (A Survey of Recent Literature on the Subject).	B. R. Sen, S. K. Mittal & A. C. Banerji	XVI-2	—	246 to 263	—

* Awarded Medal.

Serial No.	Name of Paper	Name of Author	Reference to Proceedings: Volume No.	Reference to Proceedings: No. of Paper in Volume	Reference to Proceedings: Pages	Serial No. of Paper in general index
17	Some Observations on Air Field Runway Surfaces.	Central Road Research Institute, Delhi	XVII-1	—	153 to 172	—
18	Experimental Grouted Coment Concrete Roads in Travancore-Cochin	E. U. Philipose	XIX-1	—	111 to 122	—
19	Cement Concrete Surfacing and Experimental Concrete Road Construction on Agra-Bombay Road.	R. J. Dhumal & M. A. Mehta	XIX-2 & 4	175	169 to 231-2 & 694 to 701-4	175
20*	The Influence of a Superimposed Layer in increasing the Load-Bearing Capacity of a Rigid Pavement.	S. K. Bose	XIX-3 & 4	179	499 to 549-3 & 725 to 734-4	179
21	Cement Grouted Roads.	E. A. Nadirshah	XIX-2	—	259 to 269	—
22	Resistance to Abrasion of Concrete Pavements.	P. J. Jagus & M. R. Chatterji	XXI-1 & 4	191	63 to 97-1 & 658 to 665-4	191
23*	Influence Fields for Finite Concrete Slabs Supported Freely along Two Opposite Edges and Free at the other Two.	K. C. Ray, R. Subramoniam & S. Badarud-din	XXI-2 & 4	193	265 to 281-2 & 694 to 705-4	193
24	Prestressed Concrete Pavements.	K. K. Banerjee	XXII-1	—	89 to 106	—
25	An Investigation of a Concrete Pavement Failure.	Bh. Subbaraju & Y. C. Gokhale	XXIII-2 & 4	209	247 to 278-2 & 764 to 783-4	209
26	Report of Panel Discussion on Cement Concrete Road Surfacing.	—	XXIII-2	—	335 to 348	—

*Awarded Medal.

Serial No.	Name of Paper	Name of Author	Reference to Proceedings: Volume No.	Reference to Proceedings: No. of Paper in Volume	Reference to Proceedings: Pages	Serial No. of Paper in general index
27	Investigation into Causes of Cracks in Certain Concrete Pavements.	S. K. Bose	XXIV-1 & 5	215	117 to 141-1 & 852 to 872-5	215
28	Stresses in the Corner Region of Thin Bonded Concrete Road Slabs.	S. Koteswara Rao & S. Venkata-subramanian	XXV-2 & 5	225	149 to 162-2	225
29	Strength of Axially Loaded Steel Columns Encased in Concrete.	P. C. Varghese	XXV-2	—	193 to 201	—

VII. Miscellaneous Materials and Processes; Aggregates, Test Sizes, etc.

1	Indian "Road Aggregates" Their Uses and Testing.	R. L. Sondhi	III	37	146-176	41

VIII. Bridges, Retaining Walls and Other Structures.

1	Permissible Stresses in Concrete Bridge Design.	W. J. Turnbull	II	2	358-389	32
2	Submersible Bridge across Parbati at Mile 231, Agra-Bombay Road.	S. N. Bhaduri	III	38	176-234	42
3*	A Method of Calculating the Stability of Braced Pile Piers.	Gathlac Wilson	IV	A (i)	1 (a)-16 (a) & 23 (a)	44
4*	The Dhakuria Lake Bridge.	Do.	IV	A (ii) (a)	17 (a)-23	4
5	Franki Pile Foundations for Bridges.	W. A. Radice	IV	B	1 (b)-29 (b)	46
6	Reinforced Cement Concrete Bridges of 24 ft Span Constructed in Gwalior State.	S. N. Bhaduri	IV	C	1 (c)-20 (c)	47

*Awarded Medal.

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
7*	Reinforced Concrete Bridge across the Godavari at Shahgadh in Hyderabad State.	Dildar Husain	IV	D	1 (d)-46 (d)	4
8	Some Notes on Submersible Bridges.	D. Nilsson	V	I	1 (i)-45 (i)	53
9	Design of Reinforced Concrete Bridges of Short Span for Indian Roads.	Brij Mohanlal	V	J	1 (j)-55 (j)	54
10	A Serious Failure in the Painting of a Steel Highway Bridge.	W. L. Murrell	V	R	1 (r)-10 (r)	63
11	The Sai Bridge.	M. A. Korni	VI	D-39	1 (d)-5 (d)	79
12	Intermediate Screw Piles for the Foundation of Bridges in Soft Soils.	M. S. Doraiswamy Iyengar	VII	A-40	1 & 2	76
13	Failure of a Multi-arched Masonry Bridge.	S. K. Ghosh	VII	B-40	3 to 14 (g)	77
14*	Sevoke Bridge.	Lt.-Col. J. Chambers	VII	G-40	27-34 (h)	82
15	Boat Bridge across the Indus at Gazighat.	G. C. Khanna	VIII	F-43	91-149 (k)	90
16	Submersible Bridge over the Ujh River in Jammu Province.	S. B. Tayabji	VIII	H-43	157-158 (j)	92
17	Masonry Arch Bridge across the Krishna at Deosagar, Hyderabad (Deccan).	Md. Farhatullah	VIII	M-43	299-303	97

* Awarded Medal.

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
18	Stable Causeways on Unstable Foundation Soils.	M. A. Mirza	IX-2 & 4	100	55A to. 69A-2 & 37 to 48-4	
19	Ajoy Bridge—Failure of Masonry Piers—Remedial Measures adopted.	H. K. Nivas	IX-2 & 4	102	101 to 104-2 & 72 to 83-4	102
20	Design and Construction of the Purnabhava Bridge.	J. Chambers	X-1 & 4	103	39 to 123-1 & 655 to 696 (b)-4	103
21	Standard Specifications and Code of Practice for Road Bridges—Section I.	Bridges Committee	X-2 & 4	109	229 to 331-2 & 746 to 789-4	109
22	Standard Specifications and Code of Practice for Road Bridges — Section II.	Bridges Committee	X-3 & 4	112	435 to 458-3 & 746 to 789-4	112
23	The Failure of a Steel Bridge in Bihar.	S. A. Amir	XI-2 & 4	116	160 to 176-2 & 526 to 535-4	116
24	R. C. Bridges in Travancore State.	S. Rajaraman	XI-3 & 4	118	301 to 325-3 & 569 to 576-4	118
25*	Well Foundations of the Kalabagh Bridge over the Indus.	R. K. N. Iyengar	XII-1 & 5	120	17 to 64-1 & 363 to 374-5	120
26	Failure of a Reinforced Concrete Bridge in the N.W.F.P.	Hardit Singh	XII-2 & 5	123	211 to 239-2 & 393 to 405-5	123
27	Tables for Freely Supported Reinforced Concrete Slabs for Road Bridges and Culverts.	Bridges Committee	XII-3	—	434 to 437	—

* Awarded Medal.

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
28	The Testing of the R.C.C. Bridge over the Auranga River.	J. A. Taraporevala	XII-4 & 5	129	59 to 78-4 & 434 to 441-5	129
29	Some Observations on Load Testing to ascertain the Foundation Bearing Pressures of Bridge Wells in Sandy Strata and on the Alterations required in the Design of a Bridge Foundation owing to one Well of a Pier having gone out of Alignment.	B. B. Gupta	XII-4 & 5	130	79 to 92-1 & 442 to 443-5	130
30	Some Type Designs of Unreinforced, Hingeless Masonry Arches.	Bridges Committee	XII-4 & 5	131	157 to 178-4 and 444 to 447-5	131
31	Successive Failure of Two High Level Bridges over the Barakar.	C. D. Mitra	XII-5 & XIII-4	133	247 to 266-5 & 95 to 111-4	133
32	Repairing and Healing of Cracks in Reinforced Concrete Bridges.	M. A. Korni	XIII-3 & 4	139	321 to 346-3 and 178 to 182-4	139
33	Some Causeway on Sandy Bed.	Y. K. Lall	XIII-3 & 4	140	347 to 376-3 and 183 to 192-4	141
34*	Failure of a Five Span Masonry Arch Bridge across the Bhogeswari River near Pen, District Kolaba in the Province of Bombay.	K. G. Bhate	XIV-1 & 4	142	21 to 46-1 and 485 to 499-4	142
35	Well Foundations of the Kathjuri Bridge.	Sudhindra Nath Gupta	XIV-2 & 4	144	153 to 192-2 and 507 to 522-4	14

* Awarded Medal.

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
36*	An Adaptable Steel Centring for R.C. Bridges.	A. Nageswara Ayyar	XIV-3 & 4	147	273 to 291-3 and 537 to 548-4	147
37	Discussions on the above Paper.	A. Nageswara Ayyar	XV-3 & 4	147	449 to 468-3 and 663 to 668-4	147
38	Construction of Approaches to the Malaviya Bridge at Banaras.	K. Sinha	XV-3 & 4	150	207 to 235-2 and 638 to 642-4	150
39	Construction of the Kuakhai Bridge in Orissa.	Sudhindra Nath Gupta	XV-3 & 4	155	417 to 447-3 and 659 to 662-4	155
40	Design for R.C. Pipes for Road Culverts.	A. Nageswara Ayyar	XVI-1	—	131 to 139	—
41	Causeways or Submersible Bridges.	S. P. Raju	XVI-3	—	354 to 370	—
42	A Report on Bridges and Bridge Engineering in Canada.	S. L. Bazaz	XVI-3	—	371 to 407	—
43*	The Investigation, Design and Construction of the Cauvery Bridge at Pugalur.	K. K. Nambiar & K. Namasivayam	XVII-1 & 4	161	68 to 134-1 and 579 to 588-4	161
44	Load Test of the Kuakhai Bridge.	S. N. Gupta	XVII-1	—	141 to 152	—
45	Some Examples of Prestressed Concrete Bridges.	A. E. Hiley, V. M. Silvera & B. B. Gupta	XVII-2 & 4	162	175 to 204-2 and 589 to 593-4	162
46	Bridging India's Rivers–An account of some of the Bridges built under the National Highway Scheme.	Indian Roads Congress	XVII-3	—	393 to 484	—

* Awarded Medal.

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
47	Testing to Destruction a 96 ft Prestressed Concrete Bridge Girder.	K. K. Namiar & P. V. Raj	XVII-3 & 4	164	345 to 392-3 and 602 to 606-4	164
48	A New Method of Applying Kentledge by Hydraulic Jacks for Sinking Foundation Wells.	G.P. Nagarkar & M. P. Apte	XVIII-1 & 4	165	23 to 39-1 & 566 to 576-4	165
49*	The Design of Small Bridges and Culverts	Goverdhanlal	XVIII-2 & 4	167	123 to 213-2 and 583 to 590-4	167
50	Construction of a Submersible Bridge across River Mahanadi near Bhanjanagar (Ganjam) in Orissa.	E. V. S. Iyer & D. C. Panda	XIX-1 & 4	173	91 to 109-1 & 680 to 688-4	173
51	Design and Construction of Prestressed Concrete Bridge across River Palar.	K.K. Nambiar	XIX-3 & 4	177	301 to 359-1 & 705 to 715-4	177
52	The Plastic Theory as applied to the Design of Mild Steel Beams and Frames.	Miss Shakuntala S. Joshi	XIX-3	—	461 to 479	—
53	Prestressed Concrete Bridge across the Mahi River at Vasad on National Highway — Delhi-Ahmedabad-Bombay.	V. B. Manerikar & I. K. Naik	XX-2 & 4	183	151 to 217-2 & 559 to 566-4	183
54	Timber Bridges in Kashmir.	—	XX-2	—	229 to 239	—
55	Light Suspension Bridges in Himachal Pradesh.	A. J. D'Costa & T. S. Rupal	XX-3 & 4	188	359 to 413-3 & 595 to 597-4	188

* Awarded Medal.

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
56	Load Testing of the Prestressed Concrete Bridge across Bhima River at Takli on Sholapur-Bijapur Road.	S. V. Natu	XXI-1 & 4	189	25 to 48-1 & 621 to 644-4	189
57	Design and Construction of a Prestressed Concrete Bridge across River Coleroon.	K. K. Nambiar & P. G. Nambiar	XXI-2 & 4	192	149 to 263-2 & 666 to 693-4	192
58	Indian Bridges	Y. Guyon	XXI-4	198	614 to 619 & 746 to 753	198
59	Construction of a Bridge across Pennar River at Nellore.	J. V. Prasad	XXII-1 & 4	199	19 to 73-1 & 685 to 701-4	199
60	Construction of Prestressed Concrete Superstructure for the Bridge over River Hindan at Ghaziabad.	A. S. Bishnoi & J. S. Mathur	XXII-2 & 4	201	197 to 259-2 & 718 to 725-4	201
61	Construction of an R. C. Cantilever Hollow Girder Bridge over Betwa River at Jhararghat.	P. N. Srivastava	XXIII-1 & 4	206	65 to 115-1 & 701 to 730-4	206
62	Design and Construction of Training Works over River Ghogra at Ayodhya.	N. C. Bhargava	XXIV-1 & 5	214	71 to 115-1 & 844 to 851-5	214
63	The Investigation, Design and Construction of Submersible Bridges.	D. Johnson Victor	XXIV-1	—	181 to 213	
64	Flood Discharge Estimation for Small Catchments.	B. Balwant Rao	XXIV-2 & 5	216	221 to 283-2 & 873 to 885-5	216

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
65	Design and Construction of Prestressed Contrete Bridges across Kunwary River.	Y. K. Patil & C. V. Kand	XXIV-2 & 5	217	286 to 333-2 & 886 to 916-5	217
66	Ultimate Load Carrying Capacity of Composite Beams.	P. C. Varghese	XXIV-3	—	559 to 578	—
67	Study on the Stability of Well Foundations for Major Bridges.	A. Banerjee & S. Gangopadhyay	XXV-2 & 4	226	163 to 184-2	226
68	Design and Construction of Udyavar Bridge.	A. S. Adke & C. Chidambaram	XXV-3 & 4	227	235 to 292A-3	227

IX. Traffic Statistics; Regulation and Control of Traffic; Economics of Roads and Road Transport.

1	The Trend of Development in the United Provinces in the matter of Improving Road Surfaces with Special Reference to Recent Experiments.	C. F. Hunter	I	2	107-120 & 168-182	
2	An Analysis of Delhi Road Traffic Census.	R. L. Sondhi	II	14	7-28 & 46-62	16
3	Study of Relationship between Vehicular Traffic and Road Surface as affecting the Section of Economic Road Surface.	H. P. Sinha & A. M. Abbasi	II	15	29-39 & 46-62	17
4	Traffic Census and Road Diagrams.	Lt.-Col. W. De & H. Haig	II	16	40-45 & 46-62	18

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
5	Economics of Road Maintenance.	S. Bashiram	II	17	63-72 & 93-104	19
6	Regulations and Control of Motor Transport in Mysore.	H. Rangachary	II	29	134-255	33
7	An Aspect of Traffic Statistics.	Ian A. T. Shannon	IV	H	I(h)-6(h)	52
8*	A note on the Reconstruction of Roads carried out in the U. P. with special reference to Experiments carried out and the use of Traffic Statistics.	S. N. Chakravarti	VIII	B-41	5-42(f)	86
9*	Economics of Highway Types.	K. S. Raghavachary	X-1 & 4	105	133 to 181-1 & 713 to 723-4	105
10	Allocation of Road Maintenance Cost between Motor Vehicle Traffic and Non-Motor Vehicle Traffic.	Prof. K. B. Madhava	X-2 and 4	108	218 to 227-2 & 734 to 745-4	108
11	Essay on "Post-war Goods and Passenger Road Transport and its Economics."	Prof. K. B. Madhava	XI-1	—	49 to 120	—
12	Essay on "Post-war Goods and Passenger Road Transport and its Economics."	N. S. Surya	XII-3	—	409 to 427	—
13	A Survey of Traffic on the New Howrah Bridge.	Prof. K. B. Madhava	XII-3 and 5	127	345 to 407-3 & 427 to 433-5	127
14	A Small Scale Traffic Survey in New Delhi.	C. S. Anantapadmanabhan	XIV-1 and 4	143	47 to 121-1 and 500 to 506-4	143

*Awarded Medal.

Serial No.	Name of Paper	Name of Author	Reference to Proceedings: Volume No.	No. of Paper in Volume	Pages	Serial No. of Paper in general index
15	The Design of an Experiment to Assess the Cost of Operation of Motor Vehicles on Different Types of Roads.	C. S. Anantapadmanabhan & M. K. Ganguli	XX-2 and 4	181	123 to 140-2 & 541 to 552-4	181
16	The Importance of Traffic Engineering in India.	R. K. N. Iyengar	XX-3 & 4	187	325 to 357-3 & 584 to 594-4	187
17	A Study of Accident Statistics and Some Aspects of Road User Behaviour in Delhi.	M. S. V. Rao & T. R. Sehgal	XXI-3	—	397-413	—
18	Scientific Aspects of the Road Traffic Problem.	Tejbir S. Khanna	XXII-3 & 4	204	395 to 423-3 & 756 to 774-4	204
19	Traffic Survey In and Around Calcutta.	S. K. Laha, A. K. Das Gupta & S. Chatterjee	XXIII-2 & 4	208	185 to 245-2 & 750 to 763-4	208
20	Road Transport Operation Cost on various Types of Surfaces.	N. D. Daftary & M. K. Ganguli	XXIV-3 & 5	220	517 to 540-3 & 950 to 955-5	220
21	Origin & Destination Study of Traffic of Greater Delhi.	T. S. Khanna & T. R. Sehgal	XXIV-4 & 5	221	579 to 627-4 & 956 to 968-5	221
22	Traffic Census on Non-Urban Roads.	Specifications & Standards Committee	XXV-1	—	121 to 129	—
23	Study of Parking Problems —Connaught Place & Connaught Circus Area.	Jogindar Lal	XXV-3	228	293 to 321	228
24	Traffic Signs.	—	XXV-3	—	397 to 417	—

X. Road Maintenance and Road Usages.

1	Ways and Means of Improving the Bullock-cart.	G. L. W. Moss	III	36	73-92	40

Serial No.	Name of Paper	Name of Author	Reference to Proceedings: Volume No.	No. of Paper in Volume	Pager	Serial No. of Paper in general index
2	Steel Tyre Problem Unfolds.	W. L. Murrell	VII	E-40	76-77(k)	80
3	Raising the Road Rupee Ratio with a Special Reference to the Steel Tyre.	W. L. Murrell	VII	C-41	43 to 56 (g)	87
4	Proposals for an All-India Survey of Bullock-Carts by means of Random Sampling.	J. Vesugar	VIII	J-43	185-202 (p)	94
5*	A Design for Bullock-Cart Wheels, Part I.	B. V. Vagh	IX-2 & 4	101	55 to 99-2 & 49 to 70-4	101
6	Maintenance of Gravel (Moorum) Roads under Heavy Traffic.	B. B. Gupta	X-2 & 4	107	211 to 217-2 & 730 to 733-4	107
7	The Effect of Road Camber on Road Maintenance and Wheel Design.	B. V. Vagh	XII-1 & 5	121	65 to 85-1 & 375 to 381-5	121
8*	A Design for Bullock-Cart Wheels, Part II.	Do.	XII-4 & 5	128	5 to 58-4 & 375 to 381-5	128
9*	A Design for Bullock-Cart Wheels, Part III.	Do.	XIII-2 & 4	137	181 to 239-2 & 158 to 171-4	137
10*	A Design for Bullock-Cart Wheels, Part IV.	Do.	XV-1 & 4	148	65 to 154-1 and 627 to 633-4	148
11*	A Design for Bullock-Cart Wheels, Part V.	Do.	XV-2 & 4	151	237 to 279-2 and 627 to 633-4	151
12	Stress at a point within a Semi-Infinite Elastic Medium Subjected to a Surface Vibratory Load.	C. N. Nagaraj & H.A. Balakrishna Rao	XXIV-2	—	461 to 473	—

* Awarded Medal.

XI. Standardization, Designs, Loadings, Impact, Specifications.

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
1*	The Necessity for a Reasonably Uniform Standard Loading for Design of Concrete Bridges and a suitable Loading for such and other Types of Bridges on Highways in India.	M. G. Banerjee	II	26	256 to 338 & 382 to 389	30
2	Design of Highway Bridges. The Necessity for an All-India Specification.	W. A. Radice, G. Wilson and P. F. S. Warren	II	27	338-356 & 382-389	31
3	Standardization.	D. Nilsson	VI	39	1 (k) to 16 (k)	74
4*	Impact on Reinforced Concrete Road Bridges as compared to Steel Bridges.	E. P. Nicolaides	VI	L-39	1 (l) to 57 (l)	75
5	Widths of Highway Pavements.	Specifications and Standards Committee.	XI-1 & 4	113	7 to 27-1 & 493 to 504-4	113
6	Standard Scales and Standard Sizes of Drawings for Highway Projects.	Do.	XI-1 & 4	114	28 to 48-1 & 505 to 509-4	114
7	Horizontal and Transition Curves for Highways.	Do.	XI-3 & 4	119	327 to 392-3 & 577 to 587-4	119
8	Policy Concerning Maximum Dimensions, Weights and Speeds of Motor Vehicles in India.	Do.	XIII-2 & 4	138	241 to 285-2 & 172 to 177-4	138

* Awarded Medal.

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
9	Road Boundary or Furlong Stone.	Central Roads Organisation	XIV-1	—	137 to 140	—
10	Glossary of Highway Engineering Terms.	Specifications and Standards Committee.	XIV-3 & 4	146	247 to 272-3 & 532 to 536-4	146
11	Do.	Do.	XVIII-3	170	371 to 445-3	170
12	Standards for Sight Distances for Highways.	Do.	XV-1 & 4	149	155 to 181-1 and 634 to 637-4	149
13	Vertical Curves for Highways.	Do.	XVI-1 & 4	156	22 to 76-1 & 506 to 515-4	156
14	Type Designs for Boundary & Furlong Stones.	Do.	XVII-1	—	135 to 140	—
15	Type Designs for Highway Mile Stones.	Do.	XVIII-1	—	71 to 82	—
16	Dimensions & Weights of Road-Design Vehicles.	Do.	XVIII-2	—	246 to 249	—
17	Route-Marker Signs for National Highways.	Do.	XVIII-2	—	250 to 257	—
18	Recommended Practice for Location & Layout of Road-side Motor-Fuel Filling Stations.	Do.	XVIII-3	—	447 to 451	—
19	Traffic Rotaries.	Do.	XIX-3 & 4	178	367 to 421-3 & 716 to 724-4	178
20	Glossary of Highway Engineering Terms and Hindi Equivalents.	Do.	XX-3	185	243 to 296	185

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in gen index
			Volume No.	No. of Paper in Volume	Pages	
21	Recommended Practice for Numbering Bridges and Culverts.	Specifications and Standards Committee.	XXIV-1	—	215 to 219	—
22	Type Designs for Highway Kilometre Stones.	Do.	XXV-1	—	131 to 147	

XII. Research and Experiments.

1	Test Tracks—A Suggestion.	C. D. N. Meares	I	13	204-212	15
2	General Review of the Results of Recent Road Experiments in India as revealed by Modern Practice.	K. G. Mitchell	II	21	131-141 & 160-163	02
3	Road Research Results.	C. D. N. Meares	II	22	142-159 & 160-163	24
4	A Note on "Experiments with Cutbacks of Bitumen".	P. C. Neogi	V	—	89 to 102	
5	Development and Application of Village Cement and High Silica Portland Cements for the Construction of Concrete Roads.	A. K. Datta	VI	C-39	1 (c) to 28 (c)	66
6	Further Developments in Village Cements and High Silica Portland Cements for the Construction of Cement Concrete Roads.	Do.	VII	E-41	75-91 (k)	89
7	Effect of the Physico-Chemical Properties of Soils on Road Performance.	A. G. Asghar & C. L. Dhawan	XII-3 & 5	126	329 to 344-3 & 425 to 426-5	

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
8	Cement Concrete Trackways.	Central Roads Organisation	XIII-3	—	419 to 430	—
9	Experimental Trackways for Motor Traffic on the Delhi-Meerut Road.	Do.	XIV-3	—	311 to 322	—
10	Experiments on Concrete Trackways on Black Cotton Soil.	Central Roads Organisation	XIV-3	—	323 to 343	—
11	Use of Stabilized Soil in Engineering Construction, Section I.	S. R. Mehra & H. L. Uppal	XIV-3	—	293 to 310	—
12	Do. Do. Sections II & III.	Do.	XV-1	—	184 to 204	—
13	Do. Do. Section IV.	Do.	XV-2	—	320 to 335	—
14	Stabilization of Gumbotil Soil for Highway Use.	O. H. Patel	XV-2	—	336 to 356	—
15	Use of Stabilized Soil in Engineering Construction, Section V.	S. R. Mehra & H. L. Uppal	XV-3	—	469 to 482	—
16	Do. Do. Section VI.	S. R. Mehra, H. L. Uppal & Labhu Ram	XV-3	—	483 to 491	—
17	Waterproofing of Alkaline Soil by Linseed Oil-Cake.	B. R. Sen & Manohar Lal	XV-3	—	492 to 500	—
18	An Examination of Black-top Surface Dressing laid for Field Tests in 1945 on the Bombay-Delhi Road, Mile 736.	E. Zipkes	XVI-2	—	223 to 245	—

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
19	Some Observations on Air Field Runway Surfaces.	Central Road Research Institute, Okhla, Delhi	XVII-1	—	153 to 172	—
20	Compaction of Some Alluvial Soils of India.	Do.	XVII-2	—	291 to 344	—
21	An Investigation on Some Laterites.	Do.	XVIII-1	—	87 to 119	—
22	A Suggested Classification of the Black Cotton Soils of India.	Do.	XVIII-2	—	259 to 307	—
23	A Method for Estimating the Bearing Capacity of Road Crusts with Soft Materials.	Do.	XIX-1	—	123 to 163	—
24	Use of Linseed Oil-cake as a Stabilizer in Earth Construction.	Manohar Lal & B. L. Dhawan	XIX-2	—	273 to 283	—
25	Laboratory Experiments in Sand Stabilization.	H. L. Uppal	XIX-2	—	285 to 300	—
26	Shear Failure in Anisotropic Materials.	C. G. Swaminathan	XIX-2 & 4	174	167 to 188-2 & 689 to 693-4	174
27	Use of Lime in Soil Stabilization.	S. R. Mehra & L. R. Chadda	XIX-3	–	483 to 494	—
28	Laboratory Experiments on Use of Primers in Preventing Capillary Rise.	S. R. Mehra, H. L. Uppal & L. R. Chadda	XIX-3	—	495 to 498	—
29	Effect of Size on the Compressive Strength of Soil Blocks.	H. L. Uppall	XXI-1	—	129 to 147	–

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
30	Laboratory Investigation on the Effect of Addition of Some Surface Active Agents to Stabilized Soil Mixtures.	I. S. Uppal & O. P. Wason	XXI-2	—	307 to 320	—
31	General Report on Road Research in India.	—	XXI-2	—	355 to 377	—
32	An Investigation for Mass Production of Pozzolanic Portland Cements from Overburnt or Fused Jhama and Wellburnt Bricks by utilising Brick Kilns.	A. K. Datta	XXI-3 & 4	196	381 to 394-3 & 718 to 731-4	196
33	Further Studies on Waterproofing of Alkaline Soils by Linseed Oil-cake.	B. R. Sen, Manohar Lal & B. L. Dhawan	XXI-3	—	417 to 432	—
34	Study of Soft Aggregates from Different Parts of India with a view to their use in Low Cost Road Construction, I—Rajasthan.	H. L. Uppal & Bhupinder Singh	XXI-3 & 4	197	433 to 457-3 & 732 to 745-4	197
35	Absorptiometric Analysis of Asphaltic Bitumens.	C. G. Swaminathan & S. A. Swami	XXII-1	—	109 to 134	—
36	Study of Soft Aggregates from Different Parts of India with a view to their use in Road Construction, II—Laterites.	R. L. Nanda & R. Krishnamachari	XXII-2	—	313 to 344	—
37	A Laboratory Investigation on the Stripping of Bituminous Binder from a Coated Road Stone in the Presence of Water.	C. G. Swaminathan & K. P. Nair	XXII-3	—	455 to 482	—

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
38	General Report on Road Research in India.	—	XXII-3	—	549 to 576	—
39	Chemical Stabilisation of Sand and Sandy Soils (Laboratory Experiments with Sodium Silicate as Stabiliser).	R. N. Dogra & I. S. Uppal	XXIII-1	—	161 to 172	—
40	Railing Barriers on Busy Road Intersections-Before and After Study.	Tejbir S. Khanna	XXIII-1	—	173 to 183	—
41	Gap Graded Concrete for Pavement Construction.	K. S. Sankaran	XXIII-2	—	293 to 314	—
42	Selection of Suitable Stabiliser for Checking Capillary Rise of Water from the Subgrade.	I. S. Uppal	XXIII-2	—	315 to 332	—
43	General Report on Road Reasearch in India.	—	XXIII-3	—	553 to 576	—
44	A Statistical Examination of the Classification Suggested for the Black Cotton Soils of India.	H. L. Uppal & T. R. Sehgal	XXIII-3	—	577 to 588	—
45	An Experimental Study on the Adhesion of Binders like Bitumen and Tar No. 3 with Stabilized Soil Crust.	S. R. Mehra, L. R. Chadda & H. R. Aggarwal	XXIV-1	—	145 to 162	—
46	Investigation of Some Road Failures in North Western India.	Bh. Subbarajhu, R. L. Nanda & R. Krishnamachari	XXIV-2	—	403 to 437	—

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
47	Bituminous Penetration Macadam.	C. G. Swaminatham & S. A. Swami	XXIV-2	—	439 to 458	—
48	A Study of Some Factors Influencing the Swelling Pressure of Clays.	H. L. Uppal & R. M. Palit	XXIV-3	—	543 to 555	—
49	General Report on Road Research in India, 1958-59.	—	XXIV-4 & 5	—	681 to 705-4 & 969 to 998-5	—
50	An Investigation for Evaluating an Airfield Pavement.	H. L. Uppal & H. S. Bhatia	XXV-1 & 4	223	25 to 60-1	223
51	Strengthening the Subgrades and Flexible Bases of Roads by the use of Hydrated Lime.	R. N. Dogra, I. S. Uppal & P. N. Vasudeva	XXV-1	—	81 to 118	—
52	General Report on Road Research in India, 1959-60.	—	XXV-3	—	323 to 353	—
53	A Study of Soft Aggregates from Different Parts of India with a view to their use in Road Construction—Part III, Bombay.	H. L. Uppal & Bhupinder Singh	XXV-3	—	357 to 395	—

XIII. Administration and Finance.

1	Objects and Organisation of a Permanent Indian Roads Congress.	K. G. Mitchell	I	1	11-20	1
2	Roads in India and Australia—Our Difficulties and some Suggestions.	W. L. Murrell	VI	73	1 (j) to 39 (j)	73
3	Organization of Bridging Activities.	G. R. Nangea	XV-2 & 4	152	281 to 319-2 & 643 to 647-4	152

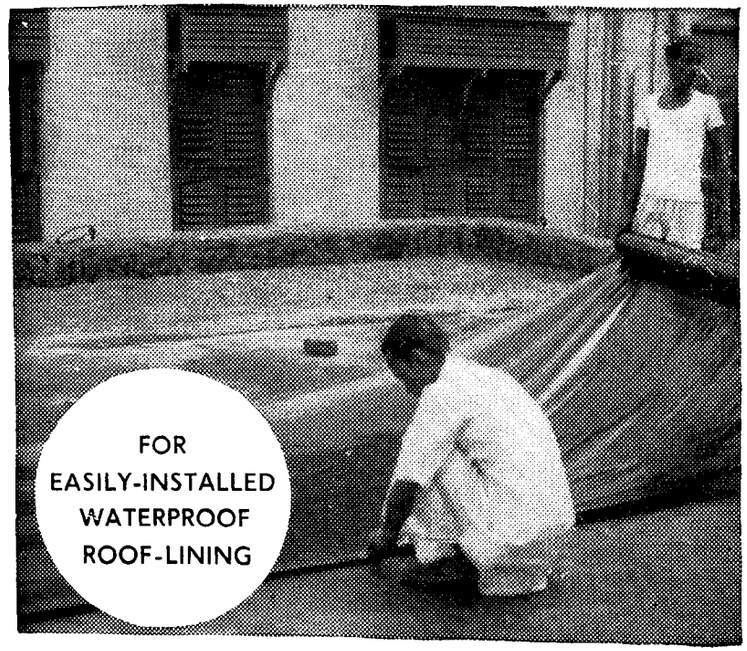
Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of paper in general index
			Volume No.	No. of Paper in Volume	Pages	
4	The Importance of Organization.	R. P. Chanda	XVI-2 & 4	159	205 to 221-2 & 545 to 555-4	159

XIV. Plant, Machinery and Apparatus.

1	Notes on the Plant used for Quarrying and Granulating and Operating Costs of the Gauhati-Shillong Road, Khasi and Jaintia Hills Division, Assam.	B. F. Taylor	I	11	199-203	17
2	Technical Note No. 1—Selection of Plant for Collection and Loading of Shingle.	Col. R. S. Dalby	XII-2	—	273 to 276	—
3	Technical Note No. 2—A Note on Road Rollers with Particular Reference to Steam Road Rollers.	Central Roads Organisation	XII-4	—	107 to 155	—
4	Technical Note No. 3—Earth-Moving Machinery for Roads.	Do.	XIV-3	—	345 to 359	—
5	Technical Note No. 4—Diesel Road Rollers Manufactured in India.	R. S. Bhalla	XV-3	—	501 to 545	—
6	A New Method of Supplying India's Requirements of Bitumen for Black-topped Roads.	W. A. Griffiths	XXI 3 & 4	194	321 to 333-3 & 706 to 710-4	194
7	Earth-Moving Machinery in West Bengal.	D. N. Ghosh	XXI-3 & 4	195	335 to 351-3 & 711 to 717-4	195

XV. Miscellaneous.

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
1	Lecture on "Satistics and Road Research".	Prof. K. B. Madhava	X-1	—	185 to 210	—
2	Memorandum on "Should Delhi as Capital of India be Developed as a Pilot Scheme".	H. E. Ormerod	X-2 & 4	—	331 to 336-2 & 810 to 814-4	—
3	Essay on "Road Mindedness—How to create a Widespread Public Demand for more and better Roads in India".	N. M. Khan	XI-2	—	285 to 292	—
4	Notes on the Work and Organisation of the Road Research Laboratory (Harmondsworth), Great Britain.	G. Sriranga-chary	XI-3	—	393 to 406	—
5	Note on "A Plea for Rational Weights, Measures and Currency".	Brij Narayan	XII-5	—	456 to 470	—
6	Tentative Proposals for the Establishment of the Central Road Research Institute.	Council of Scientific and Industrial Research	XIII-2	—	287 to 318	—
7	Essay on "Village Roads, their Maintenance and their Effects on the Development of Rural India".	N. S. Surya	XIII-4	—	199 to 207	—
8	Indian Standards—Rules for Rounding off Numerical Values.	Indian Standards Institution	XVI-1	—	141 to 143	—



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Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
9	The Ninth International Road Congress, Lisbon (Sep-Oct. 1951), Conclusions.	—	XVI-2	—	264 to 295	—
10	A Note on "A Policy on Road-side Advertisement".	Specifications and Standards Committee	XVII-2	—	71 to 275	—
11	Roads in Newzealand.	B. G. Naik	XVII-2	—	276 to 290	—
12	Some Observations on Airfield Runway Surfaces.	Central Road Research Institute, Delhi	XVII-1	—	153 to 172	—
13	A Note on Experiments with Aerated Concrete.	H. Sunder Rao	XVIII-1	—	59 to 69	—
14	Rivers and Ferries of North Bengal.	R. P. Chanda	XIX-2 & 4	176	233 to 258-2 & 702 to 704-4	176
15	Highways in Australia.	V. V. Gopalakrishna Ayyar	XIX-3	—	425 to 459	—
16	The Tenth International Road Congress.	—	XXI-1	—	101 to 126	—
17	Surface Dressing Practice in Victoria.	Hari Dutt Gupta	XXI-2	—	285 to 304	—
18	Training Highway Engineers in the Application of Aerial Surveys.	O. W. Mintzer	XXII-3	—	517 to 526	—
19	A Note on the Up-to-date Position with regard to the Use of Surkhi as a Pozzolana.	M. L. Puri & N. R. Srinivasan	XXIII-2	—	349 to 373	—

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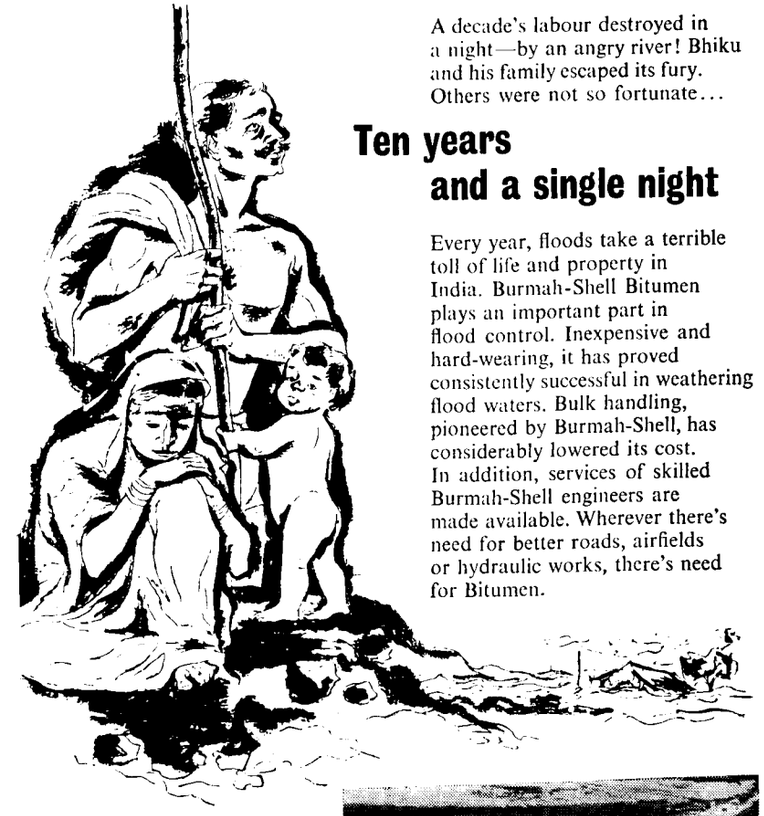

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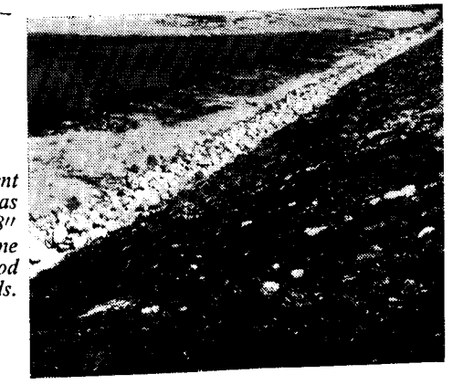

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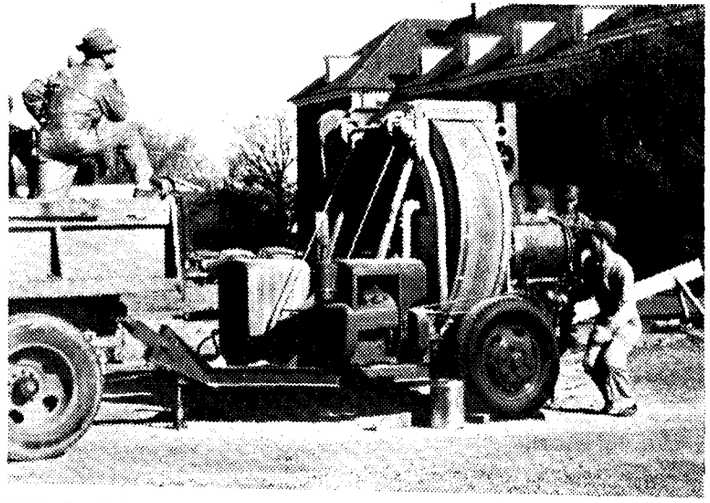

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