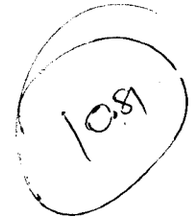
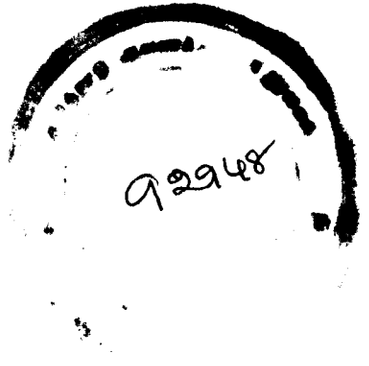
The Indian Roads Congress

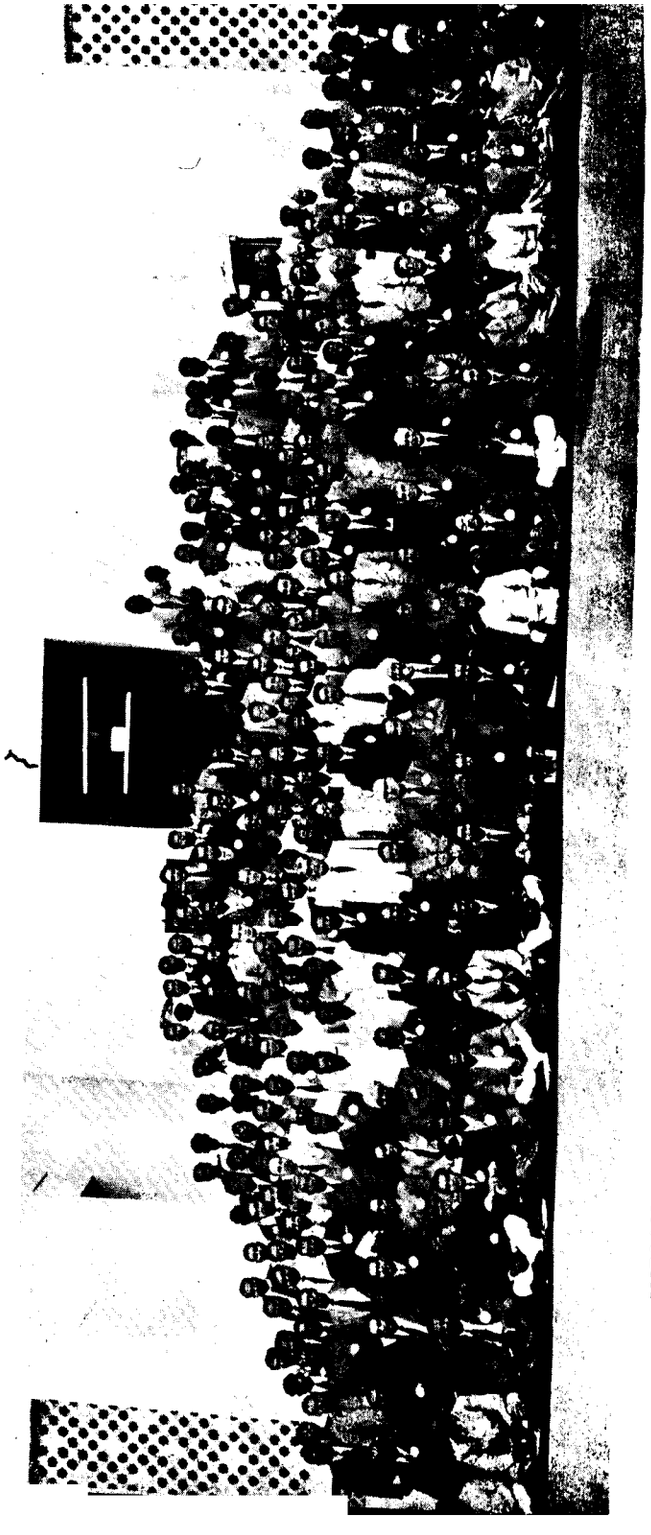
1958-59



LIST OF MEMBERS OF THE COUNCIL FOR 1958-59.

1. Dr. F. P. Antia
2. M P. Apte
3. C. J. Fielder
4. E. A. Nadirshah
5. L. R. Patel
6. Dr. L. C. Verman
7. Nilkanth Sinha
8. K. Sinha
9. S. N. Gupta
10. Dr. R. K. N. Iyengar
11. S. N. Sinha
12. P. Sirajuddin
13. N. Durrani
14. K. Barua
15. B. Prasad
16. U. J. Bhatt
17. K. V. Ekambaram
18. H. R. Gupta
19. B. S. Jootla
20. M. S. Bisht
21. R. C. Roy
22. G. S. Ganapathy
23. Kishore Lal
24. V. V. Gopalakrishna Iyer
25. D. N. Gupta
26. J. Mukand
27. Brig. S. K. Bose
28. S. R. Mehra
29. P. L. Varma
30. K. K. Nambiar





INDIAN ROADS CONGRESS, TWENTY-THIRD SESSION, HYDERABAD, JANUARY 1959.

SHRI W. X. MASCARENHAS, I.S.E., President 1958–59.

Shri W. X. Mascarenhas, was born at Bombay on 13th December 1902. He joined the Indian Service of Engineers in 1926 and had a versatile career, serving in not less than five different departments including the Ministry of Defence, Government of India. He was the Principal of the College of Engineering, Poona; Joint Secretary, Reconstruction Department, Bombay, P.W.D.; Director of Agricultural Engineering, Bombay; Chief Engineer, National Defence Academy Project, Khadakvasla, Poona; Chief Engineer and Joint Secretary to the Government of Bombay, P. W. D., from which post he retired on 13th February 1958 and is now Chief Engineer/ Executive Director in the Life Insurance Corporation of India, Central Office. Shri Mascarenhas was a member of several Government Committees including the Visvesvaraya Irrigation Enquiry Committee; Auchinleck War Memorial Committee; Bhide Land Improvement Committee and Chairman of the River Valley Projects Technical Personnel Committee. He was elected as a member of the IRC in June 1955. An elegant penman, Shri Mascarenhas is also a brilliant speaker and his recent performances at the Annual Session of the Indian Roads Congress will be remembered for long.

INDIAN ROADS CONGRESS

NOTICES AND ANNOUNCEMENTS

CONTRIBUTION OF PAPERS FOR THE TWENTY-FOURTH SESSION OF THE INDIAN ROADS CONGRESS

The next General Session of the Indian Roads Congress will be held at Bangalore early in 1960. The exact dates and programme will be communicated in due course. Members are requested to contribute Papers on any subject connected with Highway Engineering for discussion at the Session.

2. The Indian Roads Congress will be completing 25 years of life in December 1959. It is, therefore, proposed to celebrate the **Silver Jubilee** of the Congress at the next Session in a befitting manner. One of the ways by which this can be done is by presenting for discussion a set of good Papers contributed by members. After all, Papers are an index of the contribution of Engineers to the advancement of the profession and thereby to the progress of the country. At this stage of the country's road development, members will be in a favourable position to send suitable Papers embodying the results of their work and experience.

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

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

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

From past experience it is observed that most of the members send in their contributions at the last moment, when

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

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

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

6. **Medals**: The following Medals are available for award:

(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.

7. 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.

8. Rules and Regulations for the contribution of Technical Papers and the award of Medals are published on pages 10 to 15 of Volume XXIII-Part 1 of the Journal of the Indian Roads Congress—November 1958.

II. NEW ADMISSIONS

LIST OF MEMBERS OF THE INDIAN ROADS CONGRESS ENROLLED FROM 1-10-58 TO 10-5-59.

Serial No.	*Roll No.*	*Name*	*Address*
1	2440	Shri B. Chinnappa Reddy	Junior Engineer, Highways, Markapur, **Kurnool District** (Andhra Pradesh).
2	2441	Shri B. C. Shah	Lecturer in Applied Mechanics, Opp: Telephone Exchange, **Morvi** (Saurashtra) (W. Rly).
3	2442	Shri S. K. Bhattacharjee	Executive Engineer, Dharmanagar, **Tripura.**
4	2443	Shri T. N. Pandita	Assistant Engineer, Planning, Project & Planning Division, J & K., P.W.D. (R & B), **Jammu Tawi** (Kashmir State).
5	2444	Shri M. P. Jain	Addl. City Engineer, Municipal Board, **Lucknow** (U. P.).
6	2445	Shri R. R. Bendre	Bitumen Engineer, Burmah-Shell House, Ballard Estate, **Bombay-1.**
7	2446	Shri M. A. Rahim Mohajir	Asstt. Engineer (Highways) T. & M. Division, **Madras-25.**
8	2447	Shri V.Ramanathan	Junior Engineer (Highways), T. & M. Division, **Madras-25.**
9	2448	Shri Hari Ram Sarwal	S. D. O., P. W. D., B/R, **Faridkot.**
10	2449	Shri S. R. Pandurangan	Asstt. Engineer (Highways), Cauvery Bridge Sub Division, Ayyampet Post; **Tanjore Distt.,** (Madras State).
11	2450	Shri K. T. Subudhi	Executive Engineer, P.W.D., Koraput Division, **Koraput** (Orissa).
12	2451	Shri H.H. Campbell	Bitumen Manager, Burmah-Shell Oil Co., Ltd., Post Box 688, **Bombay.**
13	2452	Shri A. C. Sharma	Sub Divisional Officer, P. W. D., **Saharanpur** (U. P.).
14	2453	Shri R. Pal Sikka	A. S. W., Office of Superintendent Survey of Works (N. Z), Room No. 91 A, 'G' Block, **New Delhi.**

Serial No.	Roll No.	Name	Address
15	2454	Shri P. Venkatarao	Asstt. Engineer (Highways), Nandigama, **Krishna District.**
16	2455	Shri S. M. Mathur	Assistant Engineer, P.W.D. (B & R), **Dausa** (Rajasthan).
17	2456	Shri Romesh Chandra Joshi	Asstt. Engineer, P.W.D. (B & R), C/13/18, Residency Colony, **Jodhpur** (Rajasthan).
18	2457	Shri O. P. Mathur	Executive Engineer, Gangtok Central Division No. 1, **Gangtok** (Sikkim).
19	2458	Shri Satya Bhushan Sehgal	Asstt. Prof., Department of Highway Engineering, Punjab Engineering College, **Chandigarh.**
20	2459	Shri Bishwanath Prasad	Asstt. Engineer, P. W. D. (B & R), Narkatiaganj, N.E. Railway, **Champaran** (Bihar).
21	2460	Shri K. K. Aggarwal	Asstt. Professor, (Civil), Punjab Engineering College, **Chandigarh** (Punjab).
22	2461	Shri K. L. Bhanot	Asstt. Engineer (Designs), Office of the Chief Engineer, P.W.D., B. & R., **Patiala** (Punjab).
23	2462	Shri Damodar S. Shenoy	Junior Engineer, A/6, Karnatak Building, Mogal Lane, Mahim P. O., **Bombay-16.**
24	2463	Shri P. Nagaraja Rao	C/o. Prof. I. Vasudeva Nayak, Punjab Engineering College, **Chandigarh** (Punjab).
25	2464	Shri Kishan Singh	Executive Engineer, P.W.D. (B & R), City Division, **Bikaner** (Rajasthan).
26	2465	Shri S.K. Mukerjee	Assistant Engineer, P. W. D. (B & R), Bhilwara East Sub Division, **Bhilwara** (Rajasthan).
27	2466	Shri S.M. Khyrathi	Assistant Engineer (H), Tadepallegudem, **West Godavari Dist.** (Andhra Pradesh).
28	2467	Shri A. L. Maroo	Assistant Engineer, North Sub Division, P. W. D., B. & R., **Udaipur** (Rajasthan).
29	2468	Shri M. Ahmed Kalnad	Assistant Engineer, P. W. D., Roads & Buildings, Post Box No. 7, Kalpetta, (Via) **Kozhikode**, (Kerala State).
30	2469	Shri S. Lakshmaiah Chetty	Assistant Engineer, Highways, **Kalahasti** (Dist. Chittoor).

Serial No.	Roll No.	Name	Address
31	2470	Shri I. G. Qazi	Assistant Engineer, P. W. D., **P. O., Chakia**, Dist. Varanasi (U. P.).
32	2471	Shri M. N. Sinha	Sub Divisional Officer, P. W. D., **Saharsa** (Bihar).
33	2472	Shri T. Achyuta Ramayya	Divisional Engineer (Highways), Gowthami Bridge Division, **Alamuru**, (East Godavari), Andhra Pradesh.
34	2473	Major M.M.L. Kohli	Staff Officer (Planning), Engineer-in-Chief's Branch, Army Head-quarters, **New Delhi.**
35	2474	Shri N. K. Sinha	Assistant Engineer, C/o. Shri Jogesh Chandra Debbarman, P.O. Agartala, **Dist. Tripura.**
36	2475	Shri R. K. Gupta	Assistant Engineer, P. W. D., Bridge Division, Garhmukteshwar, **Meerut** (U. P.).
37	2476	Shri A. T. Devassy	Assistant Engineer, P.W.D., **Trichur** (Kerala State).
38	2477	Shri Keshavan Nair	Lecturer in Civil Engineering, C/o. Dr. Mrs. Nair, Lady Dufferin Hospital, **Patiala** (Punjab).
39	2478	Shri M. L. Sen	Assistant Engineer, W. & B. Department, 72, Mogra Road, Agartala, **Tripura.**
40	2479	Shri C. Rajagopala Rao	P. A. to Divisional Engineer (H), Chilakalapudi, **Krishna Dist.**
41	2480	Shri B. Ramamurty	Assistant Engineer (H), **Vijayawada-2**, Krishna District.
42	2481	Shri V. K. Arora	Assistant Engineer, Consultant, Ministry of Transport & Communications, Deptt. of Transport, Roads Wing, Jamnagar House, Shahjahan Road, **New Delhi.**
43	2482	Shri V. Rama Rao	Assistant Engineer, Highways, Gautami Bridge Division, Alamuru P.O., **East Godavari District**, (Andhra Pradesh).
44	2483	Shri J. V. Ramana Rao	Assistant Engineer (Highways), Tenali, **Guntur District**, (Andhra Pradesh).
45	2484	Shri P. Venkanna	P. A. to Superintending Engineer (H), 1st Circle, Kakinada, **East Godavari District.**
46	2485	Shri W.G. Saldanha	Executive Engineer, Mysore Division, **Mysore.**

Serial No.	Roll No.	Name	Address
47	2486	Shri Mohd. Altaf Hussain	Asstt. Engineer, Highways, **Rajahmundry** (Andhra Pradesh).
48	2487	Shri P. Venkateswara Rao	Asstt. Engineer (H), N. H. 5 Division, Tanuku, **West Godavari District**, (Andhra Pradesh).
49	2488	Shri T. Venkateswarlu	Assistant Engineer (H), Kovvur, **West Godavari District**, (Andhra Pradesh).
50	2489	Shri Shri Ram Gupta	Executive Engineer, P. W. D., **Dhar** (M. P.).
51	2490	Shri C. Rajagopala Rao	Junior Engineer (H), Surya Rao Pet, **Vijayawada**, (Andhra Pradesh).
52	2491	Shri Jaipal Singh Gupta	Assistant Engineer, Designs, P.W.D., B/R., Office of Chief Engineer, **Patiala.**
53	2492	Shri B. T. Sitaram Aiengar	Divisional Engineer, R. & B., **Kareem Nagar** (Andhra Pradesh).
54	2493	Shri R. K. Patil	Deputy Engineer, R. & B. Sub Division, Bagalkot, **District Bijapur**, (Mysore State).
55	2494	Shri Ghousdad Khan	Executive Engineer, P.W.D., R. & B., **Nizamabad**, (Andhra Pradesh).
56	2495	Shri M. Kannan	Reader, Annamalai University, South India, **Madras.**
57	2496	Shri S. C. Bandopadhyay	Assistant Engineer (W. & B.), 60-A, Lady Willingdon Road, **Calcutta-32** (W. Bengal).
58	2497	Shri K. N. Krishna Murthy	C/o. Standard Vacuum Oil Co., Stanvac Building, **Bombay-1.**
59	2498	Shri C. Thandapany	Assistant Engineer (H), 4-III, Cross Road, Gandhinagar, **Madras-20.**
60	2499	Shri B. N. Lakshmi Narasimha Rao	Supervisor, Mysore P.W.D., No. 165, IInd Block, Jayanagara, **Bangalore-11.**
61	2500	Shri S. K. Veerabhadra Chari	Supervisor, Mysore P.W.D., Office of the Chief Engineer (General); **Bangalore-1.**
62	2501	Shri M. A. Partha Sarathy	Supervisor, Mysore P.W.D., Chief Engineer's Office (General), **Bangalore-1.**
63	2502	Shri T. Chandra Mouli	Assistant Engineer (H), Bridge Investigation, **Kakinada**, (Andhra Pradesh).

Serial No.	Roll No.	Name	Address
64	2503	Shri V. R. Parliker	Assistant Engineer, P.W.D., Parbhani, **Parbhani District**, (Bombay State).
65	2504	Shri Chandra Madhav Singh	Assistant Engineer, Temporary Division, Uttar Pradesh, P. W. D., **Lucknow.**
66	2505	Shri V. V. Krishnaiah	Assistant Engineer, Highways, Narasaraopet R. S. (Ongole Division), **Guntur District**, (Andhra Pradesh).
67	2506	Shri Paidayya Vusala	Junior Engineer, Highways, Bhadrachalam, **East Godavary District**, (Andhra Pradesh).
68	2507	Syed Bashiruddin Ahmed	Executive Fngineer, Hyderabad Roads Division, **Hyderabad** (Andhra Pradesh).
69	2508	Shri Narain Vishindas Merani	Assistant Engineer, P.W.D., Bombay, Barrack No. A/37, Kalyan Camp No. 1, **Kalyan** (Bombay).
70	2509	Shri Ch. Kesava Rao	Assistant Engineer, Highways, **Navasipatnam**, (Andhra Pradesh).
71	2510	Shri H. Krishnacharya	Assistant Engineer, Koppal, P.W.D., **Raichur District**, (Mysore State).
72	2511	Shri N. Jaggayya	Junior Engineer, Highways, Office of the Divisional Engineer, (H), Chilakalapudi, **Krishna District**, (Andhra Pradesh).
73	2512	Shri Suryanarayana Murthy Kravidi	Junior Engineer (H), Vuyyur, **Krishna District**, (Andhra Pradesh).
74	2513	Shri T.S. Chathunny	Chief Engineer, P. W. D., (R. & B.), Kerala State, **Trivandrum.**
75	2514	Shri N.C. Kanjaksha Kumar	Executive Engineer, R. & B., **Dharwar** (Mysore State).
76	2515	Shri S. Chenna Reddy	Assistant Engineer, Highways, Narasaraopet, **Guntur District**, (Andhra Pradesh).
77	2516	Shri P. S. Damodaram	Executive Engineer, Corporation of Madras, **Madras.**
78	2517	Shri Brijendra Singh	District Engineer, P.W.D., **Rae-Bareli** (U.P.)
79	2518	Shri P. Vishno Rao	Assistant Engineer, Highways, Nellipaka (Bhadrachalam Tq.), **East Godavary District**, (Andhra Pradesh).

Serial No.	Roll No.	Name	Address
80	2519	Shri A. R. Bhavikatti	Deputy Engineer, Karnatak Medical College, Sub - Division I, **Hubli** (Mysore State).
81	2520	Shri Madhava Prasad Srivastava	Executive Engineer, P.W.D., B. & R., **Balaghat** (M.P.).
82	2521	Shri Mohd. Haneef	Divisional Engineer, Highways, **Bomopacholavaram** (East Godavary District), (Andhra Pradesh).
83	2522	Shri N. Ramanath	Technical Assistant to the Chief Engineer (Highways), Andhra Pradesh, **Hyderabad.**
84	2523	Shri S. M. Patil	Deputy Engineer, Karnatak Medical College, Sub-Division 2, **Hubli** (Mysore State).
85	2524	Shri Pranab Kumar Banerjee	Assistant Engineer (Roads), Basirhat Construction Sub-Division, **24 Parganas**, (W. Bengal).
86	2525	Shri Bishwa Jyoti Mukherji	Assistant Engineer (W. & B.), Berhampore Sub-Division, P. O. Berhampore, **District Murshidabad**, (W. Bengal).
87	2526	Sardar Saroop Singh	Member Chief Engineer, B. P. Team Copp., Planning Commission, **New Delhi.**
88	2527	Shri A. H. Zubairi	District Engineer, P.W.D., **Orai** (U.P.).
89	2528	Shri P. R. Reddy	City Engineer, Secunderabad Municipal Corporation, **Secunderabad.**
90	2529	Shri P. R. Wagh	Deputy Engineer, P.W.D., Sachivalaya, Fort, **Bombay.**
91	2530	Shri Naresh Chandra Saxena	Assistant Engineer, P.W.D., **Basti** (U.P.).
92	2531	Shri V. P. Kamdar	Deputy Engineer (Roads), P.W.D., 83-A, Lady Hardinge Road, P.W.D. Quarters, **Bombay-16.**
93	2532	Shri S. G. Athavala	Executive Engineer, P.W.D., 3rd Floor, Old Civil Secretariat, **Bombay-1.**
94	2533	Shri Jagdev Singh Sodhi	Assistant Engineer, P.A. to Superintending Engineer, Jullundur Circle, **Jullundur**, (Punjab).
95	2534	Shri Siddhananda Chatterjee	Assistant Engineer, 28, Chowdhury Began Lane, **Howrah**, (W. Bengal).

Serial No.	Roll No.	Name	Address
96	2535	Shri K. P. Kunhambu	Municipal Engineer, **Salem.**
97	2536	Shri J. Mukand	Chief Engineer & Secretary, P.W.D., Himachal Pradesh, **Simla.**
98	2537	Shri Kripasindhu Rakshit	Assistant Engineer, P. 509 C. I. T. Scheme No. 47, **Calcutta-29.**
99	2538	Shri Satindra Mohan Roy	Assistant Engineer (W. & B.), Govt. of West Bengal, P.O. Tamluk, **District, Midnapur**, (W. Bengal).
100	2539	Shri M. A. Khadir	Executive Engineer, P.W.D., R. & B., Mahboobnagar Division, **Mahboobnagar**, (Andhra Pradesh).
101	2540	Shri G. Bapu Rao	Executive Engineer, Roads & Buildings, **Sangaredy**, (Andhra Pradesh).
102	2541	Shri J.R.K. Prasad	Assistant Engineer (Highways) Designs, Office of Chief Engineer (Highways), Begumpet, **Hyderabad-16.**
103	2542	Shri Mahboob Ali	City Engineer, Hyderabad Municipal Corporation, **Hyderabad.**
104	2543	Shri C. V. Rama Rao	Assistant Engineer, Office of the Chief Engineer (H), Hyderabad, (Andhra Pradesh).
105	2544	Shri P. Chander Rao	Superintending Engineer, Warangal Circle, P.W.D., **Warangal**, (Andhra Pradesh).
106	2545	Shri C. Muniswamy Naidu	Municipal Engineer, **Nellore**, (Andhra Pradesh).
107	2546	Shri R. Govindaraju	Assistant Engineer (H), Muthalapuram (Via) Ettayapuram, **Tirunelveli District**, (Madras State).
108	2547	Shri Gauri Nath Sharma	Assistant Divisional Engineer, Birganj, P.O. Raxual, **District Champaran**, (Bihar).
109	2548	Shri H. C. Parameswar	Senior Research Assistant, Civil & Hydraulics Section, Indian Institute of Science, **Bangalore-12.**
110	2549	Shri R. Krishnamachari	Junior Scientific Officer, Central Road Research Institute, **New Delhi-20.**
111	2550	Shri K. L. Vuthoo	Assistant Engineer, P.W.D., Khelani Sub-Division, Khelani, **Doda Distt.** (Jammu Province), **J. & K. State.**
112	2551	Shri N. Raghavan	Junior Engineer (H), 15, Raja Street, Thiyagarayanagar, **Madras-17.**

Serial No.	Roll No.	Name	Address
113	2552	Shri Hariharbhai P. Patel	Deputy Engineer, National Highway Sub-Division No. 3, P.W.D., Himatnagar, **District Sabar Kantha**, (Bombay State).
114	2553	Shri B.V. Adaikalamkathan	Junior Engineer (Highways), Vaippar Bridge Works, **Sattur**, (Madras State).
115	2554	Shri N.S. Srinivasan	Assistant Professor, M.B.M. Engineering College, **Jodhpur**, (Rajasthan).
116	2555	Shri R. Prakasa Rao	Assistant Engineer (H), Chintapalli, **Vizag District**, (Andhra Pradesh).
117	2556	Shri K. Sudarsanam	Junior Engineer (H), 29, East Chitra Street, Srirangam, **District Trichy**.
118	2557	Shri S. P. Pavithrasagar	Junior Engineer, P.W.D., (R. & B.), Kalpettah, **Coyand**, (Kerala State).
119	2558	Shri Ramesh Chander	S.D.O., P.W.D., Lohaghat, **Almora District**, (U.P.).
120	2559	Shri Raghavendra Bhat	Assistant Engineer (P. H.), Hindustan Steel Private Ltd., Barsua, **Sundergarh District**, (Orissa).
121	2560	Shri A. K. Kaul	Assistant Engineer, (Civil), Heavy Electricals Private Ltd., Govindpur Colony, **Bhopal** (M.P.).
122	2561	Shri N. N. Chowdhuri	15/1-A, Priyanath Mallick Road, **Calcutta-26** (W. Bengal).
123	2562	Shri S. C. Tyagi	Assistant Engineer, P.W.D., Narendranagar, **District Tehri Garhwal** (U. P.).
124	2563	Shri Narain Kumar	Assistant Engineer, C. D. & N. E. S. Works, **Dumka**.
125	2564	Shri Digindra Kumar Das	Irrigation Engineer, C/o. Executive Engineer, **Agartala Division**, (Tripura).
126	2565	Shri T. S. Srinivasan	Junior Engineer (H), Designs, 4, Natesa Mudaliar Colony, Sir C. V. Raman Road, Teynampet, **Madras**.
127	2566	Shri D. V. Sikka	Assistant Engineer, Temporary Division, P.W.D., **Bareilly** (U.P.).
128	2567	Shri Sohan Lal Jain	Assistant Engineer, C.P.W.D., Jawalamukhi, **District Kangra** (Punjab).
129	2568	Shri Paul C. Thompson	USOM/Nepal, C/o. American Consul General, 5/1, Harrington Street, **Calcutta**.

Serial No.	Roll No.	Name	Address
130	2569	Shri K. V. Jauhar	Sub-Divisional Officer, Roads Construction Sub-Division, P.W.D., B. & R., Bhiwani, **District Hissar**.
131	2570	Shri Dhirendra Chandra Debnath	Sub-Divisional Officer, (Designs), P.O. Agartala, **Tripura**.
132	2571	Shri B. R. Shah	Deputy Engineer, Idar Sub-Division, P.W.D., Idar, **S.K. District**, (Bombay State).
133	2572	Shri Rameswar Prasad	Assistant Engineer, Improvement Trust, **Gaya** (Bihar).
134	2573	Shri R. B. Prasad	Sub-Divisional Officer, P.W.D., P. O. Sabour, **Bhagalpur**, (Bihar).
135	2574	Shri M. R. Kaura	Manager & Liaison Officer, William Jacks & Co. Ltd., 21, Barakhamba Road, **New Delhi**.
136	2575	Shri Hirday Nath Jalali	Sub-Divisional Officer, Shiv Bhavan, Karan Nagar, **Srinagar**, (Kashmir.)
137	2576	Major Vakil Singh Sohal	Engineer Staff Officer, H. Q. Western Command, Engineers Branch, **Simla**.
138	2577	Shri M. Khader Ali	Assistant Engineer, S. M. Block, Kashipur, Via Rayagada, **Dist. Kalahandi**, (Orissa).
139	2578	Shri Prem Chand Sanghi	Executive Engineer, P. W. D., B/R., (Mandi Division), **Hanumangarh** (Rajasthan).
140	2579	Shri J. P. Shah	Khimiya Kunj, 1st floor, Plot No. 42A, West, Sion Matunga Scheme No. 6, Sion, **Bombay-22**.
141	2580	Shri K. S. Bawa	Civil Engineer, Ammann & Whitney, P. O. Box 1423, **Tehran** (Iran).
142	2581	Shri B. B. Karki	Chief Engineer, Roads, 20/378, **Naxal**, Kathmandu, **Nepal**.
143	2582	Shri Hari Narain Singh	Assistant Engineer, C/o. P. E. O. (W & B), **Agartala** (Tripura).
144	2583	Shri C. V. Kand	Assistant Engineer, Designs, Chief Engineer's Office, Madhya Pradesh, P. W. D. (B & R), **Gwalior**.

ASSOCIATE MEMBERS

1	73	The Director	Public Works Department, Transworks House, **Colombo-1** (Ceylon).

NEW ADMISSIONS

Serial No.	Roll No.	Name	Address
2	74	The Director	Central Building Research, **Roorkee** (U. P.)
3	75	M/s. William Jacks & Co. Ltd.	Hamilton House, Ballard Estate, **Bombay.**
4	76	M/s. S. S. Marathe & Co.	Engineers, Railway Pipe Line Road, **Lonavala,** Central Rly. (Bombay State).
5	77	The Principal	M.B.M. Engineering College, **Jodhpur** (Rajasthan).
6	78	M/s. Components & Machinery Corporation	10/1 E (PART) Mercantile Buildings, Ground Floor, 9/12, Lall Bazaar Street, **Calcutta-1.**
7	79	The Director	The Punjab P. W. D., B & R, Research Laboratory, **Karnal.**
8	80	The Civil & Hydraulic Engineering Section	Indian Institute of Science, **Bangalore-12.**

III. DEATHS

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

Serial No.	Roll No.	Name	Address
1	342	E. P. Nicolaides	General Manager, M/s. J. C. Gammon Ltd, Hamilton House, Ballard Estate, **Bombay.**
2	1277	Sripada Ghosh	Retired Executive Engineer, 10/1, Ram Krishna Das Lane, **P. O. Calcutta-9.**
3	73	R. D. Ratnagar	Assistant General Manager, M/s. Hind Construction Ltd, 8, Royal Exchange Place, **Calcutta-1.**
4	1447	J. K. Roy	Executive Engineer, East Midnapore Division, **P. O. & District Midnapore** (West Bengal).
5	697	S. Jambunathan	Assistant Professor of Civil Engineering, M. B. M. Engineering College, **Jodhpur** (Rajasthan).

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.	'Artistry House' 15, Park Street, **Calcutta-16.**
2	1497	Deshpande, D. V.	63, Shukrawar Peth, **Poona-2.**
3	12	Sowani, D. G.	Bhide Wada Shevde Bol, 851-A, Sadashiv, **Poona-2.**

V. REMOVALS FROM ROLLS OF THE SOCIETY

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

Serial No.	*Roll No.*	*Name of Member*
1	83	Shri I. A. T. Shannon
2	259	,, Mohd. Ibrahim
3	303	,, M. Mahapatra
4	506	,, Meher Singh
5	514	,, M. S. Srouty
6	539	,, K. N. Bose
7	563	,, S. R. Inamdar
8	618	,, G. Srirangachary
9	651	,, Pasupati Ghosh
10	1006	,, M. V. Yogi
11	1058	,, J. S. Gill
12	1101	,, K. P. John
13	1132	,, L. F. Cantlay
14	1143	,, R. R. Gore
15	1278	,, B. Misra
16	1289	,, B. L. Yadav
17	1308	,, Arjun Thakur
18	1319	,, R. P. Sinha
19	1409	,, G. L. Mital
20	1538	,, A. N. Dhar
21	1595	,, Y. A. Shinde
22	1620	,, D. N. Dutta
23	1634	,, A. C. Chakravarti
24	1639	,, D. V. Rao
25	1650	,, B. N. Majumdar
26	1805	,, G. Patnaik
27	1809	,, M. Ittycheria
28	1810	,, R. Guha
29	1815	,, B. R. Das Gupta
30	1819	,, M. L. Shukla
31	1822	,, B. B. Pattanayak
32	1850	,, V. V. R. Shankar
33	1864	,, J. M. Frederick
34	1348	,, M. K. Chatterjee

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

Vol. XXIII-Part 4 HYDERABAD January 1959

PRESIDENTIAL ADDRESS

The Twenty-Third Session of the Indian Roads Congress was held at Hyderabad from the 6th to the 13th January, 1959, and was formally opened by his Excellency Sri Bhimsen Sachar, Governor of Andhra Pradesh at 10-30 a.m. on the 7th January, 1959, in the spacious Jubilee Hall, Public Gardens. The proceedings opened with an Address by Shri W. X. Mascarenhas, the President, the full text of which is given below:

On behalf of the Indian Roads Congress and on my own behalf I extend to you all a most cordial welcome. I am particularly grateful to you, Sir, for your kindness in agreeing to inaugurate this our 23rd Session and to your Government and your Chief Engineer, Mr. Durrani, and his officers for the excellent arrangements made for our accommodation and comfort. As head of the State, you, Shri Rajyapal, can help the State Government to make a correct appraisal of the importance of roads in the country's programme of national development and together with your colleagues, the Governors of the other States of the Union, can promote the evolution and energetic implementation of a country-wide and continuing programme of road development carried out according to a carefully conceived plan under competent and imaginative technical direction and with adequate and assured funds.

You, too, Ladies and Gentlemen, can play a useful part even if you are not Road Engineers or Road Transport Operators. After all, all of you are road users and in a democratic set-up an enlightened public opinion is an important force in determining the scope, content and priorities of any programme of national reconstruction to which good roads can make a significant and indeed striking contribution.

The Indian Roads Congress is the only forum for discussion and the only clearing house for information open to Road Engineers throughout the country. Though not a purely official

body, it has worked in the closest co-operation with Government since its inception. By its excellent work and responsible and constructive criticism, it has helped in shaping Government's policy in the introduction of various measures designed to standardise and improve highway engineering practice and promote highway expansion.

We do not confine ourselves merely to an Annual Session such as this one with all the pomp and panoply that a distinguished Chief Guest such as you, Sir, can confer on its proceedings. Serious work is done behind the scenes and no less than 17 Committees are at work throughout the year, as well as of course during the Annual Session itself, dealing with various aspects and problems of Road Finance, Construction and Administration.

A unified road plan for the whole country, based on 9 years' continuous study of road problems by the Indian Roads Congress, was first conceived at its Gwalior Session in 1943 and proved most useful to the Chief Engineers in framing the famed Nagpur Plan which now holds the field. It was largely the insistent urging of the I.R.C. that led to the establishment of a Central Road Research Laboratory at New Delhi, and it was at its suggestion that several delegations of Road Engineers were sent abroad to acquaint themselves with the latest theories and techniques of road design and construction. The work of some of its Committees has already led to uniformity of practice and procedure in many important respects throughout the country and the good work is continuing.

This Session of the Indian Roads Congress is a momentous one because a new long term Road Plan of the country has just been finalized and is under submission to the Government for their consideration. This new Road Plan, prepared by the Chief Engineers of States, was carefully scrutinized at a Special Session of the Council of the I.R.C.—which the Union Minister for Transport & Communications, Shri S. K. Patil, himself inaugurated—and valuable suggestions were offered as a result of this scrutiny. The Indian Roads Congress therefore is an organisation that rightly enjoys a very special position of prestige and even privilege among the technical associations in this country and can make its voice heard in the councils of the nation. It is therefore a matter of regret that its membership should after 25 years of existence still be some 1,700 only. Considering that there are some 4,700 graduates and a much larger number of senior diploma holders in the country engaged directly in road construction and maintenance as members of the Central and State Road Administrations, Municipalities and

D.L.Bs. and of business organizations and contractors' firms connected therewith, this is a very disappointing membership. To make the Indian Roads Congress even more effective, I would appeal for a wider membership and would therefore urge the Central and State Governments, Municipalities and D.L.Bs. to offer to pay half the membership fees of any of their engineers who join up. Business firms dealing in road materials, plant and machinery, etc., should also encourage their engineer employees and other staff connected with transport and road development to become members or associate members. Further it is my fervent plea to the Central and State Governments that they send larger delegations than they do now to the Annual Session as well as to the Meetings of the various Committees which do all the indispensable spadework.

I understand that the Government of India makes a grant of Rs 10,000 towards the I.R.C.'s Annual Budget. This is a pathetically low figure and the Central Government should have no hesitation in doubling or quadrupling it, thereby enabling the Congress to enlarge and intensify its activities. One reason for this meagre financical assistance of course has been that the I.R.C. has so far contented itself with a very modest and balanced budget. The magnitude and tempo of the road development programme demands a much more ambitious outlay and I can assure the Ministry of Transport and Communications and the State Governments who should, I suggest, also extend enhanced financial assistance to the Congress that it will be money well spent and bring in handsome dividends.

I have referred to the New Road Plan, which was first foreshadowed in Bombay at a special Meeting of the I.R.C. Council held on 11th August 1958 and finalized after informal discussions between the I.R.C. Council and the Chief Engineers at that Meeting and another convened at Delhi some two months later.

The salient features of this New Plan are as follows:

It is proposed to increase by the end of 1980-81 the total road length from 3,31,000 miles to 6,57,000 miles, of which about 2/5th will be surfaced. This will give a net-work of 52 miles per 100 sq. miles. The objective is to bring every village:

(i) in a developed and agricultural area within 4 miles of a metalled road and 1.5 miles of any road;

(ii) in a semi-agricultural area within about 8 miles of a metalled road and 3 miles of any road; and

(iii) in a non-agricultural area within 12 miles of a metalled road and 5 miles of any road.

The implementation of the plan will involve an expenditure of about Rs 5,200 crores as indicated below.

The Nagpur Plan targets and anticipated actuals by the end of 1960-61 are also shown for purposes of comparison.

	Nagpur Plan Targets (Miles)	Anticipated Actuals by 1960-61 (Miles)	New Plan Targets (Miles)	Cost of New Plan in Crores Rs
National Highways	20,000	13,800	32,000	980
State Highways	53,000	35,000	70,000	1,580
Major Dist. Roads	50,000	95,200	1,50,000	1,360
Other Dist. Roads	70,000	78,300	1,80,000	650
Village Roads	1,38,000	1,56,700	2,25,000	630
Total	3,31,000	3,79,000	6,57,000	5,200

The most important thing about a Plan is obviously its implementation; and implementation as you know, is a matter of (a) financial resources, and (b) the organization for carrying out the construction programme.

In determining the share of the national resources that may legitimately be applied to road construction and improvement, we must not only consider the services rendered by the roads to the national economy, but also assess their direct and indirect contribution to the national well-being.

As every primer on Highway Engineering tells us, highway value consists of 2 factors: (i) the indirect general benefits expressed in terms of higher standards of living and (ii) the direct reduction in the cost of vehicle operation. While it is impossible to make a precise monetary evaluaion of the indirect general benefits, it is agreed among all authorities that they are much more important than the item of reduced vehicle operation cost; all authorities are equally agreed that the indirect benefits alone more than justify the construction of a complete system of modern highways usable the year round for adequate loads with moderate comfort and safety.

The late Lord Wavell said at the end of the last World War—

"Among the social services, I put communications first, since I do not see how it is possible to effect any great improvement in health and education in the villages of India until they can be reached surely and quickly at all times."

A few years ago our own Prime Minister made the following announcement: "I have come to the conculsion that one thing to which we must give top-most priority is roads, roads of all kinds, not only very up-to-date, bituminized or cement roads, but roads of any kind to open out the vast areas of this country which are closed today and which cannot be reached unless you walk or ride. I give roads the first priority."

Our national leaders have dedicated themselves to the formidable and challenging task of raising the standard of living in the country by increasing production in field and factory, and ensuring a more equitable distribution of the national income and a fair deal for the common man. The immediate task is self-sufficiency in food and rapid industrialization, the latter preferably through the setting up of small and medium scale industries dispersed throughout the length and breadth of the land. If this task is to be fulfilled and further if the Socialistic Pattern of Society, which is the declared national objective, is to have any real meaning, the vast mass of our people living in the villages—some 86 per cent of the total population—must be enabled to share in the new ways of life and rising levels of prosperity. How can all the social services that are now planned or are already in operation, and all our schemes for establishing rural schools and dispensaries, and cottage hospitals and regulated markets with their godowns for storing grains and other primary produce ever operate successfully, how can all our much publicised plans for rural uplift, including the creation of Community Development and N.E.S. Blocks, ever come to anything tangible and permanent without an adequate and well-planned network of roads?

Some social workers never cease from exhorting young people from the villages to stay in the villages and urging educated young people from the towns such as doctors, nurses and others to go to villages and enrich them with their skills. Indeed the more idealistically inclined among them become quite lyrical about the countryside and talk with great feeling about the great open spaces and the simple life.

But the only way to arrest this steady, gravitational pull of the cities on the more enterprising and ambitious young men and women of the villages and the only way to redress the growing imbalance between town and country is not through pious exhortations or emotional appeals, but through the creation of conditions that will make life in the villages sufficiently attractive or at least worth while to young people of spirit.

A well-planned, well-built and adequate network of roads would create these conditions, and city and country would be brought closer to each other both literally and metaphorically. Townsmen would seek the country more readily for rest and recreation; it might be possible for many to live in the country and travel to their work in the town every morning thereby helping to relieve the housing shortage prevailing in the major urban centres or at least preventing it from becoming more acute. Conversely, the social, agricultural and medical facilities in the town would be more easliy available to the villagers and their life and outlook brought nearer the urban level.

Even in the matter of mere self-sufficiency in food, such a network of good roads would increase the mobility of agricultural produce and of materials and goods entering into agricultural practice; and agricultural prosperity would make a great leap forward. The range of marketing of perishable goods especially, like fish, fruit, vegetables and milk, in all of which our diet is woefully deficient, would be extended in respect of both distance and favourable selling period—to the advantage of both producers and consumers. Marginal lands which now lie fallow because of transport difficulties would also come into production.

In my address at the Inaguration of the 52nd Indian Roads Congress Council in Bombay last August, I made the point that for every rupee spent on the construction and maintenance of roads the return to the villages served exceeded three rupees, besides creating several other additional sources of revenue to Government. This was demonstrated over 15 years ago by a pilot survey in Bombay State made by the Indian Roads and Transport Development Association and other studies in the same field both in this country and elsewhere confirm this finding.

I would like to make a further point, viz., that road construction and maintenance activity as also road transport operation employs something like 3 million people today throughout the country. The significance of this figure is not in its absolute value but in the clear indication it affords that road development and road transport have perhaps the highest employment potential of all our economic activities.

All the abovementioned general benefits cannot, as I have already observed, be evaluated in purely monetary terms. As regards direct highway benefits, viz., those resulting in a reduction of vehicle operation costs, perhaps a better appreciation of these benefits can be arrived at by considering the waste and economic

loss caused by the lack of a good road system. This waste and loss can be classified under the following heads:

(a) waste of time through reduced vehicle speed and stoppages;

(b) high fuel consumption;

(c) heavy wear on tyres;

(d) avoidable accidents reflected in cost of insurance; and

(e) wear and tear of vehicles, leading to increased cost of repairs and maintenance.

In an interesting Paper read by Mr. Cristopher T. Brunner before the Institute of Highway Engineers on 17th January 1947, the possible savings under the above heads, that would accrue if the British road system were modernized, were indicated. With a total estimated expenditure of £ 648 million on the operation of mechanically-propelled road vehicles in the U.K. it was calculated, on the basis of the considerations advanced in the Paper, that the possible savings would be something as follows:

	£ per annum
Saving of time	26,000,000
Saving of fuel	12,000,000
Saving of tyres	3,000,000
Saving of repairs to vehicles	9,000,000
Saving of accidents (insurance)	10,000,000
	£ 60,000,000

The direct saving in the vehicle operation costs was thus estimated by Mr. Brunner to be something like 10 per cent for the conditions prevailing in the U.K. in 1947. It is scarcely necessary to add that the road system of the U.K. in 1947 was far better planned, better constructed and better maintained than the Indian road system of even today, and that the big saving was largely the result of refinements in an already excellent system, excellent at any rate according to Indian standards.

Mr. N. D. Daftary, General Manager, Bombay State Road Transport Corporation, in a Paper read before the Indian Institute of Road Transport in Bombay on 13th September 1954, showed how a planned programme of surface upgrading of some extensively used roads would bring down the cost of operation of

motor vehicles on these roads very substantially. His experience on the Nadiad-Dakor Road showed that the cement concreting of that road had resulted in a total saving of about 17 per cent in operation costs. Shri Daftary concluded:

"State Tranport cost of operation on average bad and kachha roads in 1953-54 amounted to Rs 5.80 crores. If all our vehicles were operating on modernized roads our saving in operating cost would have been Rs 98 lakhs approximately.

"If the vehicles in the entire State are considered, the amount will be approximately Rs 9 crores.

"In Bombay State we have 21,988 miles of metalled (W.B.M.) and kachha roads and the cost of concreting the entire surface would come to approximately Rs 130 crores.

"Thus if Government decides to float a loan for the amount the saving in operation cost will not only cover the interest but sinking fund charges also. Resulting benefits due to comfortable travel etc., are not taken into consideration in computing this."

One of my predecessors in office, Shri R. K. Batra, President of the Indian Roads Congress in 1954, estimated that the loss to motor transport on account of bad and inadequate roads in this country was of the order of Rs 38 crores per annum.

In view of the fact that road vehicles in this country are the most highly taxed in the world, as another of my predecessors, Shri M. S. Bisht, pointed out at the last Annual Session, this extra burden on the transport industry is a crushing handicap which it is the duty of the State to eliminate by providing the funds necessary for an adequate and modernized road system.

From a consideration of the direct as well as indirect benefits accruing from an adequate road system, it could be argued, as in fact it has been argued, particularly in America, that the original construction of a general utility system of roads should properly be paid for largely from general revenues and the cost of maintenance and renewal should fall on road users.

The Salter Commission took a more conservative view in the U.K. in 1932 and laid down the principle that road users should pay for two-thirds of all road bills and the remaining one-third should come from the general revenues. In this country nearly all road expenditure is financed by the road users — in fact it is only recently that road expenditure has equalled the aggregate of the user taxes collected by the Centre and the States — actually the Centre spends less than it collects and the States more than they collect - and it is high time that a more equitable and

progressive fiscal policy in regard to road communications is adopted. As a mean between American theory and the Salter Commission's principle mentioned above, I would suggest that half the road bills, i.e., both construction and maintenance costs, expressed in terms of an annual charge reflecting both elements, be paid from general revenues and the remaining half by road users.

Incidentally there is such a wide variation in the States of the Union in regard to securing road development funds and such imperative need for a co-ordinated policy of road finance, that I would suggest that all taxes on road users whether in the form of licensing or registration fees, customs and excise duties, as well as sales taxes on motor fuel, oils, lubricants, spare parts, tyres, etc., should be levied by the Centre and the amount collected on account of what are now purely State taxes redistributed to the States, on the basis of the vehicles registered and operating in each State, for expenditure solely on road construction and maintenance and that the States should be required to match the share thus received by equal allocations from their own general revenues.

The taxing of cart traffic is also long overdue. Bullock carts, as we all know, cause heavy damage to roads but do not contribute anything towards their cost. A small tax, say Rs 12 per annum, on each cart is fully justified, specially in view of the fact that there is a large programme of development of rural roads. This will bring something like Rs 10 crores to the national exchequer and might be devoted exclusively to the construction and maintenance of rural roads to the great benefit of draught-animals as well as monetary gain to their owners.

The number of motor vehicles in this country is extremely limited and it is obvious that we must greatly increase it, if road transport is to play its legitimate share in moving the progressively increasing traffic resulting from our steadily expanding economy.

Railway capacity has already nearly reached staturation point on many lines and further development can only be in the form of additional route milage, doubling of lines, electrification or dieselization of traction, better yard-marshalling arrangements, etc., all of which will involve an enormous capital outlay. The I.R.T.D.A. has estimated that by 1961 the total traffic to be moved will be of the order of 185 to 190 million tons and that the short-fall in railway capacity may well be as high as 20 to 25 million tons. The present temporary set-back to traffic resulting from foreign exchange restrictions and the consequent fall in imports will, it is hoped, soon be overcome and in any case

we are envisaging road requirements over the 20 years next after 1961, and the continued expansion in developmental activity and increased production born of it, of which road transport will have to carry its fair share.

Restrictions on the import and manufacture of motor vehicles in this country must therefore be reconsidered against this background. The astonishing fact is that in spite of heavy taxation—the highest in the world, as I have said—the high cost of automobile manufacture in the country and the high custom duties on imported vehicles and spare parts, motor traffic has expanded enormously since the Second World War and we may be sure it will do so at an even greater pace, if these high costs and duties are lowered somewhat or at any rate not increased, provided of course, that an adequate number of vehicles is readily available to meet the rising demand for them. In this matter the correct fiscal policy would appear to be the lowest duties and costs consistent with the highest return and therefore highest volume of traffic. Incidentally fuel at nearly Rs 3 a gallon for petrol and Rs 1.63 a gallon for h.s.d. oil is also a big factor in vehicle operation costs—the largest in fact after wages—and any reduction in production and distribution costs will have a marked effect on the growth of motor traffic. I was amazed to read in a recent despatch of the "Times of India" correspondent in the Middle East that the cost of crude oil in Qatar, Kuwait and other adjacent producing centres of the Arabian Peninsula varied from 3 *sh.* 9 *d.* to 4 *sh.* 3 *d.* per ton over the last 5 years and that during this period the average selling price at the shore terminals was more than £5 per ton. If this information is correct the large difference is apparently accounted for by overall prospecting charges, royalties and profits.

Now that oil has been struck also at Cambay and Lunej—let us all hope in commercially exploitable quantities—the Indian Government will have a new source of income which might be utilized largely for road development, though it is to be hoped that part of the profits will also be made available to the consumer in the form of reduced fuel prices. The price structure of motor fuel is already under investigation by Government and as a result something like a saving of Rs 10 crores is likely to accrue to the Central exchequer at the present level of taxation and retail prices. Further economies may be possible but half the money equivalent of the savings should, it is suggested, be paid into the Central Road Fund and the remaining half used to write down retail prices.

So much for road finance. I now come to the second and, to my mind, more important factor in the implementation of the road plan, because it is a factor much more within our control than finance, namely, the organization for carrying out the construction programme.

It is hardly necessary to add that efficiency and economy—to say nothing of revolutionary thinking on the subject which, in my opinion, is urgently called for—are only possible in a specialist Department. Many of my predecessors have pressed for a separate Highways Department in each State and I would reiterate their plea with one small but significant amendment. Communications must be viewed as an integrated whole and accordingly all means of transport such as highways, inland waterways, minor ports and—to the extent that the State Government are concerned with them—also airways and railways should vest in *one* authority. Moreover since it is illogical to separate the track from the vehicle using it, road transport and all other transport—to the extent that it falls within a State's jurisdiction—should also be vested in the same authority. This means that each State should have a Department of Transport and Communications analogous with the Ministry of Transport and Communications at the Centre, each such State Department having 2 Wings: (1) Communications and (2) Transport. This is particularly important and urgent in view of the fact that the principle of nationalisation of motor transport has been accepted in the country and is being rapidly acted up to in most States, as is evidenced by the setting up by them of their own Transport Corporations.

A unified Transport and Communications Department would be able to understand the relationship between track and vehicle better than two separate Transport and Communications Departments and ensure the development of both transport and communications to their mutual advantage. Incidentally any profits accruing from the Transport Wing could be ploughed back into the development of both track and vehicle.

The need for a unified Transport and Communications Department is so obvious that it is with something of a feeling of shock that we remind ourselves that very few States have a separate Highways Department. Most of them combine roads with buildings exactly as they did more than 100 years ago when the P.W. Departments were first instituted.

Even in such an important and progressive State as Bombay there is not only no separate Highway Department, but there still continues a combined cadre for the Irrigation Wing and the Roads and Buildings Wing. Even when there are separate cadres for the two Wings linking up buildings with roads is linking up two highly specialized fields, in only one of which

the average engineer can hope to be proficient. It is also a mistaken notion that any real economy is achieved by such a combination, for, the savings, in any case slight, in establishment charges will be more than counterbalanced by the loss on the workside resulting from unspecialized technical handling.

Real economy can only be said to have been achieved when for the attainment of any given engineering objective, the establishment costs plus works expenditure are a minimum. This is the only criterion which should be applied, and judging by this criterion I have no hesitation in saying that the separation of roads from buildings would be more than justified. May I suggest in passing that the prevailing housing shortage everywhere, not only in respect of Government housing but also of general housing, can be satisfactorily dealt with only by a special buildings organization in every State vested with the responsibility for the construction and maintenance of all administrative buildings required for Government purposes and residential housing for Government servants, and also for industrial and subsidized public housing now being administered in some States by a separate Housing Department. In short, let all buildings for which Government is in any way responsible go together. In any case let us separate roads from buildings.

I would like to make it clear that the road component of the Communications Wing should cover all roads, down to and including minor district roads and excluding only village roads, which should be left to the Gram Panchayats, Taluka Local Boards and other local authorities. All major district and other district roads now vesting in the District Local Boards should be immediately provincialized. It is our uniform experience that with few exceptions District Local Boards are utterly incapable of maintaining—leave alone expanding—the roads in their charge, and the provincial roads previously vesting in the State P.W.Ds. and later transferred to the District Local Boards in pursuance of the principle of decentralization have generally speaking deteriorated and in some cases been virtually destroyed. To insist on such decentralization of road administration when we are aware of its disastrous consequences is to confuse means with ends, and to make decentralization an end in itself.

With a view to evolving and ensuring the vigorous implementation of a national policy relating to Transport and Communications, I would urge that an All-India Transportation Board be set up comprising officials and expert non-officials who will deal continuously and competently with the problems arising from the needs of transportation as an integrated whole, i.e., from the stand point of the highway, inland waterway, minor port, etc., and of the vehicles and craft using them. This

body would advise the Central and State Governments with regard to all matters connected with the development of highways, waterways, minor ports, etc., as well as transport development and secure as far as possible co-ordination and uniformity of policy between the various States in regard to these crucial and inter-related matters. Such a Board should exercise primarily advisory functions, but in order that it should be really effective a certain amount of executive authority would also have to be vested in it—as for instance, the authority to fix priorities in regard to construction or development schemes financed wholly or partly from Central Funds. I am glad to note that a step in this direction has recently been taken by the Government of India by forming—

(1) Transport Development Council.

(2) Road and Inland Water Transport Committee.

(3) Central Transport Co-ordination Committee.

The State might also profitably set up similar Transportation Boards within their own boundaries to exercise the same or related functions.

I have dealt so far with departmental organization and road administration. Considering next, the question of the actual planning and execution of a road programme, an essential requirement of economy is that the dimensions and details of this programme must be carefully determined well in advance and preferably fitted into the State's overall Five-Year Plan. There should then be no departure from this programme except for the gravest reasons. It is a matter of common knowledge that road works are often budgetted for which have not been properly investigated and in respect of which no plans and estimates exist; and engineers are often pressurized into executing such projects at breakneck speed merely to ensure that the financial appropriations are expended. Any surrenders of funds are regarded as a catastrophe and the engineers who make them with the laudable intention of avoiding waste through frantic haste, instead of being commended for their good stewardship of public funds are often viewed with disfavour, if not branded as incompetent.

The attainment of fixed targets either of expenditure or of road milage should not be at the sacrifice of the quality and cost of the amenity provided. Real progress in road development must, in our country, always mean getting maximum value for money. Incidentally parochial and regional rivalries should be resolved once and for all, when the programme is framed, at the highest level—Cabinet level if necessary—and

should not thereafter be allowed to obtrude themselves, since any change during the actual execution of the programme, even of priorities only, usually leads to serious dislocation of the engineer's plans, infructuous expenditure and general waste of funds. The engineers are also, to their dismay, often embroiled in local disputes and jealousies and their morale can be seriously affected in consequence.

But even when a programme is framed after due investigations and proper field surveys and the preparation of detailed plans and estimates and after all conflicting regional claims have been reconciled, there still remain other causes of waste and inefficiency. The first is the still widely prevailing practice of basing road design, particularly the design of subgrades and wearing surfaces, on purely empirical rules, some of them dating to the time of Telford and Macadam! There is no room for rule-of-thumb and empiricism in modern engineering. Subgrades, pavements and all other parts of a highway are susceptible of being scientifically designed and should be so designed. When even small countries like Italy, Turkey, Greece, Israel, Syria and Egypt adopt rational methods of design and the most up-to-date technique of construction we should not allow a big one like India to lag so hopelessly behind.

Another prolific source of waste is the primitive methods generally adopted in the construction of modernized road sufaces. A reasonably efficient method is adopted in the construction of cement concrete pavements, but asphaltic carpets and asphaltic grouts are even today laid by such antiquated techniques, involving the use of the crudest and most rudimentary plant and machinery, that it is my belief that it is never possible to derive full value for the money spent. Quality control, which is an essential in dealing with asphalt as it is in dealing with cement, is only possible by the mechanization of the whole process of carpet making, from crushing of metal down to mixing, laying and finishing of the road surface. This is one clear case where capital-intensive methods must be preferred to labour-intensive methods.

Finally I come to the most important factor in the efficiency equation, viz., the engineer, the man on whom falls the responsibility and burden of planning, constructing and maintaining our road system. Considering the engineer's pivotal position in the country's struggle to pull itself out of the morass of stark poverty and want in which the bulk of our population is engulfed, it should be abundantly clear that we must attract some of the best talent in the country to the engineering profession. It should be equally clear that after recruitment, Government should endeavour to make its engineers contented and enthusiastic

workers determined to keep their "appointment with destiny" and play their part with all the skill and courage and fortitude of which they are capable. But what do we find? The Indian Service of Engineers, to which all recruitment ceased after 1932, has practically died out, and both in the States and the Centre we have the so-called Class I cadres showing wide disparities in emoluments and conditions of service between themselves and given pay-scales and a status incomparably lower than the pay-scales and status enjoyed by the Indian Administrative Service and the Indian Police Service.

The inequalities in emoluments, status, and prospects are startling. As an example, in one of the larger States, there are 43 Collectorates and 6 Commissioners' Divisions. The number of posts available to the members of the I.C.S. and I.A.S. as Heads of Departments, Secretaries to Govt., etc., is 36. In the case of the P.W.D. which comprises 161 Divisions and 23 Circles, the number of higher posts, none of which goes beyond the status of Head of a Department, is only 4.

It has been repeatedly urged from this platform that the time is overdue for reviving the Indian Service of Engineers and putting it in all important respects on a par with the I.A.S. and I.P.S. It is only the prestige and the prospects attaching to such a Service that will provide the needed attraction to the best talent; moreover it is only an All-India Service which might be expected to ensure continuity of policy and enable its members to exhibit greater independence of technical opinion than is possible with men belonging to the State Services—an important consideration if we bear in mind the possibility, in fact the probability, in the near future of different political parties holding power in different States or in the States on the one hand and the Centre on the other.

In the First Five-Year Plan as also in the Second Plan now under way and undoubtedly also in all future Plans, the engineer has been, is and will be responsible for spending anything between half and two-thirds of the financial appropriations made under them. On more than one occasion, the Prime Minister has stressed the pre-eminent importance of the engineer and scientist in the context of these Plans. Speaking to a meeting of the General Services at Kurnool some years ago, he said:

"The person who is important today is the engineer, the scientist and the technical man. The fact remains that the type of specialised work like that of the engineer or scientist is becoming more and more important.....the future of the country will depend more and more on them rather than on the administrators." More recently, he mentioned that in Russia the scientist and technician are "treated as demi-gods".

The present Union Minister of Transport and Communications, Shri S.K. Patil, has paid frequent and handsome public tribute to the engineer and during his Inaugral Address on the occasion of the 52nd Meeting of the Indian Roads Congress Council held in Bombay last August, he announced Government's decision to institute four additional All-India Services, including an Indian Service of Engineers.

At the same Meeting of the Council I urged the adoption of Mr. Paul Appleby's suggestion that there should be only one Civil Service for the whole country, and that administrators, police officers, engineers and others should all belong to different branches of it. This will automatically ensure that the best talent in the country will find its appropriate field freely, without differences in pay and status tending to restrict them in their choice that they often do at present. I would urge Shri Patil to press for such a combined Civil Service based on egalitarian principles relating to status and emoluments governing all its branches.

Another important measure for securing efficiency and speed is the organisation of charges. To begin with the worksload and responsibility devolving on each Officer must be such as he can carry without blunting his capacity to think out newer and newer organization and methods. Judged by this standard we shall have to increase very considerably the number of Superintending Engineers and Chief Engineers now employed in the different States.

At the instance of the I.R.C. a special Committee of Chief Engineers has examined the question of worksload and suggested norms for the different charges and I would urge the Centre and the States to apply those norms to their engineering organizations. It can never pay to drive these men beyond their capacity in the name of economy.

Then the old basic structure and pattern of P.W.D. organization, namely, territorial charges, is outmoded and outdated, and should now be restricted purely to maintenance work. All planning and construction should be organised on a functional or specialist basis.

Lastly I come to the question of the relations between the Engineer organization and the Secretariat or Ministry. Not long ago the Chief Engineer of a State used to be the Secretary to the Government also and thus had the opportunity to co-ordinate both the technical and administrative aspects of the work for which he was responsible. The position has altogether changed today. The Chief Engineer is now completely disassociated from the Secretariat and his place there has been taken up by non-technical Officers. At a time when our entire energy should be directed towards the rapid development of the country, it is absolutely essential to give the fullest encouragement and support to scientists and technical personnel. The Secretariat being the fountainhead of authority, must include suitable scientists and technical men who have a flair for administration. An administrator without an appropriate technical background will suffer from the serious handicap of not being able to appreciate fully the finer points of a technical proposal, and this is bound in the long run to hamper seriously the country's progress. The Secretariat must, therefore, have suitable scientists and technical persons for all the main branches concerning developmental activities, who should be vested with full authority for dealing with their subjects and for tendering advice direct to the Ministers.

Before requesting you, Shri Rajyapalji, to inaugurate the Session, permit me to pay a well-deserved tribute to all those official and non-official associations and individuals who have done so much to advance the cause of road and transport development. All my predecessors in their Presidential Addresses have made out well-reasoned cases for greater Government interest in road development. Though it is somewhat invidious to single out any, I must commend the Addresses of two immediate predecessors, Sarvshri P. L. Varma and M. S. Bisht, to Government's special attention. In Shri Bisht's Address particularly will be found a masterly analysis of all the factors affecting the problem.

I would also like to pay my homage to the I.R.T.D.A. for the yeoman service rendered by it for more than a quarter of a century in keeping road problems and transport development prominently before the public eye and jogging Government's elbow repeatedly. The time and attention devoted to the good cause by men like Shri B. V. Vagh and Dr. F. P. Antia have been invaluable. I am sure that there are other men equally willing and capable who would gladly follow in their footsteps and further the same cause in an official or non-official capacity, if only Government knows how to enlist their co-operation. The present Union Minister for Transport and Communications has the perspicacity to view the problem steadily and view it as a whole and the dynamic personality to provide the inspired leadership that road and transport engineers are impatiently awaiting.

INAUGURAL ADDRESS

by

SRI BHIMSEN SACHAR,

Governor of Andhra Pradesh

Mr. President, Ladies and Gentlemen,

It gives me great pleasure to be here this morning in the midst of distinguished engineers from all over India and to inaugurate the Twenty-third Session of the Indian Roads Congress. It is gratifying to learn that, during the 23 years of its life, your Congress has discussed as many as 205 technical Papers at its general session on subjects of road development in India, fixed many road standards relating to geometric and other features of road construction and maintenance, published a code of practice on bridges and bridge specifications, and appointed many committees to study detailed aspects of various technical problems. I am glad to know that the Subcommittee appointed by the Roads Congress to consider the subject of evolving an improved design for bullock-cart wheels so as to improve the pay-loads of the carts without increasing the tractive effort of the bullocks, and at the same time to decrease the destructive effect of the bullock-cart wheels on the roads, has evolved a design which has been accepted by the Transport Advisory Council of the Government of India.

India in general, and Andhra Pradesh in particular, is under-developed in the matter of communications. While the average density of road system is as high as 3.00 miles per square mile in all Western countries, it is only 0.25 mile in this State. The part played by roads in the economic development of a country hardly needs emphasis. In a predominantly agricultural country like ours, trunk roads spanning its length and breadth, and feeder roads interlacing the districts and providing an outlet for the produce of the villages, are factors of inestimable economic value. In the past our road systems were built to meet the needs of strategy and administration rather than to promote the economic development of our rural areas. It is obvious that if we have to make full use of our national resources in a balanced and coordinated manner and derive maximum benefits, it is necessary that road development is planned so as to extend transport facilities to the remotest villages. With the launching of the Five-Year Plans, road

development plans have necessarily to take into account the great industrial and agricultural development taking place in the country and the increasing volume of internal traffic.

The necessity for the expansion of routes on a nation-wide scale brings in its train the necessity for the pooling of experience of engineers from all over the country, the setting up of standards for roads, and for evolving cheap and durable methods of road construction. Much as we may desire that the development of our country should proceed rapidly, there are limiting factors, particularly our inadequate financial resources, and there is, therefore, great need for economy. It is also essential that there is no wasteful expenditure and no delay in execution at any stage. Economy in construction and design and use of available local materials without detriment to quality, would help considerably in bringing down costs.

In your illuminating address, Mr. President, you have rightly stressed the need for a well-planned, well-built and adequate network of roads connecting the villages with towns and cities. India is a land of villages, and about 86 per cent of our population live there. If the economy of our country is to be stabilised, the future road pattern of the country must not only meet the requirements of the towns and cities, but also subserve the needs of the growing economy of our countryside. It is essential that the initial and maintenance cost of these roads is well within the resources of the local authorities, the more so because under the Community Development Programme vast lengths of village roads are being constructed with contributions from the public in the shape of materials and "Shramdan". While drawing up road plans to link the villages, it is, therefore, necessary to remember that our bullock-cart will continue to play an important role in the rural economy of the country. I trust that the Roads Congress would pay special attention to this aspect of the problem.

From the papers given to me I find that the Indian Roads Congress has been continuously urging the Government of India to accept the proposals for the establishment of non-lapsing funds for highways, both in the State and Central budgets, and for the establishment of an independent Roads Board to co-ordinate road development activities in the country. I hope these proposals would receive sympathetic consideration from the Government of India.

I am glad many of your Subcommittees are actively engaged in research studies relating to economy in designs of various structures, tourist traffic, etc. I hope the Congress, which has

over 1,700 road engineers as its members, will grow from strength to strength and continue its useful work.

I now have great pleasure to declare this Conference open, and wish its deliberations every success.

JAI HIND !

PRESIDENT'S CONCLUDING REMARKS

I thank you, Sir, on behalf of the Indian Roads Congress for your kind welcome and for the encouragement you have given us by your presence here today. May I now request you, Sir, to present the "Indian Roads Congress Medal" to Shri S. R. Mehra and Dr. H. L. Uppal for their Paper No. 205 "The Importance of Subgrade Compaction in the Economic Design of Flexible Pavement". May I also request you to announce the name of the Author of the following Paper which has been highly commended.

Paper No. 200 "Asphalt Paving Mixtures—Their Design and Composition"

by Shri N. H. Taylor.

MESSAGES

DR. RAJENDRA PRASAD,

President of the Republic of India

The Indian Roads Congresss deserves to be congratulated on its achievements in improving the network of road communications in India. It has also met with considerable success in evolving better and less expensive methods of road building with a view to utilising indigenous resources to the maximum. I need hardly say what good roads and reliable means of transport mean for a vast country like India. Therefore the task with which the Indian Roads Congress is grappling is of great national importance.

On the occasion of the 23rd Annual Session of the Indian Roads Congress, I send it my greetings and the best wishes for the successful conclusion of the forthcoming Session.

SHRI JAWAHAR LAL NEHRU,

Prime Minister of India

I send my good wishes to the Annual Session of the Indian Roads Congress to be held in Hyderabad.

Roads are of obvious importance in any scheme of development of a country. But in India we have not only to make good roads but also cheap roads. That does not mean that there should be a conflict between the two. We have to devise means to use local material which is good enough for the innumerable village roads that we have to make. I hope the Roads Congress will consider this aspect of the matter.

A very great part of our expenditure on development goes towards construction work, whether it is roads or buildings. Any saving on this would help us to enlarge our development programme.

SHRI S. K. PATIL,

Minister of Transport & Communications, Government of India

I am very happy to learn that the Indian Roads Congress is holding its next annual session at Hyderabad. Although I may not be with you, I shall watch your deliberations with keen interest.

I had the opportunity to inaugurate the meeting of your Council in Bombay where All-India Road Development Plan was discussed and which, I am glad, has now been finalised. Let us hope that this plan will be a successor to the well-known Nagpur Plan and will see the country's hopes and aspirations in the matter of road development fulfilled in the course of the next 20 years.

No country in this modern era can afford to neglect its roads. India, standing as it does on the threshold of a great industrial revolution, needs the development of roads all the more—not only to link up towns and cities but also to provide access to the far-flung villages in the remote country-side.

I am glad that your Congress is devoting attention to evolving a scientific approach to the problem of road development in the light of recent advances made in the techniques of design and construction of roads.

I wish the Session a great success.

SHRI RAJ BAHADUR,

Minister of State for Transport & Communications, Government of India

I have great pleasure in sending my greetings and good wishes to the Twenty-Third Annual Session of the Indian Roads Congress which is now meeting in Hyderabad.

The Road System of a country is a safe index of the level of its development. The expansion and improvement of roads are the surest key to all progress. Roads are symbols of civilization and harbingers of prosperity. It is impossible to conceive of any programme of economic development of a country without an adequate provision of road-communications and transport. The question of expansion of the existing network of our roads in our country has, therefore, assumed a vital importance in the

context of our growing economy. The answer to this question has to be furnished by our Road Engineers. Development of roads has to keep pace with the expanding needs of transport, both for industrial development and rural economy. Roads are also essential to promote cultural and social bonds between various parts of our country.

I note with pleasure the great contribution already made by the Indian Roads Congress in promoting the growth and development of all types of roads in the country and in disseminating the know-how on the subject. I wish the delegates attending the Session of the Congress the best of success in their deliberations.

SHRI HUMAYUN KABIR,

Minister, Scientific Reasearch and Cultural Affairs

Roads are not merely necessary for movement of men and goods but they have also proved one of the greatest factors for civilisation by promoting quick movement of ideas. They help to unify the country by bringing different regions into closer contacts with one another and simultaneously they offer each region the opportunity to develop along its own lines.

The Indian Roads Congress will be rendering real service to new India if it can devise methods for construction of cheap and durable roads. A good deal of scientific work has been done in the Central Road Research Institute and it is my hope that the engineers and road builders assembled at Hyderabad will give proper attention to the results of such work and utilise them at first on an experimental basis and then increasingly on a national scale.

SHRI SRI PRAKASA,

Governor of Bombay

I am very glad to learn that the 23rd Annual Session of the Indian Roads Congress is to be held at Hyderabad during the coming month, and that a large number of highway engineers are likely to attend the same.

The problem of communications is a very important one for any country; and with our developing economy, it has acquired still greater importance for us. We are not at all satisfactorily served by roads, and the lack of them hinders the quick move-

ment of men and goods from place to place. There are many difficulties in the way, but these have to be overcome; and engineers can best help us to do so.

I earnestly hope that the engineers assembled in the Congress will be able to take decisions of a practical nature, so that regard being had both to the means and needs of our people, we might have a larger and still larger network of roads, bringing peace and prosperity to our people, and helping in the strengthening and the consolidating of our national unity.

I send my warmest good wishes for the success of the Congress, and all health and happiness to those who are participating in the same.

SARDAR PARTAP SINGH KAIRON,

Chief Minister, Punjab

I am very pleased to convey my good wishes for the success of the 23rd Session of the Indian Roads Congress.

I understand that you will consider 20-year Road Plan during this Session, which will be the basis of Third-Five Year Plan for roads.

Roads are of vital importance in the opening and development of the country, and I hope that a comprehensive and balanced programme to serve urban and rural areas will be framed.

I lay particular emphasis on village roads, as our villagers are very enthusiastic about road development and are even prepared to share the cost by "Shramdan" and free gift of land. It is hoped that greater allocation will be made for construction of village roads, in which Central Government, State Government and villagers are co-sharers. Whenever my Ministers or I go on tour in rural areas, pressing demands are made by villagers for more and better roads, and their completion at faster pace.

I trust you will pay earnest consideration to these matters, and evolve an integrated and balanced programme which will serve the future transport needs of the country.

INDIAN ROADS CONGRESS

TWENTY-THIRD SESSION—HYDERABAD, JANUARY 1959

Hyderabad also called Bhagayanagar, the Capital of Andhra Pradesh gave a most hospitable welcome to the delegates who attended the 23rd Session of the Indian Roads Congress held from the 6th to the 13th January 1959. The delegates were very much touched by the hospitality and courteousness of the host Government and they will remember this Session with warm feelings for many years to come.

Hyderabad is a city of glittering lakes, beautiful gardens, architecturally impressive buildings and inspiring monuments. Its fine, wide and clean roads provided an excellent setting for the Session of the I.R.C. This is not the first time the Congress held its Session in Hyderabad; the previous Session was held there in January 1938. It was really a matter of coincidence that in the year 1938 when the Congress held its 4th Session at Hyderabad, the Nizam Government launched their programme of road development and now in the year 1959, Andhra Pradesh along with other States has approved of an All-India Road Development Plan which will be much bigger in size and volume and would cover the whole of the country.

Two hundred ninety nine delegates from various parts of India including some representatives of Institutions from abroad attended the Session. The delegates had the privilege of meeting some of the old engineers of Hyderabad who had a hand in making Hyderabad what it is to day. All meetings were held in the beautiful Jubilee Hall, Public Gardens, Hyderabad.

Shri W. X. Mascarenhas, Retd. Chief Engineer, P.W.D., Bombay and now Chief Engineer and Executive Director (Engg.), Life Insurance Corporation of India in his Presidential Address suggested the creation of an All-India Transportation Board, consisting of Officials, and other experts, to advise the Central and State Governments on transport questions, such as the development of highways, waterways and minor ports. He said communications should be viewed as a whole. Each State should have a unified Transport and Communications department especially in view of the rapid nationalization of motor transport.

Shri Mascarenhas suggested that all taxes on road users should be levied by the Centre and the amount collected on

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

account of what were now purely State taxes re-distributed among the States on the basis of vehicles registered and operating in each State, for expenditure solely on road construction and maintenance. The States should be required to match the share thus received by equal allocation from their own general revenues.

Among other points dwelt upon by Shri Mascarenhas were the suggestion for taxing the bullock-cart to the tune of Rs 12 per annum, the revival of the Indian Service of Engineers and improvement in the status and prospects of engineers. All these measures were necessary for successful implementation of the Second All-India Road Development Plan (1961-81) which had now been finalised.

His Excellency Sri Bhimsen Sachar, Governor of Andhra Pradesh inaugurating the Session said that in the past "our road system was built to meet the needs of strategy and administration rather than to promote the economic development of our rural areas." In a predominantly agricultural country like India, he said "trunk roads spanning its length and breadth and feeder roads interlacing the districts and providing an outlet for the produce of the villagers were major economic factors."

Messages of goodwill from the President of India, the Prime Minister, the Minister of Transport and Communications, the

Minister for Shipping, the Minister of Scientific Research and Cultural Affairs, the Governor of Bombay, the Chief Minister of Punjab and several others were read. The messages referred to the good work already done by the Indian Roads Congress and

The Secretary, I.R.C. reads the messages

stressed the need for evolving further and less expensive methods of road building with a view to utilising indigenous resources of the counry to the maximum and keeping in view the needs of the rural areas.

Delegates listen to the speeches with rapt attention

Delegates listen to the speeches with rapt attention

"The I.R.C. Medal" was awarded to Messrs S. R. Mehra and H. L. Uppal for their Paper No. 205—"The Importance of Subgrade Compaction in the Economic Design of Flexible Pavement". Paper No. 200—"Asphalt Paving Mixtures—Their Design and Composition" by N. H. Taylor was highly commended.

Messrs S. R. Mehra and H. L. Uppal receive the award

Seven Papers were discussed at the Session and about eighty speakers took part in the discussion. A Panel Discussion on "Construction of Roads in Waterlogged Areas" was arranged. Waterlogging is unfortunately spreading fast in certain areas. Besides damage to agriculture, it is causing progressive deformation of roads which have so far carried the traffic successfully. This problem having become important and urgent, was discussed in great detail. The delegates also discussed a Report on Road Research work carried out in the various Road Research Laboratories of the Country for the period ending the 31st March 1958. The discussion was very stimulating and useful. Engineers as well as research workers took part in the discussion.

Shri C. G. Swaminathan introduces his Paper

Shri S. R. Mehra, Director, C.R.R.I. gave a very useful and informative lecture on his impressions about Russia which he visited recently as a member of the team of Indian Scientists and Engineers. Another lecture on prestressed concrete bridges in foreign countries was given by Shri R. N. Joshi. This was explained with slides. A demonstration of "Earthmaster Manual Rammer" was arranged by Messrs Voltas Ltd. for the delegates.

Various Committees of the Congress also met during the Session. A Subcommittee of the Specifications and Standards Committee held a meeting to draft Specifications for bituminous pavements. The Research Organisation Committee which is

responsible for the co-ordination of road research work being done in the country at its meeting reviewed the progress made on its earlier recommendations and discussed the points arising out of the discussions on the Second General Road Research Report in India.

Research Organisation Committee meeting

Another Committee in session

The Community Projects Road Maintenance Committee also held a meeting. The concensus of opinion of this Committee was that the condition of community project roads was not satisfactory and to make this milage of roads a permanent addition to our road system considerable improvement in the standards as well as responsibilities of agencies for execution and maintenance was necessary.

The Bridges Committee discussed the various comments on Section III of the Indian Roads Congress Standard Specifications and Code of Practice dealing with Plain and Reinforced Cement Concrete. The Committee decided to compile a pamphlet giving permissible stresses in concrete, mild steel, high tensile steel, prestressed concrete and other materials. Other subjects discussed by the Committee were (1) the possibilities and advantages of adopting prefabrication and composite construction for road culverts for medium span bridges, and (2) the preparation of design standards and construction requirements of the prefabricated and composite construction units for culverts and bridges of medium span. Various Subcommittees were also appointed to finalise some of the remaining Sections of the I.R.C. Bridge Code. The finalised Section II of the Bridge Code was issued at the Session.

The Education Committee discussed the Syllabus for Diploma Courses in Highway Engineering and the Syllabus for B.E. Degree Examination for Civil Engineering. The Committee also discussed the question of institution of Refresher Courses for practising engineers in Highway Engineering.

The Road Transport Operation Cost Committee at its meeting reviewed the progress made in the implementation of its recommendations, and examined the results of the analysis of the data of the experiments being conducted by various State Transport Undertakings.

The Traffic Engineering Committee discussed the Nomenclature for Traffic Engineering Terms and Standards on Road Signs and Indication Boards.

The Prevention of Ribbon Development Committee also held a meeting. The Committee recommended that the Central and State Govts. should immediately take steps to enact Bills to deal with the prevention of ribbon development. As this was likely to take time, it was decided that the Central and State Govts. should, pending enactment of such legislations, give priority to the acquisition of lands adjoining various roads. It was also emphasised that high priority should be given to the preparation of up-to-date and correct land plans for the roads and for this purpose it would be necessary to appoint special revenue officers to deal with this matter in an expeditious manner. In order to limit the access to main highways it was desirable that the future development of villages and towns should be done on group development basis. This would mitigate the chances of future ribbon development.

The Road Transport Development Committee which is charged with the work of carrying out scientific studies of road transport problems discussed a suggestion that on account of the

pressing need to strengthen bridges, culverts and road surfaces to carry the growing traffic, very high priority has to be accorded to strengthen the existing traffic bearing roads. As regards the increased assistance to the States from the Centre in respect of financial outlay on the development of roads, the Committee felt that diversion of 2½ annas only to the Central Road Fund from petrol duty is now inadequate. In the opinion of the Committee the contribution to the Central Road Fund should increase and the proportion of fuel tax to be credited to the Central Road Fund should be restored to the same value as originally envisaged by the Jayakar Committee. The Committee also noted that there has been a substantial increase in the duty of high speed diesel oil in the recent past. The non-lapsing Central Road Fund should not be deprived of the contribution received from high speed diesel oil in respect of which the Committee recommended that an equal amount of share as decided in the case of motor spirit should also be diverted to the Central Road Fund which is likely to provide an additional source of revenue for road development to a considerable extent.

The Committee agreed that greater emphasis is necessary on the maintenance of existing roads as experience had shown that in many States the maintenance of roads was lagging behind although the traffic on them was increasing by leaps and bounds. The construction of earth roads should not be undertaken unless specific financial provision for their maintenance has been made and the authority who will maintain them has been prescribed.

The Local Bodies Engineering Services Committee discussed the progress made in regard to the Provincialisation of Local Bodies Engineering Services and made certain suggestions towards this end.

The Soil Research Committee discussed the specifications for road construction in sandy areas. Other subjects discussed by the Committee were the specifications for soil-cement pavements, specifications for road construction in water-logged areas and the classification and identification of soils for general engineering purposes and classification of black cotton soils in India. The application of results of research carried out in various road research laboratories was also discussed and various suggestions were made.

The Council at their 53rd meeting apart from transacting the ordinary business of the Congress discussed the Draft Design for Kilometer Stones and approved of an amendment to the Recommended Practice for Location and Layout of Roadside Motor-Fuel Filling Stations. The Council at their 54th meeting decided to hold the next Session of the Congress in Bangalore next year.

Shri U. J. Bhatt, Chief Engineer, P.W.D., B. & R., Bombay State was elected the new President of the Indian Roads Congress. Messrs N. Durrani, B. Prasad and L. R. Patel were elected as Vice-Presidents. Shri A. J. D'Costa was re-elected as Honorary Secretary.

Other highlights of the Session were the "At Homes" by the Govt. of Andhra Pradesh, the Corporations of Hyderabad and Secunderabad and the Highway Engineers' Association, entertainment to Cultural Shows and the Indian Roads Congress Dinner which was also attended by many distinguished guests.

At Home by the Andhra Pradesh Engineers' Association

At Home by the Corporations of Hyderabad and Secunderabad

An Engineering Exhibition which formed part of the All-India Industrial Exhibition was arranged for the benefit of delegates. The exhibition showed the various techniques used in

road construction. Road statistics were displayed to show the importance of roads to the community. Various firms dealing with road building materials and machinery, the State P.W.Ds., the Central Road Research Institute, the Army Headquarters, etc., took part in the exhibition. The exhibition was formally opened by Shri M. Narsing Rao, Minister for Communications, Andhra Pradesh on the 7th January 1959.

Another view of the At Home by the Corporation of Hyderabad and Secunderabad

On the 12th January the delegates inspected the Nagarjunasagar Dam, work on which is in progress. They also visited the Nagarjunakonda relics. Extensive excavations are being carried out by the Archeological Department near the dam site to salvage the relics of a Buddhist City said to have been founded by Nagarjuna a Buddhist some 2200 years ago. The area is going to be submerged when the Nagarjunasagar Dam is completed. The relics will be preserved on the top of a nearby hill in a museum.

On the 13th the delegates made local visits to the Salarjung Museum, Osman Sagar Dam, etc. With these visits the Session came to an end.

VOTE OF THANKS

by

SHRI SUJAN SINGH,

Vice-President, Indian Roads Congress

Your Excellency, Ladies and Gentlemen,

It gives me great pleasure to propose a vote of thanks to His Excellency, the Governor of Andhra Pradesh who in the midst of his multifarious affairs and duties of the State has been kind enough to spare time to be present in our midst to inaugurate the 23rd Session of the Congress. It also gives me great pleasure to welcome amongst us Shrimati Lalita Sachar and thank her for her kindness in gracing the occasion with her presence.

Vote of thanks by Shri Sujan Singh, Vice-President, I.R.C.

We are singularly fortunate in having the Heads of the States to inaugurate our Sessions and this gives so much grace and brilliance to our functions in addition to the encouragement and inspiration we get. You, Sir, have been at one time at the helm of affairs in one of our northern most States which under

your guidance has seen tremendous progress particularly in the shape of great engineering works like the gigantic Bhakra Nangal project and in the building of the new city of Chandigarh, the capital of that State. It is providential that you should now be here to guide the destinies of the newly formed State of Andhra Pradesh.

This is not the first time that we are meeting in Hyderabad. Some of our members will have vivid recollections of our fourth Session which was held here in the year 1938 and of the lavish hospitality of Government of Hyderabad and its engineers and I may particularly mention the names of Shri Dilder Hussain, Shri M. A. Mirza and Shri J. C. Hardikar whom we have the privilege of having in our midst today. We are once again receiving the same hospitality of the Government of this State and its engineers who have spared no pains to see that every detail is worked out with the minutest care with a view to make the stay of the delegates pleasant and comfortable.

Hyderabad can boast of several big engineering works some of which our delegates will be visiting during their stay here. Its roads are also well-known to evoke the admiration of visitors and engineers alike and, therefore, this City naturally forms an appropriate setting for a Session like the one we are now having.

On behalf of the President and members of the Indian Roads Congress, I now thank you all, ladies and gentlemen, for having graced this occasion by your presence. I can assure you that we shall carry with us happy memories of our stay in Hyderabad which will be a source of great inspiration in our work for the development of India's roads.

INDIAN ROADS CONGRESS

TECHNICAL EXHIBITION—JANUARY 1959

On the occasion of the Twenty-third Annual Session held in January 1959, the Indian Roads Congress organized an Engineering Exhibition as a part of the All-India Industrial Exhibition at Hyderabad. The exhibition was opened on the 7th January 1959 at 6-30 P.M. by Shri M. Narsing Rao, Minister of Communications, Andhra Pradesh. Speaking on this occasion, the Minister stated that the importance of roads in the development of India's economy can never be over-emphasized. Recognition of this was also given by the new All-India Road Development Plan which emphasises how much still remains to be done before India has a completely modern and efficient highway system. It was fitting and re-assuring to recognize the progress that has been made so far and to pay a tribute to the skill and enterprise of the engineers who have made this progress possible.

Shri W. X. Mascarenhas, President, Indian Roads Congress while thanking the Minister for kindly opening the exhibition

Shri M. Narsing Rao, Minister for Communications, Andhra Pradesh opens the I.R.C. Technical Exhibition

said that the technical exhibition had now become a permanent feature of the Annual Sessions of the Indian Roads Congress. Such an exhibition helps to educate the road engineers about the latest methods in road and bridge construction. It also serves to educate the public regarding the achievements of the country in the field of Highway Development. The President also thanked the participants and the host Govt. for their co-operation in making this exhibition a great success. The Minister accompanied by the President, IRC. then went round the exhibition.

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

Various Government Departments and firms dealing with road building materials and machinery, scientific instruments, etc. participated in the exhibition. The Andhra Pradesh State show with a chain of stalls dominated the exhibition. In brief the participants in the exhibition were:

STATE AND OTHER GOVT. DEPARTMENTS

Andhra Pradesh, Highways Department
Bihar, PWD
Bombay, PWD
Madras, Highways Department
Mysore, PWD
West Bengal, Road Development Department
Army Headquarters, E-in-C.'s Branch
Central Road Research Institute.

FIRMS

Associated Instrument Manufacturers (India) Ltd.
Burmah Shell Oil Co.
Gannon Dunkerley and Co. Ltd.
Larsen and Toubro Ltd.
Marshall and Sons (India) Ltd.
Millars' Timber Trading Co. Ltd.
Standard Vacuum Oil Co. Ltd.
William Jacks and Co. Ltd.

OTHERS

Concrete Association of India

Minutes of the 53rd Council Meeting of the INDIAN ROADS CONGRESS held at Hyderabad on the 6th January 1959

Present:

W. X. Mascarenhas — President

Dr. F. P. Antia
M. P. Apte
J. K. Banerjee
K. Barua
D. G. Bhagat
U. J. Bhatt
T. S. Chathunny
N. Durrani
K. V. Ekambaram
C. J. Fielder
G. S. Ganapathy
S. K. Ghosh
S. N. Gupta
B. S. Jootla
Dr. R. K. N. Iyengar
S. R. Mehra
J. Mukand
E. A. Nadirshah
K. K. Nambiar
L. R. Patel
B. Prasad
R. C. Roy
Col. G. S. Sihota
H. P. Sinha
S. N. Sinha
P. N. Srivastava
Sujan Singh
D. C. Sharma

A. J. D'Costa — Secretary

The following co-opted members attended:

K. F. Antia
N. D. Daftary
P. D. Shivdasani

The following attended by invitation:

Baleshwar Nath
R. S. Bhalla
R. N. Dogra
G. C. Khanna
Y. Padmanabham
J. M. Trehan
Lt.-Genl. Sir Harold Williams

1. Approval of the Minutes of the Executive Committee Meeting.

The Minutes of the meetings of the Executive Committee held at New Delhi on the 15th October and the 20th December 1958 were approved subject to following modifications:

Item IV of the minutes of the Executive Committee meeting held on 15-10-1958.

The Council was of the view that the Council meetings other than those held at the time of the Annual Session should be held in different places as far as possible.

Item IX of the minutes of the Executive Committee held on 15-10-1958.

It was also decided that in future the names of representatives of the Indian Roads Congress approved on various

Committees of other Institutions should be recorded in the minutes of the Executive Committee.

Item II of the minutes of the Executive Committee held on 20-12-1958.

It was decided to renew the invitation to the Govt. of Ceylon to send their delegates to attend the Twenty-fourth Session of the Congress.

2. **Audit Report for the year 1957-58.**

The Report of the Auditors for the year 1957-58 was recorded.

3. **Draft Report of the General Body of Members for the period 1st January to the 31st December 1958.**

The draft report was approved with an amplification of designation under Item 2 of the Report.

4. **Budget.**

The budget estimate for 1958-59 was discussed. It was decided to place this budget at the next meeting of the Council for their approval.

5. **Design for Kilometer Stones.**

The Council discussed the draft design for kilometer stones prepared by the Specifications and Standards Committee and it was decided that before the question of finalisation of the design was considered, the Central Road Research Institute should carry out the necessary experiments and submit a complete report to the Specifications and Standards Committee before the end of June 1959.

6. **Amendment to the Recommended Practice for Location and Layout of Roadside Motor-Fuel Filling Stations.**

The Council approved the following amendment to the Recommended Practice for Location and Layout of Roadside Motor-Fuel Filling Stations:

> "In the case of existing pumps, while considering the question of renewing the licences, each case may be considered on its merits and reasonable relaxation from the prescribed standards allowed so long as the safety of the road traffic is ensured".

The meeting then ended with a vote of thanks to the Chairman.

Minutes of the Business Meeting of the

INDIAN ROADS CONGRESS

held at Hyderabad on the 10th January 1959

The Twenty-third Annual General Meeting of Members was eld at Hyderabad on Saturday, the 10th January 1959 at -30 a.m. In all 288 Members and 11 Invitees (names and articulars at pages 651-658) attended the Session.

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

The minutes of the last Business Meeting held at New Delhi n the 8th January 1958 as printed on pages 638 to 681 of the ournal of the Indian Roads Congress, Volume XXII-part 4, Jovember 1958 were confirmed.

3. **Audit Report.**

(i) The Audit Report for the period 1st October 1957 to the 30th September 1958, pages 659-661, was recorded.

(ii) It was decided to re-appoint Messrs Walker, Chandiok & Co., Chartered Accounts and Auditors, Delhi to audit the accounts of the Indian Roads Congress for the year 1958-59.

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

The Report of the Council (pages 663-691) was taken as read and approved.

5. **Resolutions of thanks.**

The following resolutions were passed:

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

(ii) The Indian Roads Congress thank His Excellency Sri Bhimsen Sachar, Governor of Andhra Pradesh for kindly inagurating the Twenty-third Session of the Congress and for his very instructive and inspiring Address on that occasion and also for his permission to print his Address.

(iii) The Indian Roads Congress thank the Hon'ble Shri M. Narasinga Rao, Minister for Communications, Andhra Pradesh for kindly declaring open the Technical Exhibition organized by the Indian Roads Congress.

(iv) The Indian Roads Congress thank Dr. Rajendra Prasad, President of the Republic of India for his encouraging message and his greetings and best wishes for the successful conclusion of the Session.

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

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

(vii) The Indian Roads Congress thank Shri S. K. Patil, Minister of Transport and Communications, Government of India for his kind and encouraging message to the members of the Indian Roads Congress.

(viii) The Indian Roads Congress thank Shri Raj Bahadur, Minister for Shipping, Government of India, for his very encouraging message to the members of the Indian Roads Congress.

(ix) The Indian Roads Congress thank Shri Humayun Kabir, Minister of Scientific Research and Cultural Affairs for his kind message to the Congress.

(x) The Indian Roads Congress thank His Excellency Shri Sri Prakasa, Governor of Bombay for his instructive message and good wishes for the success of the Congress.

(xi) The Indian Roads Congress thank Sardar Pratap Singh Kairon, Chief Minister, Punjab for his very instructive and thought provoking message and good wishes for the success of the Session.

(xii) The Indian Roads Congress thank Shri G. M. McKelvie and Shri Brijmohan Lal, Past Presidents of the Indian Roads Congress for their good wishes for a very successful Session.

(xiii) The Indian Roads Congress thank Institutions and other well wishers who have sent messages of goodwill and encouragement.

(xiv) The Indian Roads Congress thank Shri N. Durrani, Chief Engineer (Highways), Andhra Pradesh and Superintending Engineers (Highways), Shri Y. Padmanabham, (Local Organizing Secretary, Indian Roads Congress), Deputy Chief Engineer and other officers and staff of the Highways Department, Andhra Pradesh for very excellent arrangements made by them for the Session and for the convenience of the delegates.

(xv) The Indian Roads Congress thank Lalitha Kala Samithi, Hyderabad and other artists for kindly arranging a Cultural Show for the delegates.

(xvi) The Indian Roads Congress thank the All-India Industrial Exhibition authorities for kindly allowing the holding of a technical exhibition at the Exhibition Grounds, Mukhram Zahi Road, Hyderabad.

(xvii) The Indian Roads Congress thank the Government of Andhra Pradesh for kindly inviting the delegates to an "At Home" and Cultural Show.

(xviii) The Indian Roads Congress thank the Andhra Pradesh Highways Engineers' Association, Hyderabad for kindly inviting the delegates to an "At Home" and Cultural Show.

(xix) The Indian Roads Congress thank the Corporations of Hyderabad and Secunderabad for kindly inviting the delegates to an "At Home".

(xx) 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.

(xxi) 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 films.

(xxii) The Indian Roads Congress thank United States Information Service and British Information Service for offering Technical films for being screened.

(xxiii) The Indian Roads Congress thank the Director, All-India Radio for kindly recording the proceedings of the Session and the Director, Information & Publicity Department, Andhra Pradesh for the assistance rendered to the Congress.

(xxiv) The Indian Roads Congress thank the State Bank of Hyderabad, Railway Authorities, Indian Airlines, Post and Telegraph authorities for kindly opening their offices in Jubilee Hall for the convenience of the delegates.

(xxv) The Indian Roads Congress thank the Andhra Pradesh Road Transport authorities for providing very efficient transport facilities for the delegates.

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

(xxvii) The Indian Roads Congress thank the following firms for their hospitality to the delegates:

(1) M/s. William Jacks & Co. Ltd.
(2) Willcox (Buckwell India) Ltd.
(3) Tractors (India) Ltd.
(4) Larsen & Toubro Ltd.

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

Messrs Sarup Sing, J. Mukand, J. M. Trehan and G. S. Ganapathy 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.

F.P. Antia, Dr.
M.P. Apte
C.J. Fielder
K.K. Nambiar
L.R. Patel
P.D. Shivdasani

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

L.C. Verman, Dr.

9-h. Representative of District Board Engineers.

Y.K. Chaougule.

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

M. Meeran.

9-j. Representatives elected by the General Body.

S.K. Ghosh
H.R. Sayoji Rao
S.N. Sinha
H.L. Uppal, Dr.

8. **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	N. Durrani
	Assam	K. Barua
	Bihar	B. Prasad
	Bombay	U. J. Bhatt
	Madras	Chief Engineer (Highways)
	Madhya Pradesh	Chief Engineer, P.W.D., M.P.
	Orissa	Chief Engineer, R. & B., Orissa
	Uttar Pradesh	M. S. Bisht
	Punjab	Nomination awaited
	West Bengal	R. C. Roy
	Mysore	Chief Engineer (General)
	Rajasthan	Kishore Lal
	Kerala	T. S. Chathunny
	Jammu & Kashmir	P. N. Wanchoo
	Himachal Pradesh	J. Mukand
9-b.	Engineer-in-Chief, Army Headquarters	Major General R. E. Aserappa

	Name of participating Administration.	Name of Representative.
9-c.	Central P.W.D.	N. G. Dewan
9-d.	Consulting Engineer (Road Development) Govt. of India	H. P. Sinha
9-e.	Director, C.R.R.I.	S. R. Mehra

Past Presidents

9-f.	W. X. Mascarenhas
	P. L. Varma

9. The following resolution of condolence was passed, all members standing:

"The Council records with a sense of profound regret the loss sustained by them by the untimely death in October 1958 of Shri E.P. Nicolaides who was one of the founder members of the Indian Roads Congress and served prominently on the Council and the Bridges Committee for many years. His eminence and ability as a bridge engineer won him admiration and respect throughout this country. He was always ready to place his long experience and technical ability at the disposal of the Congress. His genial personality and burning enthusiasm will be greatly missed at the meetings of the Congress".

The General Body of members expressed its desire that the Secretary should convey the above resolution to the bereaved family.

LIST OF MEMBERS WHO ATTENDED THE TWENTY-THIRD SESSION OF THE INDIAN ROADS CONGRESS HELD AT HYDERABAD IN JANUARY, 1959

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)	...	24
	(b) Central Board of Irrigation & Power	...	1
	(c) Central Road Research Institute	...	17
	(d) Central Public Works Department	...	3
	(e) Engineer-in-Chief's Branch	...	3
	(f) Hindustan Steel Limited	...	2
	(g) Planning Commission	...	4
2.	**Andhra Pradesh**	...	75
3.	**Assam**	...	2
4.	**Bombay**	...	41
5.	**Bihar**	...	16
6.	**Delhi**	...	7
7.	**Himachal Pradesh**	...	1
8.	**Kerala**	...	2
9.	**Kashmir**	...	1
10.	**Madras**	...	19
11.	**Mysore**	...	15
12.	**Madhya Pradesh**	...	4
13.	**Nepal**	...	1
14.	**Orissa**	...	5
15.	**Punjab**	...	9
16.	**Rajasthan**	...	8
17.	**Tripura**	...	1
18.	**Uttar Pradesh**	...	14
19.	**West Bengal**	...	24
	Total	...	**299**

LIST OF DELEGATES WHO ATTENDED THE 23rd SESSION OF THE INDIAN ROADS CONGRESS HELD AT HYDERABAD FROM THE 6th TO 13th JANUARY 1959.

S. No.	Roll No.	Name
		1. GOVERNMENT OF INDIA
		(a) Ministry of Transport & Communications, Deptt. of Transport (Roads Wing)
1.	783	Bhargava, T. N.
2.	266	Bhagat, D. G.
3.	322	Bazaz, S. L.
4.	1446	Bhalla, R. S.
5.	758	D' Costa, A. J.
6.	879	Goverdhan Lal
7.	*Invitee*	Ganguli, M. K.
8.	*Invitee*	Harbans Singh
9.	785	Hardyal
10.	1275	Jaswant Singh
11.	2083	Keswani, N. H.
12.	1146	Menon, M. D.
13.	705	Mirchandani, N. D.
14.	1878	Navancy, M. K.
15.	950	Nagarsheth, M. P.
16.	890	Patel, B. P.
17.	752	Ramaswami, N. S.
18.	724	Rajagopalan, S. K.
19.	2020	Rao, B. Balwant
20.	1532	Sehra, P. T.
21.	191	Sinha, H. P.
22.	637	Surya, N. S.
23.	*Invitee*	Sachdev, D B. S.
24.	918	Trehan, J. M.
		(b) Central Board of Irrigation & Power
25.	*Invitee*	Baleshwar Nath
		(c) Central Road Research Institute
26.	*	Bhatia, H. S.
27.	1914	Gokhale, Y. C.
28.	833	Iyengar, R. K. N.
29.	1857	Khanna, T. S.
30.	*	Kapur, R. N.
31.	277	Mehra, S. R.
32.	2202	Natarajan, T. K.
33.	*	Nanda, R. L.
34.	2349	Puri, M. L.
35.	2183	Swami, S. A.
36.	1720	Sankaran, K. S.
37.	1345	Swaminathan, C. G.
38.	1311	Subbaraju, Bh.

* Honorary member for current year.

S. No.	Roll No.	Name
39.	*	Sehgal. T. R.
40.	*	Sethi, K. L.
41.	*	Srinivasan, N. R.
42.	847	Uppal, H. L.
		(d) Central Public Works Department
43.	2059	Gupta, D. L.
44.	1108	Puri, P. R.
45.	738	Vaish, V. R.
		(e) Engineer-in-Chief's Branch
46.	*Invitee*	Deb, A. K.
47.	*Invitee*	De, G.
48.	16-Associate	Sihota, Col. G. S.
		(f) Hindustan Steel Limited
49.	1413	Bhattacharyya, S. P.
50.	2053	Ganapathy, C. P.
		(g) Planning Commission
51.	*Invitee*	Luthra, K. L.
52.	*Invitee*	Sethi, H. D.
53.	2526	Sarup Singh
54.	1820	Vedagiri, T. S.
		2. ANDHRA PRADESH
55.	2492	Aiengar, B. T. Sita Ram
56.	2300	Amanuddin, S.
57.	2105	Atchiraju, P.
58.	1263	Abdul Rahman
59.	2413	Badaruddin, S.
60.	353	Devarajan, A.
61.	246	Durrani, N.
62.	2337	Gulam Dastagiri
63.	31	Jussawalla, J. R.
64.	2511	Jaggayya, N.
65.	2466	Khyrathi, S. M.
66.	2392	Khan, Mohd. Karimullah
67.	249	Katrak, M. M.
68.	*Invitee*	Khurshid Hussain
69.	2494	Khan, Ghousdad
70.	2505	Krishnaiah, V. V.
71.	1545	Krishnamurthy, P.
72.	2539	Khadir, M. A.
73.	891	Mohury, B. D.
74.	2317	Mohiuddin, S. M.
75.	2486	Mohd. Altaf Hussain
76.	2502	Mouli, T. Chandra
77.	2512	Murty, K. S. N.
78.	2480	Murty, B. Rama
79.	2521	Mohd. Haneef

* Honorary member for current year.

S. No.	Roll No.	Name
80.	2542	Mahoob Ali
81.	683	Nayudu, N. Dharmarao
82.	1594	Naidu, A. N. Damodaran
83.	2545	Naidu, C. Munaswamy
84.	813	Prabhala, R.
85.	672	Patrulu, P. S.
86.	2506	Paidayya Vasala
87.	1126	Punniah, P. B.
88.	1082	Padmanabham, Y.
89.	2541	Prasad, J. R. K.
90.	1013	Rao B. K. V.
91.	1113	Reddy, T. A. Ramanatha
92.	1824	Rajanna, B. V.
93.	1647	Rao, M. Subba
94.	873	Rao, R. R. Thimmaji
95.	2430	Rao, B. V. Subba
96.	472	Rao, N. Seshagiri
97.	2482	Rao, V. Rama
98.	2483	Rao, J. V. Ramana
99.	2181	Rao, H. Raghavendra
100.	1610	Rao, A. R. Satyanaran
101.	2487	Rao, P. Venkatesa
102.	2490	Rao, C. Rajagopala
103.	1768	Rao, G. Chalapati
104.	233	Rao, H. R. Sayoji
105.	1945	Rao, K. V.
106.	771	Raghaviah, M.
107.	2509	Rao, Ch. Kesava
108.	628	Raj, P. V.
109.	2479	Rao, C. Rajagopala
110.	2472	Ramayya, T. A.
111.	2515	Reddy, S. Chenna
112.	1991	Rao, G. C. Venkateswara
113.	1564	Rao, K. Bapa
114.	2518	Rao, P. Vishno
115.	1554	Rao, K. Narayan
116.	757	Rao, R. R. Mohan
117.	2528	Reddy, P. R.
118.	2540	Rao, G. Bapu
119.	2522	Ramanath, N.
120.	2543	Rao, C. V. Rama
121.	2544	Rao, P. Chander
122.	2110	Sexena, K. R.
123.	1084	Shastri, M. Balagangadhara
124.	2507	Syed Bashiruddin Ahmed
125.	2420	Seshiah, G.
126.	866	Subramanyam, P. L.
127.	2484	Venkanna, P.
128.	2488	Venkateswarlu, T.
129.	1530	Yegnanarayana, K.
		3. ASSAM
130.	889	Barua, K.
131.	55-Associate	Rajkhowa, P.—Representing M/s. Assam Oil Co. Ltd., **Digboi.**

S. No.	Roll No.	Name
		4. BOMBAY
132.	32-Associate	Antia, F. P.—Representing M/s. Cement Marketing Co. of India Ltd., **Bombay.**
133.	1522	Apte, M. P.
134.	1241	Antia, K. F.
135.	2532	Athavale, S. G.
136.	60-Associate	Amin, Dinkar T.—Representing M/s. Pashabhai Patel & Co. Ltd., **Bombay.**
137.	2445	Bendre, R. R.
138.	214	Bhatt, U. J.
139.	2451	Campbell, H. H.
140.	704	Chougule, Y. K.
141.	1739	Desai, I. C.
142.	1636	Daftary, N. D.
143.	2049	Gupte, A. Y.
144.	2505	Harris, C. D.
145.	1129	Iyengar, C. L. N.
146.	1474	Jagus, P. J.
147.	2033	Jayawant, M. B.
148.	1430	Joshi, R. N.
149.	2531	Kamdar, V. P.
150.	1670	Kale, L. W.
151.	2497	Krishnamurthy, K. N.
152.	34	Mehta, J. T.
153.	1716	Menon, T. M.
154.	2508	Merani, N. V.
155.	1946	Mascarenhas, W. X.
156.	75-Associate	Meadows, S.F.–Representing M/s.William Jacks & Co. Ltd., **Bombay.**
157.	76-Associate	Marathe, S. S.—Representing M/s. S. S. Marathe & Co., **Bombay.**
158.	1723	Natu, S. V.
159.	1565	Nerurkar, M. S.
160.	268	Nambiar, K. K.
161.	23	Nadirshah, E. A.
162.	35-Associate	Narayan Singh—Representing M/s. Caltex (India) Ltd., **Bombay.**
163.	1780	Pimple, J. S.
164.	2503	Parliker, V. R.
165.	2188	Sivaguru, N.
166.	1432	Sujan Singh
167.	1148	Shivdasani, P. D.
168.	2353	Sarkar, B. B.
169.	2031	Tambe, R. V.
170.	1501	Taylor, N. H.
171.	2351	Thakur, D. S.
172.	2529	Wagh, P. R.
		5. BIHAR
173.	1655	Aga, A. K.
174.	1637	Amanullah, N.
175.	1772	Gupta, R. M.
176.	471	Gupta, S.
177.	2305	Jyotishi, R. P.
178.	2007	Nath, S.

S. N.	Roll No.	Name
179.	1998	Prasad, B.
180.	733	Prasad, Bhagwat
181.	1299	Roy, B. N.
182.	2396	Sinha, Nand Kishore Prasad
183.	2071	Sinha S. B. P.
184.	971	Sinha, B. P.
185.	871	Sinha, S. N.
186.	1978	Sinha, B. K.
187.	1331	Sen, S. K.
188.	1300	Varma, D. N.
		6. DELHI
189.	69-Associate	Abrol, R. C.–Representing M/s. R.C. Abrol & Co. (P) Ltd. New Delhi.
190.	58-Associate	Chandrasekhara, C.S.–Representing Indian Standards Institution, New Delhi.
191.	2366	Dutt, D.
192.	2208	Dawar, A. R.
193.	1183	Nazareth, C. V.
194.	40-Associate	Shahani, T. C.—Representing M/s. Standard Vacuum Oil Co. Ltd., New Delhi.
195.	1785	Shah, Z. S.
		7. HIMACHAL PRADESH
196.	2536	Mukand, J.
		8. KERALA
197.	2513	Chathunny, T. S.
198.	1753	Nayar, K. Madhavan
		9. KASHMIR
199.	1457	Gandotra, H. K.
		10. MADRAS
200.	2516	Damodaram, P. S.
201.	2414	Ekambaram, K. V.
202.	2022	Kohli, D. R.
203.	2535	Kunhambu, K. P.
204.	1529	Kuttlanathan, L.
205.	2495	Kannan, M.
206.	2343	Mohideen, S. M.
207.	762	Muthukumara Swami, A.
208.	671	Meeran, M.
209.	1711	Natu, M. R.
210.	1754	Ramachandran, N.
211.	162	Raju, P. V.
212.	1775	Selvam, T. T.
213.	2182	Subramanian, R.
214.	1674	Subramaniam, V.
215.	2018	Sundaravadivel, N.
216.	219	Sirajuddin, P.
217.	2498	Thandapany, C.
218.	630	Thadaney, K. V.

S. No.	Roll No.	Name
		11. MYSORE
219.	242	Adke, A. S.
220.	2519	Bhavikatti, A. R.
221.	2500	Chari, S. K. Veerabhadra
222.	2398	Gurusiddiah, T. M.
223.	1641	Ganapathy, G. S.
224.	1656	aveli, S. C.
225.	2510	Krishnacharya, H.
226.	2514	Kumar, N. C. Kanjakasha
227.	1479	Narke, S. P.
228.	2493	Patil, R. K.
229.	2501	Parthasarthy, M. A.
230.	2523	Patil, S. M.
231.	2499	Rao, B. N. Lakshminarsimha
232.	2485	Saldanha, W. G.
233.	*	Wali, K. S.
		12. MADHYA PRADESH
234.	1547	Agrawal, G. D.
235.	2489	Gupta, Shri Ram
236.	1320	Hiremath, S. A.
237.	2520	Srivastava, M. P.
		13. NEPAL
238.	338	Nangea, G. R.
		14. ORISSA
239	1979	Ahmed, Z.
240.	328	Behera, S. S.
241.	304	Jootla, B. S.
242.	2204	Mukherjee, P. K.
243.	1793	Patnaik, R. M.
		15. PUNJAB
244.	457	Dogra, R. N.
245.	2491	Gupta, J. S.
246.	446	Khanna, G. C.
247.	1900	Lamba, T. S.
248.	2197	Mehta, S. S.
249.	504	Sharma, D. C.
250.	2075	Sahni, D. V.
251.	2533	Sodhi, J. S.
252.	*Invitee*	Uppal, I. S.
		16. RAJASTHAN
253.	826	Adaviyappa, S.
254.	1661	Bhatnagar, V. R.
255.	2312	Dugar, S. M.
256.	2465	Mukerjee, S. K.
257.	842	Mathur, J. L.
258.	800	Rao, K. Gopinath
259.	1971	Sarin, K. K.
260.	1181	Sharma, K. N.

* Application for membership under considertion.

S. No.	Roll No.	Name
		17. TRIPURA
261.	2397	Barman, A. K. Deb
		18. UTTAR PRADESH
262.	2196	Bhargava, J. K.
263.	2517	Brijendra Singh
264.	1525	Chaturvedi, D. C.
265.	946	Goel, R. R.
266.	1787	Gupta, G. C.
267.	1573	Guru Dayal
268.	490	Shobha Ram
269.	958	Srivastava, P. N.
270.	1889	Satish Prasad
271.	2504	Singh, C. M.
272.	960	Sinha, K.
273.	2530	Saxena, N. C.
274.	*Invitee*	Williams, Lt.-Gen. H.—Representing the Institution of Civil Engineers, London.
275.	2527	Zuberi, A. H.
		19. WEST BENGAL
276.	1628	Bose, A. K.
277.	1421	Basu, K. N.
278.	2496	Bandyopadhyay, S. C.
279.	962	Banerjee, J. K.
280.	2524	Banerjee, Pronab Kumar
281.	2534	Chaterjee, S.
282.	41-Associate	De, K. C.—Representing M/s. Bengal Chemical Ltd., Calcutta.
283.	2250	De, P. L.
284.	231	Fielder, C. J.
285.	1942	Ghosh, D. K.
286.	926	Gupta, S. N.
287.	808	Ghosh, S. K.
288.	1556	Gupta, A. K. Das
289.	863	Gupta, P. N. Sen
290.	2037	Karnik, A. V.
291.	1566	Laha, S. K.
292.	2525	Mukherji, B. J.
293.	67-Associate	Mahadevan, M.R.—Representing M/s. The United Provinces Commercial Corporation, Calcutta.
294.	21-Associate	Patel, L. R.—Representing M/s. William Jacks & Co. Ltd., Calcutta.
295.	2538	Roy S. M.
296.	2537	Rakshit, Kripasindhu
297.	1544	Ray, S. N.
298.	766	Roy R. C.
299.	65-Associate	Wahi, K. M. Representing M/s. Agrind Fabrication Ltd., Calcutta.

BALANCE SHEET AS AT 30TH SEPTEMBER, 1958.

(Excluding Transport-Communications Monthly Review).

LIABILITIES		Rs nP.	Rs nP.
SUNDRY CREDITORS			
Income tax payable on salaries	12 00		
Shri McKelvie's Silver Salver Fund	120 84		
Advance for Publications	58 61		
			191 45
Subscriptions received in Advance from :			
Ordinary Members :			
1958—59	510 63		
1959—60	55 00		
1960—61	10 00	575 63	
Associate Members :			
1958—59 ...		27 50	603 13
FUNDS			
(a) **MITCHELL MEDAL FUND** (Invested as per contra)			
As per last Balance Sheet ...		2,201 62	
Add : Interest realised ...		47 50	
		2,249 12	
Less : Bank Charges	0 13		
Cost of 10 I.R.C. Medals	315 72	315 85	1,933 27
(b) **BUILDING, MUSEUM & TECHNICAL FUND**			
Balance as per last Balance Sheet ...		1,68,810 74	
Add : Amount of Life Membership ...		801 00	
Interest on Investments ...		5,371 00	1,74,982 74
RESERVE FOR BAD & DOUBTFUL DEBTS			10,000 00
DUE TO INDIAN NATIONAL GROUP OF I.A.B.S.E.		3,343 24	
Less : Expenses during the year ...		2,504 24	839 00
PROVIDENT FUND DEPOSITS			37,513 62
PROVIDENT FUND INTEREST DISTRIBUTABLE			
Balance as per last Balance Sheet ...		478 70	
Add : Interest earned ...		955 50	
		1,434 20	
Less : Distributed ...		837 56	596 64
AMOUNT HELD IN SUSPENSE (pending adjustment)			9,329 85
CHEQUES ISSUED BUT NOT ENCASHED			5,460 29
DUE TO T. C. M. R.			1,386 61
INCOME & EXPENDITURE ACCOUNT			
Balance as per last Balance Sheet ...		1,48,744 00	
Less : Balance being Excess of Expenditure over Income as per annexed Income & Expenditure Account ...		7,212 42	1,41,531 58
Total ...			3,84,368 18

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

ASSETS		Rs nP.	Rs nP.
EQUIPMENT			
Balance as per last Balance Sheet ...		6,992 97	
Additions during the year ...		440 09	
		7,433 06	
Less : Depreciation written off ...		911 64	6,521 42
LIBRARY BOOKS			
Balance as per last Balance Sheet ...		2,243 82	
Additions during the year ...		276 61	
		2,520 43	
Less : Depreciation written off ...		252 04	2,268 39
DRAWING MATERIALS			
Balance as per last Balance Sheet ...		18 37	
Less : Depreciation written off ...		1 50	16 87
INVESTMENTS			
Rs 49,000/- 12 years National Savings Certificates ...		49,000 00	
Rs 74,600/- 10 years Treasury Savings Deposit 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	1,57,810 74
INTEREST ACCRUED ON INVESTMENTS			13,058 84
PROVIDENT FUND			
12 years National Savings Certificates ...		29,200 00	
Interest accrued thereon to 30th Sept., 1958 ...		3,577 50	
Balance with State Bank of India ...		2,456 26	
Loans Advanced ...		2,285 00	37,518 76
MITCHELL MEDAL FUND			
Rs 1,600/- 3% Loan 1963-65 ...		1,652 93	
Interest accrued thereon ...		16 00	
Balance with State Bank of India ...		264 34	1,933 27
STOCK-IN-HAND			
(Certified as to quantities & values by the Secretary)			
Journals	57,382 36		
Paper	7,064 95		64,447 31
SUNDRY DEBTORS			
Subscriptions in arrears from :			
(i) Ordinary Members	16,268 54		
(ii) Associate Members	600 00	16,868 54	
Outstandings - Publications ...		863 63	
Subsidies Receivable (includes Rs 21,000/- in arrears) ...		47,500 00	
Cost of Printing and Papers receiveable from Road Research Institute, New Delhi ...		3,960 00	
		69,192 17	
ADVERTISEMENTS			
Considered good	1,537 00		
Considered doubtful	360 75	1,897 75	
SESSION EXPENSES RECOVERABLE			
Transport Charges (of which Rs 50/- considered doubtful)	831 25		
Delegation Fees	4,145 00	4,976 25	76,066 17
ADVANCES			
The Deputy Controller of Stationery & Printing, Calcutta ...		1,110 18	
Staff (against Cycles Purchased) ...		1,788 44	
Recoverable from the Local Organising Secretary against the Government Grant ...		3,218 29	
Indian National Society of Soil Mechanics & Engineering ...		233 74	
Advance to Deustsche Notenbank, Berlin (against purchase of book) ...		5 75	6,356 40
CASH & BANK BALANCES			
With State Bank of India ...		10,670 01	
Cheques pending realisation ...		7,648 00	
Stamps in hand ...		52 00	18,370 01
Total ...			3,84,368 18

AUDITORS' REPORT.

We have audited the Balance Sheet of the INDIAN ROADS CONGRESS (excluding Transport-Communications Monthly Review) as at 30th September, 1958, above set forth, and have obtained all the information and explanations we have required.

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

(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 17th day of December 1958.

INDIAN ROADS CONGRESS

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 30TH SEPTEMBER, 1958.

(Excluding Transport-Communications Monthly Review)

EXPENDITURE	Rs	nP.	Rs	nP.	INCOME	Rs	nP.	Rs	nP.
To Opening Stock of Journals as at 1st October, 1957 ...	53,449	77			By **Subscriptions :**				
,, Paper Consumed ...	23,160	60			Ordinary Members (includes Rs 150/- of members restored)				
,, Printing Charges and incidentals ...	21,731	17			Associate Members ...	30,180	00		
,, Salary paid to Representative at Madras ...	900	00			Life Members ...	3,760	00		
	99,241	54			New Members ...	70	00		
Less : Closing Stock of Journals as on 30th September, 1958 ...	57,382	36	41,859	18	Associate New Members ...	2,590	00		
					...	300	00		
,, Establishment ...			31,749	45	,, **Entrance Fees :**			36,900	00
,, Local & other Allowances ...			19,416	36	Ordinary Members				
,, Honorarium to Secretary ...			1,200	00	Associate Members ...	1,575	00		
,, Bank Charges and exchange (Net) ...			201	40	...	360	00		
,, Provident Fund Contribution ...			1,934	00	,, **Sale of Publications**			1,935	00
,, Audit Fee for 1956–57 ...			600	00	*Less* : Sale Returns ...	10,280	35		
,, Postage & Telegrams ...			6,996	49	...	178	75		
,, Office Printing & Stationery ...			1,979	62	,, **Advertisements**			10,101	60
,, Uniforms to Class IV Servants ...			570	97	...			4,536	50
,, Telephone, Revenue Stamps and other Miscellaneous Expenses ...			1,617	36	,, **Subsidies** (including arrears.) ...			53,500	00
,, Publicity Expenses ...			600	00	,, Interest on Cycle Advances ...			54	95
,, 22nd Session Expenses ...	11,458	75			,, **Receipts on amount of :**				
Less : Contribution made by Delegates towards dinner ...	1,508	25	9,950	50	(i) Delegation Fees				
,, Subscriptions to other Societies ...			350	00	(ii) Transport Charges etc. ...	8,570	00		
,, Bad Debts written off ...			3,136	50	...	2,435	00	11,005	00
,, 52nd Council Meeting Expenses (Bombay) ...	4,599	13			,, **Income for Printing of 'Road Research' Papers**				
Less : Contributions received ...	10	00	4,589	13	Income				
,, Depreciation written off ...			1,165	18	Expenses ...	14,332	50		
					...	11,661	83	2,670	67
					,, Balance being Excess of Expenditure over Income carried to Balance Sheet ...			7,212	42
Total			1,27,916	14	Total			1,27,916	14

41-L, Connaught Circus,
New Delhi.
Dated, this 17th day of December 1958.

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

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

INDIAN ROADS CONGRESS

Transport-Communications Monthly Review

INCOME & EXPENDITURE ACCOUNT FOR THE YEAR ENDED 30TH SEPTEMBER, 1958.

EXPENDITURE	Rs	nP.	INCOME	Rs	nP.
To Paper Consumed ...	9,390	72	By Sales and Subscriptions of the Journal ...	4,269	72
,, Printing Charges (including Rs 600/- paid as proportionate salary to Representative at Madras and other incidentals) ...	9,103	65	,, Advertisements ...	9,057	75
,, Postage ...	1,351	27	,, Balance being Excess of Expenditure over Income carried to Balance Sheet ...	6,683	14
,, Telephone & Miscellaneous Expenses ...	75	67			
,, Bank Charges ...	71	85			
,, Bad debts written off ...	17	45			
Total ...	20,010	61	Total ...	20,010	61

BALANCE SHEET AS AT 30TH SEPTEMBER, 1958.

LIABILITIES	Rs	nP.	Rs	nP.	ASSETS	Rs	nP.	Rs	nP.
SUNDRY CREDITORS					**BOOK DEBTS**				
For Goods ...			850	64	For Advertisement (of which Rs 222-06 are considered doubtful) ...	3,794	31		
					For Sale of Journal ...	162	00	3,956	31
SURPLUS ACCOUNT					**DUE FROM GENERAL ACCOUNT** ...			1,386	61
Balance as per last Balance Sheet ...	12,124	24			**STOCK IN HAND** (Certified as to quantities & values by the Secretary) ...			915	18
Less: Balance being excess of Expenditure over Income as per annexed Income & Expenditure Account ...	6,683	14	5,441	10	**STAMPS IN HAND** ...			33	64
Total ...			6,291	74	Total ...			6,291	74

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

AUDITORS' REPORT

We have audited the Balance Sheet of the INDIAN ROADS CONGRESS (Transport-Communications Monthly Review) as at 30th September, 1958, 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 17th day of December, 1958.

(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 1958.

[*The report covers the period from the 1st January to the 31st December, 1958, though a few matters referred to in it are carried beyond the latter date for convenience and completeness of record.*]

1. GENERAL

The Twenty-second Session of the Indian Roads Congress was held at New Delhi in January 1958 when 284 members and 18 invitees attended the Session. The 7 Papers published in the Journal of the Indian Roads Congress, Volume XXII-parts 1 to 4, were read and discussed. Seventeen Committees were reconstituted to deal with various engineering and administrative problems. The Executive Committee held meetings at New Delhi on the 8th March, the 14th July, the 15th October and the 20th December 1958. The Council held its 52nd meeting at Bombay from the 9th to the 11th August 1958. The Proceedings are published at pages 25 to 62 of I.R.C. Journal, Volume XXIII-part 1.

2. ADMINISTRATION

Shri W. X. Mascarenhas, Chief Engineer and Executive Director, Life Insurance Corporation of India, Bombay was elected President at the New Delhi Session. Shri H. P. Sinha, Consulting Engineer to the Government of India (Road Development), continued to function as Honorary Treasurer. Shri D. G. Bhagat, Deputy Consulting Engineer (Roads) continued to work as Honorary Deputy Treasurer.

Shri A. J. D'Costa continued to work as Honorary Secretary.

3. OFFICE

The office continued to function in New Delhi. It disposed of 14,000 receipts and issued 25,000 letters during the period under report.

The staff worked satisfactorily.

4. MEMBERSHIP

(1) The number of members on the rolls on the 30th September 1958 was 1682 (1 Honorary, 1 Associate Honorary, 1641 ordinary and 39 associates). During the year there were 134 new admissions and 45 removals from the rolls. The removals were the result of: resignations 18; deaths 3; non-payment of arrears of subscription 24.

(2) **Life membership**: During the Congress year, 1st October 1957 to the 30th September 1958, 7 members were enrolled as life members. The number of life members on the 30th September 1958, was 148. This number is, however, included in the total number of ordinary members. The fees received from them have been transferred to the Building, Museum and Technical Fund after deducting Rs 10 per member for initial expenses.

5. DEATHS

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

C. Janardan Rao

E. P. Nicolaides

Raghbir Singh

R. D. Ratnagar

T. K. Sahay

Sripada Ghosh

6. BUDGET

The budget for the year 1958-59 and the "actuals" for 1957-58 were placed before the Executive Committee at their meeting held on the 15th October 1958 and later on these were approved by correspondence. The estimates have been placed before the Council at their 53rd meeting. The actuals for 1957-58 show a deficit of Rs 15,474 against an estimated deficit of Rs 859.

The total contribution received from the State Governments during the year ending the 30th September 1958 amounted to Rs 53,000. The defaulter States are being urged to expedite payment of the outstanding contributions. It is expected that the outstanding contributions will be realized during the current year. Sums totalling Rs 5,000 have been received after the 30th September 1958.

Part 'A' States were approached in 1949 to sanction annual contribution for five years at ½ per cent of their share from the Central Road Fund or a fixed sum on that basis subject to a minimum of Rs 2,000. Part 'B' States were also making contributions to the Congress. The question of approaching the States for fresh sanctions, as a result of the reorganisation of States, is being examined and they will be addressed shortly.

The arrears of subscription at the beginning of the Congress year 1956-57 amounted to Rs 13,128 which were due from 290 members. The names of 25 members, who had failed to pay their subscription, were removed from the rolls. Consequently, a sum of Rs 3,095 standing as arrears against these members was written off by the Executive Committee during the year 1957-58.

A sum of Rs 2,525 was realised from 75 members during 1957-58.

After adding the arrears for 1957-58, the total as arrears on the 1st October 1958 stood at Rs 16,868 due from 341 members. Efforts are being made to realise the arrears.

7. AUDIT

At the Twenty-second Session at New Delhi it was decided to appoint M/s. Walker, Chandiok and Co., Chartered Accountants and Auditors, Delhi, to audit the accounts of the Congress for 1957-58. The report was examined by the Executive Committee on the 20th December 1958. It was also placed before the Council at their 53rd meeting on the 6th January, 1959.

8. PUBLICATIONS

There was a steady demand for the publications of the Indian Roads Congress during the year under report.

The balance of the publications on the 30th September 1958 was as under :

Name of Proceedings	*Volume*	*Balance*
I.R.C. Proceedings	I to VII-part 1	Sold out
Do.	VII-part 2	46
Do.	VIII	Sold out
Do.	IX-part 4	118
Do.	IX (Bound)	55
Do.	X-parts 1 to 3	Sold out
Do.	X-part 4	208
Do.	X (Bound)	Sold out
Do.	XI-parts 1 & 2 (Bound)	19
Do.	XI-parts 3 & 4 (Bound)	23

Name of Proceedings	*Volume*	*Balance*
I.R.C. Proceedings	XI-part 4	154
Do.	XII-part 1	Sold out
Do.	XII-part 2	404
Do.	XII-part 3	378
Do.	XII-part 4	433
Do.	XII-part 5	417
Do.	XII-parts 1 to 3 (Bound)	290
Do.	XII-parts 4 & 5 (Bound)	101
Do.	XIII-part 1	273
Do.	XIII-part 2	358
Do.	XIII-part 3	705
Do.	XIII-part 4	Sold out
Do.	XIII-parts 1 & 2 (Bound)	481
Do.	XIII-parts 3 & 4 (Bound)	51
Do.	XIV-part 1	281
Do.	XIV-part 2	370
Do.	XIV-part 3	276
Do.	XIV-part 4	408
Do.	XIV-parts 1 to 4 (Bound)	420
Do.	XV-part 1	703
Do.	XV-part 2	320
Do.	XV-part 3	322
Do.	XV-part 4	393
Do.	XV-parts 1 to 4 (Bound)	457
Do.	XVI-part 1	Sold out
Do.	XVI-part 2	97
Do.	XVI-part 3	108
Do.	XVI-part 4	146
Do.	XVI-parts 1 to 4 (Bound)	515
Do.	XVII-part 1	47
Do.	XVII-part 2	119
Do.	XVII-part 3	Sold out
Do.	XVII-part 4	153
Do.	XVII-parts 1 to 4 (Bound)	598
Do.	XVIII-part 1	Sold out
Do.	XVIII-part 2	Sold out
Do.	XVIII-part 3	26
Do.	XVIII-part 4	121
Do.	XVIII-parts 1 to 4 (Bound)	88
Do.	XIX-part 1	Sold out
Do.	XIX-part 2	19
Do.	XIX-part 3	Sold out
Do.	XIX-part 4	43
Do.	XIX-parts 1 to 4 (Bound)	606
Do.	XX-part 1	21
Do.	XX-part 2	Sold out
Do.	XX-part 3	41
Do.	XX-part 4	145
Do.	XXI-part 1	176
Do.	XXI-part 2	277

Name of Proceedings	*Volume*	*Balance*
I.R.C. Proceedings	XXI-part 3	275
Do.	XXI-part 4	238
Do.	XXII-part 1	163
Do.	XXII-part 2	154
Do.	XXII-part 3	83
Do.	XX (Bound)	882
Road Research Bulletin No. 1.		84
Road Research Bulletin No. 2.		96
Road Research Bulletin No. 3.		627
Road Research Bulletin No. 4.		641
Nagpur Report		849
Paper on "Water-Bound Macadam"		Sold out
Type Designs for Boundary and Furlong Stones		3490
Route-Marker Signs for National Highways		2830
Dimensions and Weights of Road-Design Vehicles		1283
Type Designs for Highway Milestones		1691
Recommended Practice for the Location and Layout of Roadside Motor-Fuel Filling Stations		249
Standard Specifications and Code of Practice for Road Bridges—Section I—General Features and Design		2370
Paper No. 167—"Design of Small Bridges and Culverts"		Sold out
Lecture on Statistics and Road Research by Prof. K. B. Madhava		16

It is noticed that the demand for the last Part of every Volume is smaller than that for the other Parts. This is so because the last Part does not contain any Papers. The discussions on Papers are printed in the last Part of each Volume and they are as important as the Papers, as they bring out fresh points of view. Steps have to be taken to improve the sale of these issues.

Members who do not possess a complete set of the Journals of the Society will be advised to purchase them before the Volumes in hand are sold out.

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

The Transport-Communications Monthly Review: The Indian Roads Congress is popularising modern ideas on Road Development and Road Engineering for the benefit of Engineers who, owing to their whole-time pre-occupation with official

duties, are not able to keep abreast of the advances in the science of Road Engineering. Original articles on roads and bridges are also being published in the Review.

The members of 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 320 subscribers for this publication.

Complimentary copies of the Review are being issued as usual to important persons and engineering colleges in India. Also complimentary copies of the issue for February 1958 were given to all members of the Indian Roads Congress.

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

9. INFORMATION

Enquiries from members as well as non-members on problems relating to Highway Engineering and allied subjects were attended to. The subjects on which information was sought are given below:

(1) Addresses of tar & bitumen manufacturers
(2) Basis for the formulation of the Nagpur Road Plan
(3) Bridges and cross drainage works
(4) Comparison of loadings for bridges in U.S.A. and India
(5) Diesel and/or steam road rollers
(6) Enquiries about motorable routes
(7) Enquiries about road materials
(8) Figures of road milage, etc.
(9) I.R.C. Standard Specifications and Code of Practice for Road Bridges in India
(10) Lateral distribution of wheel loads on deck slab and girder bridges
(11) Literature on concrete and bitumen roads
(12) Limit of working stresses in bridges
(13) Laying of wearing coat on bridges
(14) Masonry arches for submersible bridges
(15) Road compaction

(16) Roller and rocker bearings
(17) Road signs
(18) Road widths, minimum curvature at junctions, etc.
(19) Siting of motor-fuel filling stations
(20) Specifications for R.C.C. bridges
(21) Specifications for R.C.C. pipes heavy duty
(22) Soil stabilized roads
(23) Specifications for steel bridges
(24) Specifications for the rocker bearing for R.C. bridges
(25) Standards for ruling gradients, formation widths, metalled surface widths, etc.
(26) Specifications for the manhole covers on a bridge designed to class A loading
(27) Steel bearings for bridges
(28) Steel plate slide and fixed bearings
(29) Type designs for highway milestones, furlong and boundary stones
(30) Type designs of unreinforced hingeless masonry arches, Tables and Graphs showing the thickness of abutments, abutment piers and piers on different depths below springing and details of arches for longer spans.

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

98 books were issued on loan during the year under report. This is a very small number considering that the Society has a

membership of nearly 1,700. Members have to be urged to make more use of these libraries. Photostat copies of any article can be supplied on payment.

11. MEDALS AND PRIZES

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

Paper No. 193—"Influence Fields for Finite Concrete Slabs Supported Freely along two Opposite Edges and Free at the other Two" by Messrs K. C. Ray, R. Subramoniam and S. Badaruddin.

The Committee also highly commended Paper No. 191—"Resistance to Abrasion of Concrete Pavements" by P. J. Jagus and M. R. Chatterjee and Paper No. 192—"Design and Construction of Prestressed Concrete Bridge across River Coleroon" by K. K. Nambiar and P. G. Nambiar.

The award was made by the President of India at the Inaugural Ceremony of the Twenty-second Session at New Delhi in January 1958.

12. COLLECTION OF PARTICULARS OF BRIDGES

The Indian Roads Congress have been collecting particulars of bridges of lengths of 100 ft and above for publication in the form of a book. The information collected is under compilation in the Roads Wing of the Ministry of Transport & Communications. As soon as compilation is complete, the question of its publication will be taken up.

13. MEMBERSHIP OF SOCIETIES

(1) The Indian Roads Congress is a member of the Indian National Society of Soil Mechanics and Foundation Engineering. Shri S. R. Mehra is the representative of the Indian Roads Congress.

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

Engineering Division Council. Shri Goverdhan Lal continued to represent the Indian Roads Congress on the Engineering Division Council of the Indian Standards Institution.

The Executive Committee at their meeting held on the 30th November 1957 reviewed the names of the representatives of the Indian Roads Congress on the various Councils and Committees of the Indian Standards Institution and decided to nominate the following for the next three years:

(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:**

— Shri E. P. Nicolaides*

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

Principal representative — Shri D. P. Nayar
Alternate ,, — Shri Kartik Prasad

(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 ommittees 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).

* Since he died fresh representative will be nominated shortly.

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

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

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

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

The following represent the Indian Roads Congress:

Executive Council—President, Indian Roads Congress (Principal Representative)

Shri D. G. Bhagat — (Alternate representative)

Scientific Advisory Committee — Shri Goverdhan Lal

Road Research Committee — Shri J. M. Trehan

14. TECHNICAL ACTIVITIES

(1) Specifications and Standards Committee

The Committee held meetings on the 4th January and the 10th August 1958. The following subjects were discussed:

(i) Design of kilometre stones;

(ii) Layout for fuel filling-cum-service stations;

(iii) Limiting gradients and lengths for cycle tracks;

(iv) Numbering of bridges and culverts;

(v) Standards for roads within urban limits;

(vi) Future programme of the Committee; and

(vii) Metricization in matters concerning road design, etc.

The standard on the design of kilometre stones has since been finalised by the Committee and will be placed before the Council before its publication as the finalised standard of the Indian Road Congress.

The Committee discussed the various difficulties in the layout for fuel filling-cum-service stations and decided that this question should be examined in detail; the oil companies should submit within three months proposals if any, so that these might be kept in view while working out draft standards. Accordingly the oil companies were requested to send in their proposals. These will be examined on receipt and later placed before the Specifications and Standards Committee.

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

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

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

The comments of various Municipalities obtained on the Recommended Practice for the Design and Layout of Cycle Tracks have been passed on to the Committee. The Recommended Practice when finalised will be published by the Indian Roads Congress.

The standard entitled "Numbering of bridges and culverts" as approved by the Committee and later by the Council by correspondence will be published shortly.

As decided by the Committee, the space standards for urban roads framed by the Town Planning Organisation for Greater Delhi have been circulated to the Chief Engineers of States for their comments. After the comments are received the matter will be referred to the Committee to lay down standards for roads within urban limits.

The Committee decided to allot the drafting of standards on some subjects to the existing concerned Committees of the

Indian Roads Congress. For some other subjects on their agenda, they decided to set up subcommittees for drafting standards and codes of practice.

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

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

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

The amendment allowing reasonable relaxation to the Recommended Practice for Location and Layout of Roadside Motor Fuel-Filling Stations was circulated to members of the Council. Certain important suggestions made were discussed by the Council.

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

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

The report on the question of standardising the Affinity Test which had been entrusted to a subcommittee is still awaited.

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

The Council at their meeting held in August 1958 discussed the draft standard form for recording traffic census on non-urban roads. It will be finalised by the Convenor of the

Committee in the light of comments of the members of the Council.

The following subjects are under consideration of the Committee :

(i) Design of road intersections at grade ;

(ii) Specifications for water-bound macadam ;

(iii) Arboriculture ;

(iv) Standard section and profiles of road on curves ;

(v) Concrete pavements ;

(vi) Bituminous pavements ;

(vii) Earthwork for roads ; and

(viii) Base courses.

(2) Bridges Committee

The Committee held meetings on the 6th and 7th January & 10th and 11th August 1958.

Section I of the Bridge Code dealing with General Features of Design was printed last year. The printing of Section II dealing with "Loads and Stresses" recently finalised by the Committee has been taken up.

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

(i) Prestressed Concrete ;

(ii) Steel Structures ;

(iii) Masonry Structures ; and

(iv) Reinforced Cement Concrete.

(3) Test Track Committee

The Committee held its meetings on the 4th January and the 5th December 1958.

The Committee discussed the programme about the laying of the 11th series of tests which relate to bituminous carpet over (a) sand-soil aggregate stabilised base course with and without stone metal grafting, (b) stone metal grafted sand-

moorum stabilized base and (c) sand-soil-cement stabilised base course having stone grafted and water-bound macadam surface.

This series of tests was concluded in November 1958 and in the meeting on the 5th December the Committee reviewed the results of the tests. Conclusions drawn by the Committee are awaited.

Tests on surface dressing laid on the Delhi-Mathura Road near the Central Road Research Institute, Okhla (Delhi), have been under study for about 4½ years. A detailed report presenting the details of various specifications together with their cost analysis and service performance received from C.R.R.I. is under consideration with the Committee.

(4) Research Organization Committee

The Committee held its meeting at New Delhi on the 4th and 5th January 1958 and later on at Bombay on the 11th August 1958.

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

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

On the recommendation of the Research Organization Committee, the Executive Committee, at their meeting on the 14th July 1958, decided that laboratory experiments should be carried out to examine the possibility of using lean concrete mixes in road works, preferably leaner than those so far tried.

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

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

The Government of India have been requested to recommend to State Governments to establish, in the cases of big cities

traffic engineering cells in the engineering set-ups of the concerned Municipalities or Corporations. In the case of other cities, the problems relating to traffic engineering should be referred to the State Chief Engineers for advice. The offices of Chief Engineers should be staffed with suitable specialists in this line.

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

> Various road research laboratories have been requested to carry out research to establish a co-relation between the compressive strength and abrasive resistance of cement concrete.

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

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

The road research laboratories have been advised to send lists of their requirements of labaratory equipment to the Central Road Research Institute who would sort out the equipment not available in India and pass on that list to the Thacker Committee, requesting them to arrange for the manufacture of such equipment in India. The Central Road Research Institute has also been requested to supply the list of research equipment available in India for circulation to all road research laboratories.

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 1958. The annual reports were studied and a general report has been published in Volume XXIII-3 of the I.R.C. Journal for discussion at the Session of the Congress at Hyderabad.

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.

(5) Soil Research Committee

The Committee held meetings on the 4th January and the 11th August 1958.

It was decided that as soon as specifications for stabilising black cotton soil were ready, the Chief Engineers of States should be requested to lay experimental stretches of sufficient length to those specifications.

The 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. The Central Road Research Institute have been requested to chalk out the line of action which will be circulated to various laboratories for research.

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 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 have been addressed accordingly.

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

The Committee decided that the Classification of black cotton soils suggested in Road Research Note No. 6 should be accepted tentatively and that the various road research laboratories should be requested to test this classification in the field and report practical difficulties and suggest modifications, if necessary. In particular, Bombay, Hyderabad and Madras should take up the investigation and correlate black cotton soils with the new sub-groups. The Committee desired that the National Buildings Organization and Central Board of Irrigation and Power should be requested to test the classification from the buildings point of view. The Railway Research Centre at Lucknow should also be requested to test the classification. The question of addressing the various authorities is under consideration.

The Central Road Research Institute has been requested to finalize the specifications for stabilized soil base courses and wearing courses 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 finalized specifications are awaited.

The Committee discussed the question of stabilization of black cotton soils. The Director, Central Road Research Institute, explained that the results of research carried out at his Institute had indicated that the usual 18-in. thickness of the hard road crust in black cotton soil areas could be reduced to a total of 8 to 10 in. if the subgrade soils were stabilized with lime. On account of the economy envisaged it was suggested that the Indian Roads Congress should recommend that field experiments should be carried out. The Director, Central Road Research Institute is being requested to supply the necessary specifications including that of lime for circulation to State P.W.Ds. for field experiments.

The Committee at their meeting held on the 13th May 1957 had noted that there was a feeling that although considerable progress had been made in the knowledge about soils and the possibility of their use in developing low-cost all-weather roads, under suitable conditions, sufficient use was not being made of that knowledge. Certain suggestions were considered. Further action will be taken on receipt of written comments from members.

The Committee had also decided that the State Governments should be requested to exploit the local materials (soil and soft aggregates) to the greatest extent possible and that the Central and State Governments should earmark a certain percentage of

their highway budgets for constructing roads using such local materials. The Executive Committee at their meeting 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.

The Committee discussed a note on "Soil Classifications for India". Members were requested to send in their written comments. It was agreed that the Central Road Research Institute would take into consideration the comments of various members, as well as the work done by the Committee previously, and prepare an authoritative note for circulation to members. The record of the studies made by the Indian Roads Congress on the classification of soils for road purposes had already been passed on to the Central Road Research Institute. The Indian Standards Institution have since forwarded for the comments of the Indian Roads Congress the draft Indian Standard for Classification and Identification of Soils for General Engineering purposes. This will be considered by the Committee in its meeting during this Session.

(6) Education Committee

The Committee held its meeting on the 4th January and 11th August 1958.

Following up the reply from the All-India Council of Technical Education stating that the Universities could not switch over to the Indian Roads Congress Education Committee's syllabus for Highway Engineering taking up 60 hours of study in the Bachelor's Degree Course, an inquiry was made to find out how many hours of study were devoted for this subject at present in the different insitutions. Their replies indicated that 3 out of the 4 institutions have already more than 60 hours' duration for Highway Engineering in the curriculum of their degree course in Civil Engineering. The substitution of the existing syllabi with syllabi prepared by the Committee was, therefore, recommended pointing out advantages of an uniform training method in all the colleges. It was also recommended that the universities which did not have this minimum curricular time for Highway Engineering should reconsider and provide adequate number of hours.

A syllabus in Highway Engineering for inclusion in the diploma courses for overseers and supervisors was being prepared by the Committee.

A syllabus for the M.Sc. degree examination in Highway Engineering at Punjab College of Engineering, Chandigarh, who

have curtailed the period of study from their original plan of 16 months to one year was circulated amongst the members of the committee for comments. This syllabus and the one adopted by the Roorkee University this year, were studied by the Committee at their meeting held on the 4th January 1958 and they expressed their opinion about them.

The views of the Education Committee on the institution of refresher courses at Universities and Colleges were accepted and as decided the authorities concerned have been requested for the starting of similar refresher courses for senior engineers at the Central Road Research Institute.

The Committee had already prepared a draft syllabus for a Refresher Course. It has to be finalised by the Committee.

(7) Provincialization of Local Bodies Engineering Services Committee

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

(8) Manufacture of Road Making Machinery and Mechanization Committee

The Committee held meetings in January 1958 and August 1958.

One of the indigenous manufacturers started production of diesel road rollers in January 1957. The second unit has also started the production a few months back and brought the road rollers in the market sometime past. The third unit is expected to go into production sometime in the beginning of next year. The indigenous manufacturers can increase their production if effective assistance is given by the Government of India in getting them the required quantity of steel and in importing the components for the manufacture of road rollers.

One unit has already started producing stone-breakers in the country. To give protection to this indigenous industry, import of stone-breakers up to the size of 20 in. × 10 in. has been banned.

No difficulty is now being experienced by the indigenous manufacturers of concrete mixers and the industry seems to be going on well.

The question of the manufacture of earth-moving machinery in the country is already being considered by the Committee appointed by the Ministry of Commerce and Industry on which the Ministry of Transport & Communications (Department of Transport—Roads Wing) is represented. It is hoped that necessary action to license manufacturers in this regard will be taken shortly.

At the last Committee meeting, it was decided to examine the possibility for the manufacture in India of motor graders and bitumen distributors. Forecasts of the requirements of these items of machinery are being collected from the State P.W.Ds., etc. The matter will be further considered at the next meeting of the Committee.

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

The Committee has also been entrusted with the compilation of a list of all big and small machinery manufacturers, suppliers and dealers in different parts of India along with their addresses and the types of machinery sold by them. Such a list would be useful source of information to members of the Indian Roads Congress in the course of their work.

(9) Road Transport Operation Cost Committee

The Road Transport Operation Cost Committee which was appointed at the instance of the Government of India to study (i) the cost of operation of motor vehicles on different classes of roads, and (ii) the economy resulting from road improvements, at its meeting held on the 5th January 1958, considered the results of the various experiments carried out by Bombay and Uttar Pradesh State Transport Undertakings according to design and specifications supplied by this Committee. The experiments are being conducted both on katcha and pucca roads. The Committee studied the report on the analysis of the data received so far. The estimates for the cost per vehicle mile on fuel, engine oil, tyres and spare parts were examined. The data revealed some deficiencies in observation and it was decided to evolve a more rational form of co-relating the primary data. In respect of the cost of spare parts it was felt that the data should be collected for a longer period in order to arrive at consistent results. For eliminating variations resulting from the driver characteristics it was decided to engage the drivers on different types of routes by rotation. It was further decided to widen the scope of the study by including hill roads also.

The Committee felt that it was difficult to obtain similar data in respect of earth roads as a long stretch of purely earthen road over which service is being run is not easily available. However, efforts are being made to obtain this data through the co-operation of some of the Transport Undertakings, if possible.

In the meeting of the Committee held on the 11th August 1958 at Bombay, an interim report containing the results of the analysis of the data received till then was considered and the differential response in respect of fuel consumption, tyre costs and spare parts consumption for the different types and conditions of the roads was discussed. Following decisions were arrived at the meeting:

1. Details regarding the different experimental roads like the width of the road, traffic intensity, etc., and the variations in surface of road, if any, should be called for.
2. The level of lubricant oil should, as far as possible, be kept constant for all the vehicles in the experiment.
3. The Uttar Pradesh State Transport Undertaking should be requested for utilising a repaired tyre again on the same road and on the same vehicle.
4. Clarifications should be sought from the Uttar Pradesh State Transport Undertaking as to whether all the spare parts consumed by the different vehicles engaged in the experiment have been listed in the data supplied.
5. The Convenor of the Committee will contact the local members and arrange an inspection of the experiment in progress in Bombay by November 1958.

The Committee's recommedations have been communicated to the Bombay and Uttar Pradesh State Transport Undertakings from whom replies are still awaited.

The State Transport Board, Assam, have been requested to intimate to the Committee their decisions regarding the controlled experiments to be undertaken by them to assess the costs of operation of motor vehicles on different types of hill roads and the Himachal Government Transport Undertaking have also been requested to intimate whether they have already started the experiment.

The Committee have further received daily data for 6 months from Uttar Pradesh and for 3 months from Bombay in addition to the daily data for 27 months from Uttar Pradesh and 16 months from Bombay received earlier. The analysis of the data is in progress.

(10) Cement Concrete Road Surfacing Committee

The Committee held its meetings on the 4th January and the 11th August 1958.

The Committee finalised the answers to the questionnaire issued on cement concrete road surfacing which have since been published in Volume XXIII-part 2 of the Indian Roads Congress Journal.

A subcommittee had been formed to draft a standard form of condition survey of concrete roads. In this connection, the Committee decided that as at present the basis of design of concrete slabs for roads in India was totally inadequate to meet the increased traffic coming on most of the main roads, it was necessary to review the prevailing practices in various countries and modify our practice to present day requirements. To help formulation of such recommendations, it was suggested that Shri C. L. N. Iyengar should prepare a charted summary of concrete road surfaces from various countries and also prepare a note on the basis of design for discussion at the next meeting of the Committee. Further progress in the matter may be awaited.

(11) Road Transport Development Commitee

The Committee held a meeting on the 11th August 1958..

The Committee has stressed the need for implementing the recommendations made by the Committee. The Government of India to whom the recommendations were sent have been reminded in the matter.

Any progress made will be reported to the Committee at its next meeting.

(12) Stabilized Soil Roads Committee

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

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

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

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

The Commitee has to meet again shortly and inspect the stabilized soil roads built in the southern States. Further recommendations of the Committee will thereafter be circulated to the members of the Council.

(13) Community Projects Roads Maintenance Committee

Since the Committee started functioning during this year only, the work mostly comprised collection of information from various States of the prevailing practices. Chief Engineers of States were requested to submit a brief report of the prevailing arrangements in their States. Written reports were received only from the Punjab and the Uttar Pradesh States. At the meeting of the Committee held on the 10th August 1958 at Bombay, however, Chief Engineers of Andhra, Bihar, Madras, Rajasthan and West Bengal States gave imformation about their States which showed that the condition of these roads was not satisfactory and to make this milage of roads a permanent addition to our road system considerable improvement in the standards as well as responsibilities of agencies for execution and maintenance was neccssary. A summary of written views collected from various States was also reported by the representative of the Roads Wing. After a lengthy discussion, it was decided by those present that a report should be prepared by this Committee and brought up for discussion again at a subsequent meeting.

(14) Traffic Engineering Committee

The Committee held meetings on the 4th January and the 10th August 1958.

The priority of various subjects to be taken up by the Committee was fixed as under:

(i) Nomenclature for traffic engineering terms ;

(ii) (a) Traffic marking and markers ; and
(b) Traffic signals ;

(iii) Parking and loading ; and

(iv) Street and highway lighting.

The Committee at its meeting held on the 10th August 1958 discussed a note on item No. (iii).

The Committee also discussed item No (i). It was decided that a complete list of terms should be prepared and circulated for comments to the traffic authorities of big cities having a population of ten lakhs and above.

The Committee thought that it was very essential that a few delegates from India be sent to partake in the International Study Weeks of Traffic Engineering organized in other countries and to include in such delegations representatives of the concerned committees of the Indian Roads Congress as it was felt that the attendance of such Traffic Engineering weeks by delegates from India would give them first-hand information on current traffic engineering practices in other countries with a view to the application of the results to our problems. The recommendation has been forwarded to the Government of India.

A study week on Highway Safety is being organised in Bombay under the auspices of the ECAFE sometime in July 1959. As decided by the Executive Committee, members of the Indian Roads Congress were requested to contribute Papers for this Traffic Study week. Details of this study week have also been published in Indian Roads Congress Journal and Transport-Communications Monthly Review. The Indian Roads Congress will also nominate shortly a few delegates to participate in this traffic study week.

(15) Prevention of Ribbon Development Committee

The Committee considered a note giving the progress made by the various State Governments towards the prevention of ribbon development on roads.

The Committee felt that to stop further deterioration of the existing position, immediate action was necessary to prevent undesirable building activities on road land margins as the

acquisition of the land would not only be difficult but also costly in course of time. As, however, the enactment of necessary legislation and administrative steps for its effective enforcement were likely to take considerable time, the Committee felt that the State Governments should be persuaded to implement the restrictive clauses of the draft model Highway Bill by issue of suitable executive orders similar to those issued by the Government of Bombay.

The Committee held the view that before the issue of executive orders mentioned above, it would be necessary to examine the legal implications of such orders. It was, therefore, decided that the Roads Wing of the Department of Transport, Ministry of Transport & Communications should be requested to consult the Ministry of Law in the matter.

It was suggested that the Highway Bill should provide that the development of villages should be done on Group Development System. The Committee considered the suggestion and expressed the view that it might be difficult to incorporate this idea in the body of the Bill but agreed that it would be desirable to make mention of this suggestion in the preamble of the Highway Bill to be passed by the State Legislatures as a remedy for prevention of ribbon development.

15. MISCELLANEOUS

(1) PAPERS

19 Papers were received during the year, five were already in hand. Out of these 24 Papers, 7 were accepted for publication, 4 were published as articles in T.C.M.R, 5 were rejected, and 8 are under consideration for the next session.

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

The Council should 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) TEST VALUES OF ROAD STONES

The Government of India, Ministry of Transport and Communications, circulated a standard form to all State Public Works Departments to supply data on test values of road aggregates. As a result of this circular, information from many State P. W. Ds. has been received. After the information from all States has been received, it will be compiled and published.

(3) POINTS ARISING OUT OF PRESIDENTIAL ADDRESS—22ND SESSION

The Executive Committee at their meeting held on the 8th March 1958 considered the various suggestions made in the Presidential Address of the 22nd Session and as decided by them various recommendations dealing with the salient features of the All-India Road Development Plan, financing of road development, transport and geometrics have been made to the Government of India.

(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 discussions and written replies were studied by the Central Road Research Institute and a note on the subject has been received. A further note is expected from them. As soon as it is received the subject will be referred to the Specifications and Standards Committee.

LIST OF JOURNALS

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

Minutes of the 54th Council Meeting of the

INDIAN ROADS CONGRESS

held at Hyderabad on the 11th January 1959

The Council met with Shri W. X. Mascarenhas in the Chair.

Present

G. D. Agarwal	M. Meeran
F. P. Antia, Dr.	S. R. Mehra
M. P. Apte	J. Mukand
K. Barua	K. K. Nambiar
D. G. Bhagat	L. R. Patel
V. R. Bhatnagar	B. Prasad
U. J. Bhatt	R. C. Roy
T. S. Chathunny	H. R. Sayoji Rao
Y. K. Chaugule	P. D. Shivdasani
N. Durrani	H. P. Sinha
K. V. Ekambaram	S. N. Sinha
G. S. Ganapathy	P. N. Srivastava
H. K. Gandotra	D. C. Sharma
S. K. Ghosh	H. L. Uppal, Dr.
B. S. Jootla	V. R. Vaish

A. J. D' Costa—Secretary.

The following co-opted members attended:

K. F. Antia	Goverdhan Lal
J. K. Bannerjee	G. C. Khanna
N. D. Daftary	E. A. Nadirshah
R. N. Dogra	Sujan Singh

The following attended by invitation:

R. S. Bhalla	J. M. Trehan
Hardyal	M. P. Nagarsheth
G. R. Nangea	Y. Padmanabham

R. K. N. Iyengar, Dr.

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 53rd Council Meeting.

The Minutes of the 53rd Council Meeting held at Hyderabad on the 6th January 1959 were confirmed.

3. Office Bearers.

The following were elected to hold office till the next election.

President	— U. J. Bhatt
Vice-Presidents	— B. Prasad N. Durrani L. R. Patel
Honorary Secretary	A. J. D'Costa

At this stage, the newly elected President, Shri U. J. Bhatt took the Chair and a vote of thanks for the outgoing President for the excellent work done by him was passed with acclamation. The Council also recorded a hearty vote of thanks to the Executive Committee.

4. Venue of the next Session.

Two invitations were received for holding the next Session of the Indian Roads Congress, viz., one from the Government of Mysore and the other from the Government of Madhya Pradesh.

The Council decided to accept the invitation of the Government of Mysore to hold the Twenty-fourth Session at Bangalore in early 1960. The date and programme will be finalized by the Executive Committee in consultation with the Chief Engineer, Mysore.

The Council thanked the Government of Madhya Pradesh and expressed hope that their kind invitation would be availed of sometime later.

As the Society would be completing 25 years of its existence in December 1959, the Council expressed the view that the Executive Committee should examine whether the Silver Jubilee should be celebrated in 1960 or in 1961 to synchronise with the Twenty-fifth Session of the Congress.

5. Committees.

The Convenors of the Committees were appointed as under:

(1)	Specifications and Standards Committee	Govardhan Lal
(2)	Bridges Committee	S. L. Bazaz
(3)	Test Track Committee	R. C Roy.
(4)	Research Organization Committee	H. P. Sinha
(5)	Soil Research Committee	Director, CRRI.
(6)	Education Committee	E. A. Nadirshah

(7)	Provincialization of Local Bodies Engineering Services Committee	Fateh Chand
(8)	Papers Committee	H. P. Sinha
(9)	Manufacture of Road Making Machinery & Mechanization Committee	R. S. Bhalla
(10)	Organization Committee	H. P. Sinha
(11)	Road Operation Cost Committee	N. D. Daftary
(12)	Local Committee of the Test Track Committee to supervise Delhi-Mathura Road Tests	Director, CRRI.
(13)	Cement Concrete Road Surfacing Committee	E. A. Nadirshah
(14)	Road Transport Development Committee	Dr. F. P. Antia
(15)	Traffic Engineering Committee	D. G. Bhagat
(16)	Prevention of Ribbon Development Committee	H. P. Sinha
(17)	Community Projects Road Maintenance Committee	K. K. Nambiar
(18)	Stabilised Soil Roads Committee	M. S. Bisht

The Council also appointed Shri Shoba Ram as Deputy Convenor of the Provincialization of Local Bodies Engineering Services Committee.

6. Budget.

The budget estimate for 1958-59 was approved.

7. Issuing of up-to-date Road maps.

Dr. F. P. Antia raised the question of issuing up-to-date road maps of India. He suggested that the Roads Wing should be requested to arrange to issue a road map every year. In order to make the map more useful, he suggested that it should include railway lines as well as inland waterways. The Consulting Engineer (Road Development) agreed with the views expressed by Dr. Antia in regard to the need for up-to-date road maps. He then explained that this matter had been taken up by the Roads Wing with the Survey of India. The issue of such maps was a very elaborate process as data had to be collected from hundreds of road engineers all over the country. To expedite matters it had been arranged that the Executive Engineers should furnish the data direct to the Survey of India each year. In this connection Shri S. R. Mehra suggested that perhaps it would be better

if every Chief Engineer were to collect the information from his Executive Engineers and pass it on to the Roads Wing, who, in turn, could pass on the same to the Survey of India.

After general discussion, the Council expressed the view that as it was very desirable and essential that road maps of this country were kept up-to-date, the Survey of India should be requested to arrange the printing of such maps at least every three years. Further, it was suggested that all the State P.W.Ds. should also print periodically the road maps of the respective States showing more details. It was also suggested that in order to make the road maps more informative, the railways and inland waterways should be shown, as far as possible, on the road maps.

8. Miscellaneous

(1) Award of Medals.

Shri Shivdasani suggested that each of the Authors of a Paper selected for the award of medal should be given a medal. He did not consider the present practice of issuing only one medal to a Paper irrespective of the number of Authors as very encouraging because normally the medal can be retained only by one Author. Dr. F. P. Antia supported this view. The President then explained that this matter had already been considered in detail by the 42nd Council meeting held on 4th February 1954 where it was decided that only one medal should be awarded for a Paper irrespective of the number of Authors. However, the members of the Council expressed the view that as the medal did not cost much, the matter should be re-examined by the Executive Committee after finding out the practices followed by other institutions in such matters.

(2) Copies of Second Road Development Plan.

The Council desired that the Consulting Engineer to the Government of India (Road Development) should be requested to supply copies of the All-India Road Development Plan for distribution to members of the Council. The Consulting Engineer (Road Development) explained that he would place the request before the Government and after it is accepted, copies of the Plan would be supplied for distribution to the members of the Council.

(3) Traffic Study Week.

The Council selected the following members to represent the Indian Roads Congress at the Traffic Study Week to be held at Bombay in July 1959 under the auspices of E.C.A.F.E.

(1) D. G. Bhagat
(2) N. D. Daftary
(3) S. N. Gupta
(4) C. L. N. Iyengar
(5) W. X. Mascarenhas
(6) K. K. Nambiar
(7) Dr. R. K. N. Iyengar

(4) International Road Congress.

Shri Sujan Singh pointed out that it was desirable that selection of delegates to the next International Road Congress at Rio de Janeiro is made as early as possible as delegates should have sufficient time to prepare for the Conference.

While considering the composition of India's delegations to International Conferences it was stressed that all such delegations should have a representative character. It was decided that the Executive Committee should suggest the names of delegates for the next International Conference for communicating to the Government of India.

Further, it was suggested that the Government of India should be requested to repeat their invitation to the International Road Congress to hold their Twelfth International Congress in this country.

(5) Bridge—Code Section II.

The Council placed on record their thanks to the Bridges Committee for finalizing Section II of the Standard Specifications and Code of Practice for Road Bridges in India.

(6) Provincialization of Local Bodies Engineering Services.

Shri Y. K. Chougule enquired about the progress made about the provincialization of local bodies engineering services. The Consulting Engineer (Road Development) explained that the Special Officer appointed by the Government of India to study rural communications had already submitted his report in which he had recommended the provincialization of local bodies engineering services. The report is under examination with the Government. The Council desired that the Government of India should be requested to expedite the implementation of the recommendations contained in the report.

The meeting then ended with a vote of thanks to the Chair.

TOUR NOTES

23rd SESSION HYDERABAD, JANUARY 1959

NAGARJUNASAGAR DAM PROJECT

The Nagarjunasagar Project was commenced during 1955-56 as a joint scheme of the Andhra and Hyderabad States for the utilisation of the available water of the Krishna river in the lower Krishna basin. In this basin, there are wide areas where the rain-fall is precarious, erratic and flashy. Within this catchment lies a large extent of scarcity affected area than could be found in any other river basin in India. The Krishna basin lies chiefly under the influence of the South-west monsoon and it brings as much as a million cusecs of water from June to October—the maximum discharge is twice as much as that of the Nile or the Cauvery. This is a typical Deccan river and in the summer, it dwindles down sometimes to 100 cusecs. The annual dependable flow at Vijayawada is approximately 1715 T. M.Cft., of which the existing utilisation is about 27 per cent. Works to utilise another 18 per cent are under construction in the States of Bombay, Mysore and Andhra Pradesh. The balance flow of the river has been allotted to the various States at the inter-State conference convened by the Planning Commission in 1951. The Nagarjunasagar Project will ultimately utilise about 464 T. M. Cft., to irrigate the arid lands of Guntur, Kurnool and Nellore districts on the right side and Nalgonda, Khammam, Krishna and west Godavari districts on the left side. The project under construction will utilise 306 T. M. Cft., and serve Palnad, Sattanapalli., Vinukonda, Narasaraopet, Guntur, Bapatla and Ongole taluks (Guntur district) and Markapur taluk (Kurnool district) under the right Canal and Miryalaguda and Huzurnagar taluks (Nalgonda district), Khammam taluk (Khammam district) and Nandigama taluk (Krishna district under the left Canal).

The Project under construction envisages the construction of a masonry dam near Nandikonda village, 290 ft high (Spillway) above foundation level upto F.R.L.-520, with 5 ft, falling shutters and two canals, 135 miles and 108 miles long on the right and left side of the river, to irrigate 20.6 lakh acres, including 1.5 lakh acres of 1st crop and 1.5 lakh acres 2nd crop under the Krishna delta. The dam will be of the masonry gravity type. In the centre of the river will be located the masonry spillway, 1880 ft long at F.R.L.-520, with 5 ft falling shutters for discharging the floods. The non-spillway and power dam blocks will be raised to an Elevation of-360. On the left side, in the non overflow section, the dam is provided with 8 penstocks of 14 ft diameter to enable generation of firm and secondary power totalling to 300,000 K. W. Of this, firm power at 60 per cent load factor will be 167,000 K.W. Two penstock openings of 25 ft dia-

meter are also left on the right flank non-overflow section at the head of the right bank irrigation canal, to enable installation of two units of 30,000 K.W. each, to generate another block of seasonal power of 60,000 K.W. The detailed design features of the dam are being worked out in consultation with the C. W. & P. C.

The dam involves 185. 24 M. Cft. of concrete and masonry. The work itself is a straight one and the site is one of the most favourable ones that are met with. The basic problem is not so much one of design or construction as of organisation, to develop and handle economically and speedily the huge quantities of materials involved and exercise adequate quality control over construction. To this end, the construction programme has been phased over three periods. In the first 3 years, the dam will be constructed to a level of R.L. 300 to 350, in the bulkhead and—260 to —270 in the spillway section. This will involve about 61 M. Cft. or about one-third of the work. In the second period commencing from the 4th year to the sixth, the dam level will be raised to 520. The amount of masonry and concerte involved will be another 124 M.Cft. in this period. The work in this period will have to be done by using the trestle bridge. In the final year, viz., the 7th the dam will be completed to its designed level.

The reservoir formed by the dam under construction will be well contained within the gorge and will spread over 110 sq. miles. The storage capacity of the reservoir at F.R.L. will be 9.30 M.A.ft., with a live storage of 1.5 M.A.ft. The cost of the dam including the cost of penstocks for the hydro-electric scheme, is estimated to be Rs 86.57 crores.

Salient Features

Dam	
Masonry dam length	3900 feet.
Earth dam (left side) length	7960 feet.
Earth dam (right side) length	3220 feet.
Masonry dam height	367 feet.
Gross storage capacity	9.30 M.A. cft.
Utilisation of water	5.39 M.A. cft.
Reservoir area	110 sq. miles.
Canals	
Right canal	Left canal.
Length 135 miles	108 miles.
Discharge 11000 cusecs	11000 cusecs lined. 8000 cusecs unlined.
Bed width 250 ft	99 ft

Velocity	6 ft, per sec. lined 3.5 ft per sec. unlined	6 ft per sec. lined. 4.81 ft per sec. unlined.
Ayacut	9.7 lakhs acres	6.7 lakhs acres.
	1st crop	1st crop. 1.2 lakh acres 2nd crop.
	Krishna Detala	1.5 lakh acres 1st crop. 1.5 lakh acres 2nd crop.
Cost	Rs 29.33 crores	Rs 23.40 crores.

Total cost of Project: Rs 86.57 crores.

Total area benifitted by project 20.6 lakh acres.

PROGRESS

Dam:

Coffer dam completed 3000 ft long.

Bridge across the Krishna completed.

11 mile railway line from Macherla completed.

Access roads laid (total length 75 miles).

Water supply, medical, public health and labour amenities provided.

High school, hospital, hostel and main offices completed.

Electric installation completed and power from Machkund now being used.

Post, telegraph, telephone and banking facilities proivded.

Residential accommodation 1330 buildings completed and 25 buildings under progress.

Excavation of foundations in 2/3rd. river-width completed.

Right canal:

Entire length of main canal investigated and alignment finalised upto M. 52.

Canal excavation work in progress in miles 0/0 to 28/0.

Area block-levelled: 37.27 lakh acres.

Left canal:

Entire length of main canal investigated and alignment finalised upto M. 35

Canal excavation work in progress in miles 6, 7, 9, 10, 13, 15, 16 and from 19-25

Area block-levelled: 5,71,137 acres.

Expenditure on project to end of October, 1958: Rs 16 crores.

Construction programme as envisaged in project estimate

DAM

Year		Overflow section	Left non-overflow	Right non-overflow
1957-58	...	+244	+299	+302.5
1958-59	...	+274	+315	+312.5
1959-60	...	+315	+360	+360
1960-61	...	+375	+415	+415
1961-62	...	+430	+520	+420
1962-63	...	+520	+560	+560

CANALS

Both canals are programmed for completion by 1963-64.

Nagarjuna Konda, Relics

Extensive excavation are being carried out by the Archaeological Department near the dam site to salvage the Relics of a Budhist City stated to have been founded by Nagarjuna budhist some 2200 years ago. The excavations are still in progress and a Chapter of the forgotten glory of the old days is unfolding.

The area is going to be submerged when the Nagarjunasagar Dam is completed. These relics will be arranged on the top of the hill in a museum and preserved.

The remnants of Aswamedha Yaga—skeleton of the horse used—are still found and the drainage system is also clearly seen. How the city came to be lost is still a speculation.

Nawab Salar Jung's Palace and Art Museum: On Pathergatti street, containing the best one Man's collection in the East is now a " must " for all visitors to the city. There is an entrance fee for it of Re. 1 and Re. 0-8-0 extra for the jewellry room.

Hussain Sagar: This has a circumference of 11 miles and was built during Qutub Shahi times. Its one mile long bund carries a fine cement concrete road. The tank is used for yachting and as an evening resort for the citizens.

Discussion on Paper No. 206 *

" Construction of An R. C. Cantilever Hollow Girder Bridge over Betwa River At Jhanjhat "

By

P. N. SRIVASTAVA

Wednesday, January 7th 1959.

Shri R. C. Roy (Chairman), introduced Shri P. N. Srivastava and called upon him to introduce his Paper.

Shri P. N. Srivastava in his introductory remarks explained the main difficulties encountered in the construction of this bridge. Referring to the serious problem relating to the construction of foundations, he stated that there was only a very limited working period due to impounding of about 20 ft depth of water by the dam on the downstream side of the bridge site. A time schedule was, therefore, prepared according to which in the month of January, when the reservoir got empty, the foundation work was started. Firm rock foundation was not encountered for six piers and, therefore, they had to go a few feet deeper into the rock than originally contemplated. As given in para 4.2, page 69 of the Paper, in the case of pier No. 30 the foundation had to be stepped and extra bond rods in the rock and concrete as well as a few re-inforcement rods across the plane of differential foundations had to be provided. The progress of work was so regulated that the piers built were higher than the full supply level of the reservoir and work continued throughout by bringing the materials by row boats to the piers.

The second serious difficulty was about centring, It was decided to use lattice girders for centring. There were three continuous span with two cantilevers on either side which formed one unit. Three sets of centring consisting of welded girders had to be manufactured for continuing the work of superstructure. The weight of each girder was about $1\frac{3}{4}$ tons and it was a problem to erect them. Therefore, cranes fixed on big boats were arranged. The other problem regarding the centring was how to fix the girders between the piers and for that brackets were bolted to the piers to support three girders as shown in Photograph No. 8 in the Paper. Another problem was the removal of the centring after the deck was laid. That could not be done

* Published at page 64 to 115 of Volume XXIII-Part 1 of the Journal of the I. R. C., November 1958.

without any means to lower the trusses bodily clear off the soffit of slabs. That was achieved by introducing sand jacks placed over the brackets under the trusses. As soon as the plunger was removed, the trusses got lowered and they were easily removed from underneath the structure. After removal they were shifted to the next set of spans.

The third problem during the construction was the shuttering and the pouring of concrete in the box girders. After a lot of discussion a pouring chart was devised as given on page 78, and the various operations of laying the soffit-slabs beams, etc., are given on pages 76 and 77 of the Paper.

The question of removal of shuttering from underneath the main slab was a tedious job. A passage was left under the soffit slab at the end of the cantilevers in each box girder which meant that the shuttering had to be dragged through half the length of the continuous beams of three spans and two cantilevers, i.e., about 100 ft. Some difficulties were anticipated in removal of the shuttering underneath the top slab but this was overcome after one or two sets were removed. The whole measuring 4 ft × 2 ft under the soffit slab was closed by movable steel sheets after the construction.

Construction of approaches was also a difficult job and had to be completed along with the bridge. The earthwork on Jhansi side had to be done by manual labour and donkeys whereas the earthwork on Jhararghat side, where the soil was clay, was done by machinery.

The web of the girder was only 9 in. thick. There was difference of opinion whether this was feasible for putting in re-inforcement etc. During pouring special care was taken to see that the concrete was properly vibrated throughout the depth of the web to ensure homogeneous mass. He personally felt that there was no danger in having a thin 9 in. web provided care was taken during construction. Similarly at articulation points in the design a lot of steel was placed. Difficulties were experienced due to many steel bars coming up at one place. Special care was taken during construction to encase all the bars completely in the concrete to produce the requisite bond.

Shri S. K. Ghosh pointed out the following errors and omissions in the Paper, some of which were probably due to printing.

Page 91 (*Design of Articulation*)

(i) There was reference to moment at 'A' but the connected diagram did not indicate the position of 'A'.

(ii) "Width of beams" probably referred to the total width of the 3 ribs taken together. It was mentioned at bottom of page 71 that the general width of each rib was increased from 9 in. to 12 in. near the articulation. In that case, the total width should be 3 in. × 12 in. or 36 inches.

(iii) The meaning of the next line "Therefore D = 26.3 in." was not clear. He wanted to know the significance of the word 'Therefore' and what was referred to as 'D'?

(iv) "All included" (a few lines below) was probably a printing mistake for 'inclined'.

Page 91 (*Design of Cross-beams*).—D.L.M. at mid-support had been printed as plus; evidently this would be minus.

Pages 93, 94 & 95

(1) In the Tables the unit for moments had not been indicated; presumably this was "Ft-Kips".

(2) In the last Table on page 94—last two columns, probably "Ft" was a mistake for 'Nos.' and 'In.' for "Dia. of bars in inches."

In Shri Ghosh's view the very title of the Paper appeared to be a misnomer as from the subsequent description of the bridge it was apparent that the bridge was not what was usually meant by a Cantilever Bridge. It was a continuous span bridge. The fact that cantilevers with suspended spans had been incorporated at some intervals for limiting the effects of temperature variations did not change the main type of the structure.

He further pointed out that on page 66, para 1.2, it was mentioned that right upto January the causeway remained submerged, while on page 77, para 9.2, there was reference to the river bed being *dry*. In Bengal, the water level in rivers was generally very low during January but the conditions were probably different in U.P. In order to increase the utility of the Paper it would have been better, he stated, if the local conditions as regards the seasons and the water level variations, etc., had been given in more detail.

It had been mentioned in para 2.2 that the bed of the river consisted of rock and open foundations were possible. The conditions appeared to be ideally suited for the adoption of an R.C. rigid frame bridge with slender R.C. piers and R.C. slab superstructure (i.e., a sheet slab without beams). Again there

was mention on the same page that the hollow-box type design was found to be more economical than the ordinary T-beam construction but he wondered whether the slab-type rigid frame or other possible types had been given due consideration. The hollow box-type girder had three main advantages, viz.,

(1) distributes the load practically eqally on all the ribs;

(2) provides a compression flange for heavy negative moments;

(3) provides more space for conveniently accommodating the main steel reinforcement.

In small spans, advantages Nos. 2 and 3 were of little importance as the ribs of T- beams provided from other considerations were generally sufficient for these purposes. In spans of medium lengths (say 90 to 100 ft) it might sometimes be necessary to provide a small flange. The advantages of a box-girder were really effective when dealing with spans much larger than the one under discussion. He, therefore, very much doubted the soundness of the categorical statement in para 7.1 on page 1 that the design adopted worked out to be the most economical. The economy was likely to vary from place to place depending upon several factors such as cost of the different materials, labour, etc. He did not like to be presumptuous but from his experience he was almost sure that the rigid frame bridge would have been more economical, if not the most economical, in that particular case. Apart from anything else, that would have (a) obviated the necessity of the use of steel rocker and roller bearings which were very expensive and difficult to get these days, (b) for the same effective waterway the length of the bridge could have been reduced on account of the slender piers, and, incidentally, (c) the cost of the approaches also would have been less as the formation level could have been lowered on account of the smaller depth of the slab superstructure.

Referring to the special arrangement given in para 4.2 for the foundation of pier No. 30 where rock was found for only half the length of the pier, he presumed that the other half had to be founded on ordinary soil and, in order to guard against any possible complication due to unequal settlement along the length of the pier, dowel bars were put in to anchor the foundation to the rock in the portion where rock was available. If there was any unequal settlement, these dowel bars would be in tension and bond length of 1 ft only would be too inadequate to develop the full tensile stress of $\frac{3}{4}$ in. dia. bars. The anchorage should have gone much deeper.

Incidentally, the mention of the dowel bars for this particular pier gave the impression that such dowel bars were not used in the other foundations. It would perhaps be better to anchor such foundations to the rock, as a general rule, in all cases where such a rock was available near the bed level.

If the cost of the steel bearings and that of the whole superstructure had been given this would have given an idea of the cost of steel bearings against the total cost of the superstructure. In many bridges in West Bengal, R. C. bearings had been very economically adopted for spans much larger than that of the bridge under discussion.

Regarding the statement in para 7.3 that even the simply supported suspended spans were of box-girder construction, he felt that in that case the soffit slab did not function as a compression member and its main utility was, therefore, inoperative. On the other hand, that added to the dead weight, thereby increasing the moments. Had it been provided for architectural considerations only (i.e., to give the idea of a flat sheet arch), the thickness thereof could have been reduced.

Referring to the same para about articulation and the design data given on page 91 along with a sketch, he stated that the arrangement of the reinforcement at the ends of suspended spans given therein was quite alright. But examination of the arrangement of the articulation at the cantilever and in regard to the reinforcement of the midspan, given in Plate III, did not show any vertical bars in the top half of the articulation. He was not sure if the work was done as per this drawing or there was any subsequent modification. There was no reason, he stated why these bars were provided at the ends of the suspended spans but omitted at the cantilever ends. Those bars were very important and the omission thereof left a possibility of a horizontal crack developing tending to separate the lower portion from the top. It had been rightly stressed by the Author that the design of the articulation required very careful scrutiny and meticulous care in detailing. Any defect was likely to cause serious trouble, and the Paper by Dr. M. A. Korni—'Healing of Cracks in Reinforced Concrete' discussed at the Ranchi Session of the Indian Roads Congress, was an example of such a failure at the articulation. Unfortunately, Shri Ghosh had not yet come across any book of reference which gave the design of such articulations in full details, but suggested as a guide, the Paper of Mr. John Chambers, 'Design and Construction of the Purnabhava Bridge,' published in Vol. X-1 of the I.R.C. Journal, where full design and detailing of the reinforcement of such an articulation was available.

In para 9.2 it was mentioned that the concrete was vibrated and that the slump adopted was 3 in. to 4 in. This slump appeared to be too high for vibration and was likely to cause segregation.

The design of the deck slab showed the theoretical requirement of steel per foot strip as 0.56 sq. in. for the cantilever slab (vide page 87 bottom) and 0.665 sq. in. for the deck slab in the transverse direction (vide page 88 a few lines from the bottom). Against those, the steel provided in both these cases was 5/8 in. dia. bars at 4½ in. centres which worked out to about 0.81 sq. in. per footstrip. From practical considerations it might be necessary to provide the same steel in both the cases but even then providing 0.81 sq. in. against the theoretical requirement of 0.665 sq. in. would appear too much.

In the 'Note' near the middle of page 89, the Author had mentioned that for calculating shear, no correction had been made for haunches as the slope in haunches was nominal. He felt that the presumption ignoring the effects of the varying depths of the ribs was not very logical. The slope was not so small, specially near the pier-supports. In a joint Paper by Mr. John Chambers and the speaker, "Shear reinforcement in R. C. beams with special reference to beams of varying depths", published in the Indian Concrete Journal, July and August 1942, that aspect had been dealt in great detail and a practical example had also been worked out of a balanced cantilever bridge beam and comparison made of the results: (a) ignoring the haunch correction, (b) applying the haunch correction by an approximate method commonly adopted by German authorities, and (c) the theoretically accurate method by applying the shear correction in the influence lines themselves. A comparison of the results given therein would at once show the importance of this haunch correction. There might not be much difference in the *total area* of the shear stress diagram but there was a considerable change in the *shape* of the diagram with consequential change in the positions of the shear reinforcement.

On pages 91 and 92 the Author had dealt with the design of the cross-beams and of the stiffeners separately. From the drawing it appared that the member was a cross-beam-cum-stiffener and acted as one. It extended throughout the full depth of the longitudinal ribs but there was an opening near the middle evidently for constructional facility of removing the shuttering of the compartments. The hole could not perhaps be taken to have functionally split up the member into two distinct parts, the top part to act as a pure cross beam and the bottom portion as a pure stiffener. He wanted the Author to throw more light on that point.

In the 'Note' at the middle of page 94, it had been mentioned that in combining dead and live load moments of opposite signs, *half only* of the dead load effect had been added to the live load effect. He did not know if that method had been advocated in the reference books quoted by the Author or if that was the idea of the Author himself to ensure additional factor of safety. In any case, he failed to see the justification of that principle. The dead load was always there and he could not follow the logic of ignoring the dead load by as much as half simply because it had a reducing effect on the total moment. It was also not clear if the effect of the variation of moment of inertia in the continuous spans was taken into consideration in calculating the values of the bending moments.

From page 71 and also page 95 it appeared that in some cases 2-legged stirrups of 3/4 in. diameter were used. The diameter appeared to be too large for use as stirrups as it was very difficult to provide the sharp bends required in these large diameter bars where the stirrups turned round the main bars. He had not come across any previous case where bars of such a big dia. had been used for stirrups. He had never used stirrups of diameter greater than ½ in. Where necessary the spacing had been reduced and the number of legs of each stirrup had been increased to 4 or more. He would like to know if the Author experienced any difficulty in using 3/4 in. dia. stirrups.

Shri J. S. Gupta wanted to know as to why in view of the excessive cost of cast steel, limited facilities for casting, and acute shortage of steel, R. C. C. bearings were not considered. They had been used in the past; moreover, even if steel bearings were to be used, why forged or fabricated steel bearings were not considered. Those would have been considerably cheaper than cast steel bearings and facilities for their manufacture would also have been more readily available.

It was not very common to have bridge girders continuous over 3 spans in this country. The Author had stated that the chief consideration in adopting continuous beam designs, was that the foundation were resting on firm rock. He wished to suggest that construction of continuous beam of slab superstructures for bridges not founded on firm rock particularly for short spans might also be considered which could lead to great economies. Perhaps undue importance was given to the settlement of foundations. It would be interesting to know as to how many bridges constructed in the past had been known to have settled. Moreover, he felt, that it should not be difficult to provide arrangements to raise the decking in continuous superstructures for small spans at a later stage, if necessary, presuming of course that the usual reinforcement provided over the

supports in a continuous superstructure would be adequate to take up any redistribution of stresses that might take place due to settlement of piers.

Shri S. G. Athavale said that as good rock was easily met within the river bed, one would have expected an arch type bridge to suit ideally the site. The arches would have reduced the use of steel which was so scarce and would have provided a solid structure at a place where one was not sure about the high flood level of the river. He requested the Author to explain why an arch bridge was not considered suitable and economical.

Being interested in relative economy of various types of structures, the following quantities of concrete, steel and bearings had been roughly worked out and compared with the hollow type box structure constructed. Only the quantities for deck and pier caps had been shown in the Table, the masonry quantity was almost the same for all the types of structures.

Item	Hollow box-girder.	Simply supported T-beam & Slab.	60 ft span arch type bridge.	Approximate Rate. Rs
C. C. 1 : 2 : 4 mix	96,000 cu. ft.	1,06,000 cu. ft.	1,25,000 cu. ft.	5 per cu. ft.
M. S. reinforcement	620 tons	534 tons	288 tons	1,000 per ton.
Bearings	65 tons cast steel	6 tons M.S. bed plates	Nil	2,500 per ton,
Head wall masonry & moorum filling	—	—	54,000 cu. ft. masonry 2,00,000 cu. ft. filling	150 per 100 cu. ft. 10 per 100 cu. ft.
Cost	12,62,000	10,90,000	10,13,000	

The above Table indicated that the arch type bridge would have been the most economical and would have saved about 330 tons of mild steel and 65 tons of cast steel.

Shri M. P. Apte said that in para 3.1 it was stated that for a discharge of 5,70,000 cusecs, the required waterway worked out to 1,850 rft. It was not understood which formulae had been

adopted for this calculation. The minimum waterway required as per I.R.C. Code worked out to 1,887 feet according to his calculations.

The design adopted for the superstructure of the bridge was a hollow box girder continuous over three spans and with two cantilevers of 12 ft on either side. In view of the solid nature of foundations, other cheaper designs were possible. However, even assuming that hollow box girder had to be adopted, the economy made by having cantilevers of 12 ft was not understood. The shuttering for the hollow box girder and for articulations was very expensive. The purpose of cantilevers could have been served if out of the three continuous spans, the central span would have been a little bigger than the two end spans (for example say 62 ft, 84 ft and 62 ft instead of three spans of 66 ft 8 in.)

One peculiar feature of the design of continuous concrete beams which required special attention was that the support section was simultaneously subjected to maximum bending moment and maximum shear. The present R. C. Codes did not make any provision against heavy cracking at this section due to high principal tension developed in the top region. There appeared to be no provision made for this in the design of this bridge. He learnt that the Indian Standards Institution was collecting information on this point to make some provision on this account in their next edition of the R.C. Code. He wished the Bridges Committee of the I.R.C. had also given some special consideration to this feature of continuous beams.

In para 4.1 the Author had described how the actual foundation had to be taken deeper than expected because surface rock was not dependable. That, however, was not an unusual experience. He knew the case of 'Indrayani Bridge' which was designed to be founded about 3 feet in bed rock. It was actually found that at a depth of about 7 to 8 feet in bed rock, there was a thick layer of volcanic ash i.e. 'Geroo' and the actual foundation was taken 22 feet below the river bed rock level.

In para 5, some new practices adopted in pier masonry had been described. It would have been interesting if some more details of masonry work, such as specifications for face work and hearting and thickness of joints, etc. were given. Whereas a horizontal layer of concrete had been provided at every five feet because long header stones were not available, no mention was made about any provision made in lieu of vertical headers. In his opinion, the raised pointing as adopted in this bridge, con-

cealed the defects in the dressing of face stones and the thickness of joints. He believed the raised pointing must have been done much later than the actual masonry. The usual pointing done immediately after the day's courses of masonry were completed would add to the strength of masonry.

The principal deterrant against the use of masonry for high piers was the Bridge Code requirement regarding longitudinal force. Rough calculations led to the conclusion that the masonry piers under the fixed bearings of this bridge could not stand the heavy longitudinal force specified in the Code.

In para 6.2, under the details of bearings, it was stated that the maximum variation in the size of beam of 2.5 inches was calculated to be adequate for the entire expansion of the three continuous spans. Though there was no objection to design the bearings for larger play, it was not understood why the entire expansion of three spans had to be taken into account. As the fixed bearing was located on one of the intermediate piers, the maximum expansion had to be calculated for only two spans and the cantilever.

It was not clearly understood why the live load bending moment of 78,080 in lb for class AA loading calculated on page 88 was later ignored. Experience had shown that the use of Pigeaud's theory in such designs sometimes led to absurd results.

The reinforcement calculated for the cross griders and slab appeared to be rather heavy. Economy in steel would have been possible in both the cross girders and the slab if the cross girders were treated as mere diaphragm walls provided for the purpose of stiffening, with a little gap under the slab, and if the slab was designed as spanning across the main beams in one direction only.

The details of the centring truss given in Plate VI were indeed very instructive. He enquired whether the knee struts were provided as a later thought after the design for the truss was prepared. The provision of the knee strut makes the truss statically indeterminate. He also wanted to know whether the truss was regularly analysed as an indeterminate truss to satisfy the condition that the masonry end of the knee strut suffered no deflection. Such analyses many times converted some tensile members of the original truss into compression members which had to be carefully designed against buckling. The provision of wind bracing helped to restrain the top compression chord of the truss from buckling. In some cases, the shrinkage of concrete gave rise to horizontal forces on the top of props and had to be accounted for.

The practice of shuttering adopted for the superstructure, as described in para 8.4, appeared to be rather crude. After concreting of the soffit slab and the beams, ten days were required to erect the shuttering of the top slab. That was too much. He remembered that in the case of 'Dhansari Bridge' in Assam, the design of the shuttering was so ingenious that the centring of the top slab could be fitted within twelve hours of the concreting of the soffit slab.

The clear width of this bridge, as mentioned in para 9.4 was only 22 feet. When the work was started in 1955, he felt that the width of the bridge should have been 24 feet as per I.R.C. Code.

The construction joints in the wearing coat had been provided at distances of 32 feet as mentioned in para 9.4. It was better to locate those joints on the supports and the points of contraflexure in the case of a continuous beam with cantilevers. However, if that was not followed, at least the joints could have been placed at distance of 33 feet 4 inches instead of 32 feet because the spans of the bridge were 66 feet 8 inches each.

Appendix 6 on page 101 mentioned that the densest mix was sample 4. He could not understand its reason. According to the principle of proper gradation as well as the density, sample number 2 having a weight of 11 lb 10 oz, was in his opinion, the best.

Shri R. N. Joshi pointed out that it was not understood how the dowel bars could prevent the settlement of foundation. For, in case of any settlement of foundation the latter would remain hanging from the structure. Dowels could only serve against shear and in some cases against bending but not against settlement.

In the masonry of piers and abutments, where it was difficult or costly to secure long headers, he suggested the use of cement concrete in situ headers from one face to another by doing masonry first and leaving a gap for 'concrete in situ header'. Such headers would be very effective in action.

On the continent, cast steel bearings were frequently replaced by R.C.C. or prestressed concrete bearings, or by bearings using hollow M.S. pipes compacted with concrete inspite of the fact that their foundry capacity was many times more than in India. He urged that the authorities should give special thought to this topic to find a substitute for cast steel bearings which formed a bottleneck at present.

In the case of suspended span, cast steel sliding bearings could have been substituted by M. S. and copper plate sliding bearings.

Use of smaller diameter bars in the articulation portion would be more advantageous from the point of view of bond.

The soffit slab had a uniform thickness of 5½ in. as mentioned on page 75. It seemed doubtful if that thickness was sufficient to take flexural compression at the support points. It was also doubtful if the soffit slab thickness had been taken into consideration for finding out the effective flange width. Soffit slab thickness of 5½ in. at the support appeared to be on the low side.

It would be of interest to know from the Author the amount of deflection of centring trusses actually obtained.

Slump of 3 to 4 in. of concrete adopted seemed to be too heavy.

In Table on page 95, B. M. & steel requirements were worked out for main beam end spans. Values were worked out at 0.25 L 1 and—50 L 1 from A. The worst stresses would, however, occur in between.

Dr. R. K. N. Iyengar stated that on page 69, para 4.1, it had been mentioned that it was anticipated that firm rock would be encountered immediately after removing the top disintegrated portion. It had, however, been found that there were plenty of fissures when about 4 ft of rock was blasted. He was of the opinion that in a major bridge of this nature it was always very advisable and helpful to take borings or at least make detailed preliminary investigations to find out to which strata the bridge foundations should be taken down. Quite possibly there might be some rock outcrop on the top and then clayey strata, then conglomerate and again rock. It would have been far better if borings had been taken beforehand for proper design of foundations.

Secondly, it was noticed that after careful geological investigations it was finally decided to go deeper and the rocks were further blasted to additional depths of 6 to 10 ft at places. That was a very wise action taken, but he wanted to know whether any fissures were noticed after going down another 10 ft and whether any cement grouting was done under pressure at all.

Referring to page 69, para 4.3, giving details about the blasting under hard as well as soft rocks he wanted the Author to give the cost of foundations under soft rock and hard rock. It would have been better and interesting if costs for substructure, superstructure and foundations, etc. had also been given separately, so that it might be helpful in preparing future estimates for such typical bridges in other areas.

With regard to the statement in para 3.3, page 68, that on account of heading up of 20 ft of water in Sukhwan Dukhwan weir working period was curtailed, Dr. Iyengar suggested that it would have been easier and cheaper if big barges had been anchored alongside the piers to supply the materials at site.

Shri N. D. Daftary mentioned that the Author had stated that they had to go very deep on account of rock containing fissures. But if the rock was good and capable of taking the load, it was not known why it was necessary to go very deep. He would like the Author to enlighten him on this point.

In para 4.2, page 69, the Author had stated that cracks were considered structurally ineffective for foundations. This was not very clear. He wanted to know whether the cracks were so insignificant that they could be ignored.

It had also been mentioned that dowel bars were used for anchoring. It was not known why this kind of anchoring was considered necessary. The Author might clarify the point.

Shri K. K. Nambiar stated that the title of the Paper gave an impression that the bridge was a hollow box, but actually it was a girder bridge.

On page 68, in dealing with the economy of construction, it was stated that the design was found to be the most economical. He felt that if tenders had been invited calling for alternative designs, it would have thrown light whether that was actually the most economical design. To him it appeared that a T-beam design with ordinary 3 T-beams, would have required very cheap form of shuttering and this would have effected saving in cost. Also, the cost of bearings could have been minimised. Facility of execution should be one of the important factors in working out designs. It had been mentioned by more than one speaker that rock in bed was not always an unmixed blessing; sometimes it happened to be expensive.

With regard to the dowel bars, it had been stated already and he agreed with that view that the dowel bars provided were insufficient, both in length and spacing. If slipping and sliding of foundations was expected, they were totally inadequate. It was more of a psychological precaution to provide these dowel bars in this particular case.

He had executed a continuous box girder extending over three spans and much longer than the bridge described in the Paper, about 300 ft overall length, and the difficulties experienced there were numerous. The Author had already referred to the difficulty of extracting the shuttering after concrete was set. It would be found from the Paper that in some of the diaphragms and cross beams, small opening of $1\frac{1}{2}$ ft × 3 ft had been provided for people to go through these diaphragms to extract the shuttering. It was a most complicated job and, in fact, in one of the 3-span continuous girders referred to by him they became tired of getting the timber shuttering out and finally left it there; then to make amends for the extra load put inside the box, the thickness of wearing coat had to be reduced and instead of a cement concrete wearing coat of 3 in. at the centre and 2 in. at the sides an asphaltic concrete wearing coat $1\frac{1}{2}$ in. and $1\frac{1}{4}$ in. thick was laid. The Author had stated that he had waited for 10 days after pouring the beams to put the deck slab. He felt it was structurally not a very good thing to wait for so many days.

With regrad to bearings, they might have cost Rs 2 lakhs or more. With 3 T-beam type, perhaps even simply supported, they might have managed without the bearings. For example, in various bridges in Madras State of 60 ft and 70 ft spans they had used only mild steel plate bearings and they were functioning very well. With such bearings the cost would have been reduced by about 25 per cent.

With regard to the concrete slump, previous speakers had also referred to the high slump of 3 to 4 in. used and the water content of $5\frac{1}{2}$ to $6\frac{1}{2}$ gallons. Specially when the P.W.D. had recourse to steel centring and part of the shuttering was also made of steel, if they had made complete steel shuttering and used shutter vibrators, they could have had a much smaller slump and better concrete. Here they had used needle vibrators for this large bridge.

With regard to the roadway, the 22-ft width appeared to have been tamped in one stretch, of course using a central sheet of expansion jointing to separate the two halves. In actual practice, it had been found that it was difficult to tamp 22 ft of wearing course with manual labour. Why could it not have been done in two halves? And, if it had to be done in 22 ft width, it was not clear why there was need for a central expansion joint.

Finally, regarding the cost of the bridge, as already remarked, it was rather on the high side considering that the foundations were on rock near the bed level.

Shri R. L. Nanda stated that from page 79 para 10.1 and Appendix 3, it appeared that the Author had found Portland cement to be satisfactory only by physical test and not by chemical analysis. Although alkalies in the water had been determined, the harmful constituents such as high alkali content, magnesia and sulphuric anhydride in Portland cement had not been analysed. These constituents were equally important for the soundness of concrete construction and could not be detected simply by physical tests. Recently, the quantity of alkali in cement had assumed great importance in America. Alkalies of cement react with Portland silica of the aggregate and form silica jelly. This causes expansion and extensive cracking. The most noteworthy example of that type of concrete failure was the Porter Dam in the U.S.A. Researches in America had shown that if alkalies in cement was below 0.6 per cent, that type of reaction did not occur. Le Chatelier boiling test had been performed for finding out the soundness of Portland cement. This test indicated only expansion due to free lime, but free lime present in the form of high boiled free lime or the delayed expansion due to high magnesia content could not be detected by that test alone according to the opinion of certain authorities on chemistry of Portland cement. For all important works Auto-boiler expansion tests should be performed for detecting the delayed action in cement and concrete.

Shri K. F. Antia stated that the dowel bars as put in one of the piers would not be effective and that had been very clearly pointed out by Shri R. N. Joshi. On the other hand, he considered that substantial dowel bars should have been put in every pier. In 1943, on a railway bridge of several spans of 60 ft., two piers were completely washed away after having stood for half a century. That bridge had been founded on rock which was at a depth of about 15 ft. below the bed level, and it had stood all the floods. When the bridge was rebuilt care was taken to put in very strong dowel bars as it was very necessary to prevent sliding of the piers under very high floods.

Mention had been made about chutes being used for putting in 1:3:6 concrete in foundations. From the photograph the chute seemed to be rather long and he would like to know whether segregation took place in the concrete in its passage through the chute.

The question of concrete bands had already been dwelt upon. His only comment was that the bands should have been brought right up to the surface and not covered with facing stones, because the facing stones were the ones that needed connection with the interior which was made of random rubble.

On a point of economy, he was not clear as to why nine sets of trusses were necessary for casting the girders. He appreciated that the bridge had to be built in two seasons and for very short periods in each season, but surely some other methods might have been tried; for instance, rapid hardening admixture which would have reduced the time of removal of centring and reduced the number of these centrings. It would be interesting to know the percentage cost of the formwork and its supports compared to the cost of the girders themselves. He had a suspicion that the percentage would be high.

Regarding bearings, he would mention that on the Indian railways for many years a very simple rocker bearing had been in use. It consists of nothing more than a square piece of steel welded to a plate attached to the bottom of the girder and resting on a bed plate with welded stops. Of course, he was referring to steel girders, but he did not see any reason against its application to concrete girders as well.

Shri D. C. Chaturvedi stated that as mentioned in Para 2.2 of the Paper the U. P., P. W. D. Research Institute at Lucknow was called upon to examine the rock bores and to recommend the probable depth of foundations for the piers and abutments, and the following information might in a way explain the querles raised by several speakers.

At this site, pinkish coarse grained granite rock was exposed all over the river bed. A dolerite dyke intruded the granite and cut across the foundation beds of pier No. 30 and the abutment on Lalitpur side almost in the middle. The granite at places enclosed small pockets and clots of clay. Joints and fractures were common and were generally local features.

Petrographic study of the core samples showed that the rock near the surface had been affected by weathering specially by water which found access along cracks and joints. Below a certain level the rock was almost fresh and was little affected by weathering. It was adopted as the criterion for fixing the depth of foundations by examination of cores. The laboratory investigations showed that the core loss in drilling was excessive where the rock was weathered or where there were clay pockets. This indicated the necessity of careful examination of the rock bed at the time of placing of the foundation.

The compressive strength of the fresh rock was determined and it varied between 13,000 to 15,000 lb per sq. in. whereas the weathered rock had given values between 2,000 and 10,000 lb per sq. in. Depths of foundations for piers and abutments were fixed provisionally on the basis of these laboratory investigations.

The foundations of various piers and abutments were examined by the Geologist of the Research Institute from time to time during excavation and depths in a number of cases had to be varied due to following difficulties :

(1) In several cases seams and lenses of weathered rock or soil met with in the parent rock varied in thickness from one in. to a foot and were either horizontal or at various dips. As these were expected to induce settlement of piers it was thought advisable to pass them over. In case of horizontal seams, uniform excavation of bed rock could be done but in case of high inclination, stepped foundations were suggested.

(2) In several cases difficulty was felt where the bed rock was intensely fractured and jointed and continued upto great depths. These could not be passed over and the alternative was to increase the thickness of foundation concrete. Some of these cases had been dealt by the Author in the Paper.

It was observed that the final depth of foundation fixed after site excavation was more or less the same as predicted on the basis of laboratory investigations of the core samples except that in some cases the level of foundations had to be kept higher or lower than suggested due to reasons stated before.

The results showed that the examination of bore hole samples give a fair idea about the probable depths of foundations but structural peculiarities might often necessitate the change in the depth of foundations and it was necessary that thorough geological investigations should be done before finally adopting the depth of foundations.

Regarding testing of river water for use in concrete, mentioned in para 10.1, the Author might explain the necessity of getting the water tested. Was the river water suspected to contain any harmful constituents?

In regard to density of coarse aggregate obtained by mixing different percentages of 3 sizes of aggregates given in Appendix 6, Shri Chaturvedi stated that from the results, the density was found to be maximum in sample No. 2 and not in No. 4. The Author might clarify this point. It might be interesting to note that the proportions of different sizes of coarse aggregate which might give maximum density, need not give maximum strength in the concrete.

Referring to para 11.1.4 regarding compaction of earth done by wooden sheeps-foot rollers, he requested the Author to give some details of the roller as he did not understand how good compaction could be attained by wooden sheeps-foot rollers. The

type of soil for which this type of roller was found suitable might also be indicated.

As regards Shri R. L. Nanda's point that tests on cement for chemical analysis should have been done, he felt that such an elaborate analysis was not necessary and the physical test results gave enough information about the suitability of cement.

Shri G. C. Gupta mentioned that on page 79, it was stated that wearing coat was laid separate and that the expansion joints were provided longitudinally at 11 ft and transversely at 32 ft distances. Besides the old controversy of having separate wearing coat and adding to the dead load rather than using the deck slab itself as a wearing coat, he wanted to know the function of the expansion joints in the wearing coat as the concrete wearing coat was resting on the concrete deck slab, both of which had the same co-efficient of expansion. Provision had already been made for expansion of the deck slab. There would be no relative movement in between the deck and the wearing coat. He, therefore, wanted to know the function of having independent expansion joints for the wearing coat.

Shri K. L. Sethi said that on page 97, vide Appendix 3, the tensile strength of cement at 3 and 7 days had been reported as 327 and 425 lb per sq. in. respectively, whereas on page 98 the strengths reported were very high. There was no indication which cement had been used. Again, while designing the concrete mix the strength taken into consideration was at the age of 28 days while the Author had not mentioned anything about the strength obtained at 28 days in the laboratory. The strengths reported are at about 2 to 3 months age, which were of no value. He would like to know the strength in the laboratory and then the strength in the field, so that for future designs some empirical factors could be found which would give an idea of the variation in strength.

On page 80, it was stated that crushed granite $\frac{3}{4}$ in. gauge was used, while on page 101, material passing 1 in. and retained on $\frac{3}{4}$ in. had been used while designing the mix. The grading should have been 1 in. size instead of $\frac{3}{4}$ in. size.

Shri M. Meeran stated that, principally, a hollow box girder design was supposed to be simple and straightforward, provided the salient features of a hollow box girder design were observed. In this design that aspect seemed to have been ignored or not thought of. A hollow box girder was essentially a girder where the bottom flange was supposed to take the full tension. In a concrete girder, all the tension members were supposed to be accommodated in what was called the bottom of

the socket, which should be really the bottom flange of the girder. Of course, tension goes to the top beyond certain sections where, again, it should be accommodated in the top slab.

He did not want to go into the question of economy of the design adopted in this case. It was definitely economical to use hollow box girders so as to make use of the bottom flange and the top flange to function as the regular flanges as in a steel girder. They could only derive the maximum benefit of hollow box girders when they would be able to accommodate all the main reinforcement in both the slabs. He had occasion to design certain hollow box girder roofs for an auditorium building. This principle was adopted and it was found that the design was simple, economical and the construction also was quite easy.

Shri K. M. Nayar observed that the Author had stated that "the hollow girder design was more economical than the ordinary T-beam construction". That statement required some worked out data in support. The pamphlets on concrete girder bridges published by the Portland Cement Association of America which the Author had quoted did not say so. It was also known that continuous hollow girder road bridges recently built in U.S.A. did not have such short spans. It was true that the live loads assumed in India were a little bit greater than those in the United States. Still, he thought that it would have been more economical had the spans of the continuous hollow girders been longer, i.e., about 100 ft or so.

The superstructure being of the continuous girder type only one bearing was required over a pier under each girder and that would normally be at the centre of the pier (in cross section). The pier masonry would not then normally be subjected to any overturning moment or couple unlike the case of simple spans. The width of the pier could, therefore, have been slightly less. This required clarification.

Considerable economy could have been also effected had the massive and expensive type of high abutments been replaced by suitable land spans.

Dr. M. L. Puri stated that study of Appendix 6 shows that an attempt was made by the Author to design concrete mixes by using the densest combination of 3 sizes of coarse aggregate, i.e., 1 to $\frac{3}{4}$ in., $\frac{3}{4}$ to $\frac{1}{2}$ in. and $\frac{1}{2}$ to $\frac{1}{4}$ in. For this purpose, the Author had tried six different combinations of various sizes and determined the unit weights. The speaker was of the opinion that any attempt to determine the densest combination with three sizes of coarse aggregate could not give the correct results by using the method adopted by the Author, because there would be

so many permutations and combinations that it would be almost impossible to try all of them. It was not understood why the Author did not make use of Talbott's Maximum Density Curve to arrive at the correct proportion of each size of aggregate required to give the maximum density of the combination of three sizes. By following that method, the results would have been more accurate without any trouble of carrying out any laboratory experiments. The values could have been calculated from the screen analysis.

Shri Jagdish Bahadur * said that the Author had not mentioned the method adopted for striking the shuttering and releasing the centring. It had been noticed that there was some movement of the free cantilever ends both laterally and vertically as soon as the centring from below the cantilever was removed. In fact, the movement was quite noticeable on the bearings. He would like to know if the cantilever ends were loaded to the designed dead loads before removal of centring from underneath these ends or the centring was kept in position till the suspended spans were also concreted and centring removed. The Author might also kindly say if the horizontal displacement of roller bearings and the angular movement of rocker bearings was observed in various stages of the work. Such a record was likely to provide useful information in determining the actual flexibility of the structure and its behaviour on bending.

The concreting of one unit of 3 spans and 2 cantilevers was done in 5 stages. Obviously, it would have taken several days necessitating construction joints to be given at the end of each day's work. The Author might throw light on the detailed procedure adopted in doing so.

In a balanced cantilever design, there is always crowding of reinforcement at the cantilever end. The bars from the bottom come up, from top go down, and the stirrups are also very close together. And usually the concrete is poured from over the top of the beams or girders. As such, the mortar sticks around the reinforcement on the day the soffit slab is concreted. Most of the mortar cannot be cleaned away and gets hardened by the time the concrete reached the top bars. He wanted to know what method was adopted to overcome this defect and ensure proper bonding of concrete with the steel.

It had been mentioned that the horizontal rails of the railing were further strengthened with vertical struts, two in each panel. He wanted to know whether these vertical struts were precast or cast-in-situ. If they were precast separately, they

* This and subsequent comments were received in writing.

could hardly add to the strength and if they were cast-in-situ, how was the expansion provided for.

The exact mix as designed by the Research Station, Lucknow had not been given in the Paper. It might also be stated what was the water-cement ratio adopted for the concrete which had a slump of 3 in. to 4 in. and where the vibrator was used. Also he asked if the mix was obtained by volumetric or weigh batching method. Sample No. 4 (in App. 6) was stated to be densest which appeared to be wrong. It should be sample No. 2.

Shri Fateh Chand stated that the Author had mentioned that the Jhararghat causeway remained submerged upto January, due to the existence of Sukhwan Dukhwan weir 7 miles downstream. He had further mentioned that the flood velocity was so great that the working of the ferry had to be suspended for the duration of floods. He liked to know the top levels of the weir and the causeway and the bed slope of the river for a mile up and a mile downstream of the bridge site.

The discharge appeared to be based on the assumed H. F. L. of 921.78. He wanted to know the catchment area and the intensity of rainfall and whether the discharge obtained by the above hydraulic data was compared with the value obtained by Dicken's Formula and the rainfall intensity formula as laid down in I. R. C. Paper No. 109 and the higher value adopted. He also wanted to know the maximum flood velocity and afflux allowed in the design of the bridge. Comparison of discharge obtained by the different methods appeared to be particularly necessary in this case, due to the disputed H. F. L.

He further desired to know whether the utility and cost of a prestressed C. C. floor was considered. If so, the difference in the estimated cost of a Tee-beam, hollow box type, and prestressed concrete superstructure should have been given.

There was said to be 20 ft deep water at the bridge site due to the existence of the weir. He liked to know the methods adopted for excluding water from the foundations, i. e., whether coffer dam, a spur, or an ordinary bund, was made and of what materials and its dimensions. Shri Fateh Chand enquired whether advisability and cost of providing R. C. C. over the cracks in foundation rocks was considered instead of providing $\frac{3}{4}$ in. diameter dowel bars.

He also enquired whether cement concrete 1 : 4 : 8 instead of 1 : 3 : 6 was considered and whether the bearing capacity of the former was not found to be sufficient for the span and the loading adopted for the design.

The calculations of the principle on which the double reinforcement of the 3 ft thick cap slabs over abutments and piers was based should also be given.

Further, what were the considerations in favour of double reinforcement of deck slab in preference to the usual single reinforcement.

Was it not possible to schedule the construction work in such a way as to utilise the truss centring of 3 spans in the alternate 3 spans without prolonging the period of construction beyond two seasons, particularly when iron trusses were used for centring? For how long was the centring allowed to stand in each span?

Kailwood scantlings and planks were used for shuttering. Did it keep shape well under moisture conditions and would the Author recommend its use for important works, in place of costly teakwood adopted in a large number of bridges in the past?

Would it not have been better, in the opinion of the Author, to lay the wearing coat simultaneously with deck slab and whether tell-tale blocks were used in the wearing coat to watch its wear?

Gunny bags were used for curing. Did the Author consider this method as economical and efficient as making compartments on top and keeping the same filled up with water or sand?

What was the water-cement ratio and how was it ensured and maintained? What was the range of temperature and to what maximum and minimum limits was the above ratio allowed to be altered?

Were any wheel guards used and, if so, of what material and dimensions. What was the width of the roadway between wheel guards? For what distance, on either side of the bridge, were the approaches kept level and what gradient was given thereafter?

Shri C. V. Padmanabhan wanted to know if for the waterway of 1850 rft, provision of 21 spans of 90 ft clear was considered for comparison of costs.

At the bed of the foundation was rock, but it was not fully reliable. Under such situation, dowel bars were provided against any future trouble due to settlement. Hence it appeared that even if a settlement occurred in any of the central piers of one continuous unit of deck, the calculations

for moments would need revision. The Author was requested to clarify how the 4 span unit was arrived at.

He was also requested to clarify if through rods were provided in the concrete pads in piers. The effect of long bond stones could be had by precast concrete bond stones.

The provision of a big restricting moment to 2.5 inches, might come in as a handicap, if, by chance, there was slight error in fixing the bottom plate or any other component.

It might be clarified how the main girders were stiffened by the soffit slab. It might also be confirmed if the torsional stresses in the soffit slab, under the conditions assumed in this case, had been considered.

It was observed in actual construction in another case that the small vertical struts in the panel of railings were difficult to execute. It might be stated if similar difficulty was experienced in the case of this bridge.

A shear of 3,28,000 lbs was assumed to be taken up by bent-up bars and web. As shear failure was controlled solely by the strength of the compression zone of the concrete, it appeared to be preferable to utilise stirrups and, bent-up bars alone, ignoring the concrete in web.

As the concrete used for beams was of ordinary grade 1: 2: 4 it might be stated if spiral reinforcement was provided in the beams over bearings to take local concentration.

Shri P. N. Srivastava in his replies to the various comments stated that regarding economic aspect of the design, they had tried orthodox T-beam design, and other types of designs also. Rigid frame design was not tried due to insufficient experience in that type of bridge. **Shri S. K. Ghosh** had doubted the economy of design of this bridge to which Shri Srivastava replied that he did not have the figures of comparative cost with him, but all the three alternatives were considered and the design adopted was found to be economical.

Another point referred to by Shri Ghosh was about making use of any other type of decking whereby in his opinion, the formation level of the bridge would have been lowered. He (Author) was doubtful about that because any other design was likely to raise it higher.

Regarding dowel bars, the Author replied that this may not be theoretically effective for slipping or sliding action completely but in his opinion the bars provided some anchorage of the piers with the foundation. A few reinforcement bars across the

plane of differential foundation were given to safeguard the action of unequal settlement.

Shri Ghosh and **Shri J. S. Gupta** had asked why R. C. C. bearings instead of cast steel bearings had not been used although the former were economical. In some bridges, the Author said, R. C. C. bearings had now been used, but in this case the usual and well tried bearings were used as originally envisaged. Each bearing cost about Rs 2,000 and Rs 1.40 lakh was the total cost.

Regarding the point of wastefulness of the soffit slab under the suspended spans, when the entire bridge had got a uniform soffit slab it would have looked odd to have suspended spans without a soffit slab.

The other points raised by Shri Ghosh were clarified by the Author as under:

Item I-page 91-Design of Articulation

The point A should be section A-A and it is along the dotted line shown in the sketch at 7 in. from the edge.

Width of beam means total width of all the three ribs. Only the calculated width has been taken for articulation although for constructional facilities the width of the web has been increased to 12 in.

'D' refers to the effective depth and because the 'D' has been derived from formulae and steps of derivation have not been shown, hence 'therefore' has been used.

All 'included' is a mis-print. It should be 'inclined.' On page 91, at mid support the sign should be minus and not plus.

On pages 93, 94 and 95—Item No. I—The moments given in the Tables are in foot kips.

Regarding the last Table on page 94 instead of 'ft' it should be 'numbers' and instead of 'inches' it should be 'diameter in inches'.

As regards Shri Ghosh's comment that on page 66 it is mentioned that the causeway remains submerged in January whereas on page 77, para 9.2, it is said that the bed being dry etc., the Author replied that both are correct as the bed became dry after February and the work continued in the bed right upto May.

Regarding the point of Shri Ghosh's comment for omission of the vertical bars at the articulation point, the Author referred to Plate No. 3 in which it was already noted that in this

portion there were vertical bars although they had not been shown in the drawing to give space for showing inclined bars more prominently.

Regarding the slump the Author informed that it was 2 in. to 3 in. slump which was used and not 3 in. to 4 in.

Regarding the comment of Shri Ghosh that some steel in the reinforcement could be reduced, the Author replied that the design of the slab was done according to PIGEAUD'S METHOD. However, the Author agreed that slight reduction could be made as suggested by Shri Ghosh.

As regards the comment of Shri Ghosh on the note near the middle of page 89, the Author replied that no correction was made for this as slope in the haunches is nominal. Besides, the effect is zero at the support and at the centre. The variation in the shear due to haunching shall be maximum at quarter and neighbouring points and had been taken into account in curtailing shear reinforcement.

As regards the point as to why separate design for cross beams and stiffeners had been done, the Author inviting attention to the diagram on page 89 pointed out that beams marked 2 & 3 were only cross beams although they were performing the job of stiffeners as well on the other hand.

The beams marked 1 & 4 at the articulation points were designed as stiffeners. Hence separate calculations had been given for these two types of beams.

Regarding Shri Ghosh's objection to the use of $\frac{3}{4}$ in. diameter stirrups, the Author replied that mostly two legged half inch stirrups had been used but where the spacing was too close or where there were too many bars $\frac{3}{4}$ in. diameter stirrups were also used for facility of construction.

Regarding his comment about adding half the dead load, the Author replied that this had been done on the basis of advice given by TAYLOR AND THOMASON—RCC Design, Vol. II—page 173.

The Author stated that the factor of safety was taken as two in this case.

Regarding **Shri J. S. Gupta's** comments on para 6.2 on page 70, the Author stated that while making provision for expansion the effect of fixed bearings was also taken into consideration for complete length of the beam. The Author agreed that sometimes the designs based on PIGEAUD'S THEORY give erroneous results but in this particular case every care had

been taken and the results so obtained had been checked by other methods also and were found reasonably correct.

As regards **Shri S. G. Athavale's** question as to why arches were not used for this bridge, the Author thought that providing an arch would have been difficult on account of centring.

Regarding his statement that if cantilevers were not provided in the design there would have been a saving of about Rs 2 lakhs, the Author wanted to know in more details the basis for this assumption.

As regards **Shri M. P. Apte's** comment regarding waterway, he stated that they had worked out 1,850 rft. to be adequate for a discharge of 5.7 lakh cusecs.

Regarding the provision of steel for taking up principal tension cracks, he thought enough provision had been made by them, although he did not have detailed calculations with him.

As regards his comments about the raised cement pointing on C.R. stone work not being satisfactory, the Author replied that pointing looks artistic and was being used on many bridges. There was no doubt that the joints were perfectly full.

As regards the observation of Shri Apte for using diaphragms and not using cross beams, the Author agreed that this could have been one of the methods of design.

The Author also agreed with the suggestion of Shri Apte regarding the spacing of joints in the wearing course.

As regards Appendix 6, page 101, the Author mentioned that the densest mix was No. 2 and not No. 4 which was a misprint.

Regarding the design of trusses, the detailed designs were not gone into because it was felt that the trusses were of adequate design and strength for use as centring. They did introduce end strutting and it helped in the stability of the centring.

Regarding provision of uniform layer of 9 in. to 1 ft thick concrete every 5 ft or so of the height of piers, the Author said that they did not go right upto the face so as to give uniform appearance of the masonry.

As regards the design of soffit slab, the points mentioned by **Shri R. N. Joshi** were not taken into consideration as the soffit slab only served as stiffener supporting its own weight as mentioned on page 96. The Author said that he had not taken any reading of deflection of the centring trusses.

As regards **Dr. R. K. N. Iyengar's** comment about fissures, the Author stated that these fissures were wide at the surface and went to about 5 ft depth. In one of the rocks the fissure about 2 in. wide went down to just a fine crack at 5 ft depth. When foundations were taken deeper some borings were made but these were not very useful. The Author also stated that some of the cracks in the solid rocks were ineffective structurally.

At the time of concreting whenever the reservoir was found empty, mixing was done at the base of the river where coarse aggregate as well as fine aggregate and water were available. The concrete was mixed and lifted up. Regarding the query as to why no stationary barge was fixed for mixing concrete when there was water in the reservoir, the Author replied that this idea was considered but it involved carriage of all the materials to that barge first by rowing boats. They had proceeded from one side where the concrete was mixed and trollied the concrete along the centring and poured it in position.

As regards **Shri N. D. Daftary's** comments, the Author stated that wherever homogeneous rock was encountered they did not go deeper but where hetrogeneous rock was met with deeper foundations were resorted to. No doubt the bearing capacity of the rock was enough to support the load but in the opinion of the Author only homogeneous rock could be trusted for such foundations.

Regarding his comment on para 4.2, page 69, the Author stated that the cracks were so insignificant in his opinion that they could not affect the structure.

Regarding **Shri K.K. Nambiar's** comment about removal of the shuttering through the holes left under the cross beams, the Author stated that they had also anticipated some trouble in the beginning but after one or two operations, the labour got used to it and there was no difficulty. The Author agreed with Shri Nambiar that it would have been better if the shuttering of the deck slab was arranged quicker than ten days but felt that it did not produce any structural unsoundness.

Regarding **Shri R.L. Nanda's** observation about testing the cement for chemical analysis, the Author was thankful for enlightening him on the subject. The Author stated that chemical tests of various brands of cement were made in the P. W. D. Research Station at Lucknow and any defects observed were brought to the notice of the factories concerned at once.

As regards the suggestion of **Shri K. F. Antia,** the Author stated that it would have been theoretically more sound to calcu-

late the number of dowel bars to check the sliding but it would have been very expensive and in the opinion of the Author no such danger was anticipated at this site.

As regards the use of chutes, the Author's observation at site was that there was not much segregation of concrete which was poured through the chute. The slope was very gentle.

As regards high percentage cost of centring and shuttering, the Author stated that he was not able to provide the actual cost of centring as he did not have the figures but he stated that it was fairly cheap as the entire material was usable again with very little loss.

In reply to **Shri D.C. Chaturvedi**, the Author clarified that he had got the water tested for any possible dissolved alkaline matter which might affect the cement in the concrete. As already stated before, the sample No. 2 had the maximum density and not sample No. 4.

As regards wooden sheepfoot roller, the Author stated that these were locally made of the same design as the usual sheepfoot roller for giving better compaction than with ordinary wooden rammers. The soil met with was laterite—light and heavy type and black clay on Lalitpur side.

Regarding the comment of **Shri G.C. Gupta**, the Author considered that it was better to have separate wearing course than the deck slab. Generally some wear takes place in the wearing course in course of time and this could be renewed or replaced without adding any additional weight to the structure.

As regards his suggestion that joints were not needed in the various bays, the Author replied that as the two slabs were laid separately and the wearing course was exposed to greater variations of temperatures, separate joints were considered necessary. Of course, joints were essential over the joint of the deck slab.

Shri K.L. Sethi had desired to know the strength of cement after 28 days. As this information was not available with him, a reference had been made to the Research Station, Lucknow.

The Author considered that $\frac{3}{4}$ in. size well graded, crushed granite was better than 1 in. for workability in RCC sections.

As regards the comment of **Shri M. Meeran** the Author stated that possibly some economy could have resulted, if the soffit slab was also considered to function as suggested.

Regarding **Shri K. M. Nayar's** point about economy by reducing the abutment size, the Author was doubtful about this.

Regarding the suggestion of **Dr. M. L. Puri** the Author stated that while designing the mix "TALBOTT'S MAXIMUM DENSITY CURVES" were consulted on the basis of which the mix was worked out and was tested for actual field conditions and Appendix 6 shows the results of such tests.

As regards **Shri Jagdish Bahadur's** query the Author replied that centring was not removed from the cantilever portion till the suspended span was also laid. No observations for movement of roller and rocker bearings were taken during construction operations.

As already indicated on page 76 in para 9.1, stages of pouring concrete were evolved and no regular construction joints were necessary at the junction of various stages.

As regards the constructional details of the balanced cantilever, the Author replied that when one stage of concreting was over, the bars which had hardened mortar around them were thoroughly scraped off by manual labour before the next concreting operation was done. This was carefully examined.

Regarding his observation for the vertical struts in the horizontal railing, the Author replied that it was cast-in-situ.

Regarding the enquiries made by **Shri Fateh Chand**, the Author stated that all the aspects had been taken into account while calculating the maximum discharge for the river but as the Paper only deals with the construction aspects, these calculations were not given.

1 : 4 : 8 concrete was considered weaker for laying in the foundations instead of 1 : 3 : 6.

There was no necessity of making any coffer dam etc. for foundations. There was rock right from the bed level of the river. Excavations had to be done by blasting the rock. A lot of seepage water came into the foundations which was dewatered by pumps.

As regards the shuttering, soft timber was used with galvanised iron sheet facing. This gave very satisfactory results.

Regarding the comments of **Shri C. V. Padmanabhan**, the Author stated that the case of 21 spans of 90 ft was not considered for comparison of costs. Simply supported T-beam spans of 90 ft would not be economical in any case.

As already stated core samples of each rock under every pier were tested and the foundations were taken deep enough to

rest on firm sound rock and there was no danger of any settlement whatsoever. Dowel bars were used for extra safety measures. A four span unit had been taken as is the practice for such bridges. No through rods had been provided in the concrete pads in piers as these were not considered necessary.

As the bottom plates of all the bearings are always fixed with great precision, there was no question of any handicap as referred to.

The soffit slab in a hollow girder bridge acts as compression flange of the beams on the support and up to the quarter point. At other places it was supposed to tie the three beams and the main reinforcement was placed therein. No torsional stresses for the soffit slab were considered as based on the standard practice adopted for the design of hollow girders. It was assumed that the hollow girders acted as one unit.

Not much difficulty was felt in the construction of small vertical struts or panel of railing although special shuttering had been made for it.

Originally a certain portion of the web was assumed to take up shear stresses, but it was later on worked out that the shear reinforcement provided was safe even after all the allowances for shear taken by the web were ignored. No spiral reinforcement was provided in the beams over bearings to take up local concentration.

Shri R. C. Roy (Chairman) in his concluding remarks thanked the Author for presenting a very interesting Paper giving full details both of design and construction. He also thanked all the speakers for the keen interest shown by them. Such a discussion was particularly helpful at a time, when due to the shortage of foreign exchange they would not be able to construct for the next 3 or 4 years any prestressed concrete bridges and full attention would have to be given to reinforced concrete construction. He appreciated all the efforts made by the Author and his staff for quick completion of such a big bridge in two seasons.

Discussion on Paper No. 207 *

"Adequacy Assessment of Highways"

By

D. G. BHAGAT

Thursday, 8th January, 1959.

Shri U. J. Bhatt (Chairman) introduced **Shri D.G. Bhagat** (Author) and called upon him to introduce his Paper for discussion.

Shri D. G. Bhagat (Author), while introducing the Paper said that for successful planning and execution of the future road development schemes and to make the present road system, with its woeful insufficiency in its qualitative aspect, satisfy day to day increasing transport and traffic needs, both the improvement and maintenance aspects must be based on rational considerations. Any estimate prepared in this respect must conform to the basic iconcepton of the actual condition of the existing roads in regard to their adequacy and safety irrespective of any personal likes and dislikes or any other extraneous considerations. It would certainly be unwise to attempt to prepare an estimate in any but a standardised and correct manner and any deviations from the same have necessarily to be avoided. An attempt had, therefore, been made in the Paper to introduce an element of factual perception in assessing the utilisation value of a road.

Relative urgencies must be justified on realistic and comparative evaluation concepts, and once that was done, it would be indefensible for an engineer to compromise his judgment.

It would be seen from the Paper that the basic elements which, under the present conditions, mostly influence the performance and service characteristics of roads, had been taken into consideration, and had been grouped together and evaluated by the most commonly appreciated and easily comprehended system of marking. There could, however, be many other elements contributing towards the efficiency of a road under a particular set of conditions, e.g., the facilities of frontage roads, grade crossings, flyovers, traffic segregation contrivances, etc. But their application was confined to very few and specific instances. It would obviously not be sound in practice to consider elements

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* Published at pages 117 to 157 of the Journal of the Indian Roads Congress, Volume XXIII-Part 1, November, 1958.

which did not have, as far as possible, a uniform application and it was only where the relative merits of road usage were based on a common datum that comparative adequacy evaluation could be correctly assessed.

The proposed system apart from providing material for estimating comparative values of adequacies of road surfaces could also form a rational basis for preparation of engineering estimates. It was imperative that the factors adopted for evaluation of adequacies could also serve as basis for determining standards to be applied for preparation of estimate of costs.

Besides, compilation of the condition assessments at frequent and regular manner on "continuation" basis would also help in depicting dimensional characteristics for generally determining projected traffic and capacity of highways in the future. The pace of the correction of deficiencies as computed from the successive condition surveys would also indicate the capacity of the road to keep pace with the evolution of traffic patterns after taking into consideration the rate of obsolescence resulting from normal destructive forces plus traffic growth.

Attention was particularly invited to the "Words of Caution" given in the Paper. The system envisaged therein was not to be considered on very rigid premises. It was primarily intended to be used as an overall guide and could be suitably varied both in respect of the emphasis and marking of the elements to take into consideration any special conditions and circumstances that might develop at any stage. For example, recently due to very severe precipitations, two important National Highways emanating from Delhi were put out of use for prolonged periods because of submersions and damaged surface. Prior to the occurrence of the damage these roads would easily have on assessment answered to "tolerable" standards but, today, improvements of very substantial character were immediately required to restore them.

The assessment system would, in its present make-up, necessarily apply only to extra municipal roads. The city streets and other roads within municipal limits answering to the needs of traffic of purely local character, would require a different approach for assessment of their adequacies. Though the basic concept would be the same the emphasis on the nature of and genesis of the elements and their par values would vary considerably.

The main idea underlying the writing of the Paper had been to excite interest and promote enthusiasm amongst the Highway Engineers to understand the road on its factual worth and not

be solely guided by abstract and unrealistic considerations. Any suggestions to improve the basic approach, principle and the mode of treatment of the system would be highly welcome.

The Author pointed out that the following errors which had unfortunately crept in, were required to be corrected in the body of the Paper—

(1) On page 124 — Under Para 4.2.2 — sub-para 2, the contact area should be 100 sq. in. instead of 10 sq in. as shown in the Paper.

(2) In the formula for evaluating "passing opportunities" given in Annexure 2 on page 150, the fraction of "one fifth" should apply percent values of all the five factors grouped together, viz., III (E), IV (A), IV (C), III (B) (i) and traffic volume. The repetition of III (B) (i) is to be scored out.

(3) Again on page 151, the bottom line showing adjusted adequacy assessment index should be $= I + II + III + IV \pm T - E$. The adjustment due to the traffic element T could be both "plus" or "minus".

(4) The "Asterik" given in Annexure 4 at page 156 applies to the figure 40 and not to the whole bracket.

The standards indicated in Annexure 1 of the Paper are, by and large, those which were generally being followed in different States and also by the Indian Roads Congress and the Roads Wing of the Ministry of Transport & Communications Government of India.

The curves given on page 126 of the Paper showing adjustments to be made in basic rating values on the considerations of traffic volumes had been generally adopted from those recommended by Gordon Baird in his article on "Records Help Us to provide Better Facilities for Travel" appearing in *Better Roads*, Vol. 24, No. 4.

Shri. S. N. Gupta stated that so far as the States were concerned the introduction of the study of adequacy assessment of highways was a little too premature. Engineers were faced with the problem of providing immediate requirements of rural communication and under force of circumstances very often compelled to forget about adequacy of traffic requirements. Development was more in the form of stage construction.

He, therefore, considered that maintenance assessment was at the moment far more important than the adequacy assessment. The Author had given only 3 per cent marks to this

aspect against 100 marks of adequacy assessment—P. 122 group I item (e).

Shri Gupta then suggested that the highway actuaries should study the road life statistics and find out with fair amount of accuracy the pattern of retirement of a highway system in order to plan a well balanced maintenance budget for years to come.

He also suggested that the Author should take up actual study on a section of N.H.W. in order to draw up a useful conclusion.

Shri N. S. Surya stated that traffic carrying capacity and accident rates were also important for a rating system particularly in case of roads leading to large cities like Calcutta and Bombay.

As an example of such a system he quoted the method used in Tennessee (U.S.A.) where the rating was based on three criteria. The first relates to structural condition and takes into account subgrade, drainage, base and surface. The second is called facility of movement and considers the influence of excessive traffic, too steep grades, bad alignment, lack of passing sight distance, narrow pavements and narrow shoulders. The third criterion is named safety and is measured by the number of accidents per mile. Using these factors a rating is obtained in the form of a number of 3 digits, a number 0 to 9 being given for each of the three criteria.

But as stated in the last paragraph of the Paper, the purpose of the rating is to provide a uniform yardstick and the yardstick could be designed to suit the conditions of the road systems to be rated.

Shri S. A. Swami desired the Author to clarify how the total par values of 20,20, 30 and 30 of the four groups, namely Situation, Structural sufficiency, Safety and Service respectively had been arrived at. Though the various factors had been well distributed within these four ' S ' s, he felt that structural sufficiency should have a higher total par value at least for the present, when few of the existing roads were built on scientific design in this country.

Further he desired the Author to clarify how the absolute par values of the various classes of roads, as given in Table on page 128 of the Paper, should have their divisions into groups, i.e,. whether the par values of the 4 'S' rating was applied proportionately. He asked whether it would not be better if different classes of road could have different rating groups, instead of one

single rating system, since the relative importance of certain factors was more or less according to the type of the road.

Shri Tejbir S. Khanna in his comments stated that field study was very essential before any American Standards could be modified to suit our needs. Then there was the question of minimum tolerable standards which should be accepted by this country.

He was also doubtful if at this stage the study suggested was necessary because it would need very elaborate organization and the only object of it was to find out which roads needed improvement. Actually, roads which needed improvement were well known. Only they were required to be brought up to a certain minimum level in the matter of their geometric, structural and other design and construction standards.

The Author had emphasised four main points for assessing the adequacy, viz., situation, structural sufficiency, safety, and service. Supposing according to this assessment a particular road got 60 marks, it meant 10 points less in each group thus leaving out 40 points. Another road getting full marks in all other aspects and zero in safety, would get 70 points in the total thus showing that it required less attention than the road that had 60 points. Safety was an important factor for a road and, therefore, he would suggest that besides a road passing in the aggregate marks it should also pass in safety and in service individually also.

On page 124, para 4.2.2. (a), the Author had talked about correction adjustment. He had not pointed out as to how the type of traffic would affect the adjustment. Under para 4.2.2. (b), volume of traffic, the Author had mentioned that the proportion of bullock-carts to the total traffic would play a great part in determining the service efficiency of a road surface. But he had not further elaborated on this subject. On the contrary, instead of volume he had talked about tonnage of traffic. It was doubtful whether the volume of traffic, particularly in this country, could always be expressed in terms of tonnage because of the variety in types of vehicles.

On page 125, para 3, the Author had mentioned that daily tonnage of 800 seemed to be a reasonable basis for rating in relation to which compensation factor should be reckoned. It was supposed the Author meant 800 tons per 12 ft width in both directions on single lane road and either direction on a double lane road. Furthermore, the Author had not mentioned the particular formula with the help of which the graph had been drawn. He suggested that perhaps the formula, given below, as

developed by the State of Colorado (U.S.A.), might be substituted more conveniently for the one given by the Author as it took into account the volume of traffic instead of tonnage.

Formula:

$$Y = \left(\frac{x - 100\,x}{50 \log T_s}\right)(\log T - \log T_s)$$

where

Y = Adjusted sufficiency rating.

x = Basic sufficiency rating.

T_s = Average daily traffic expected to be carried out

T = Average daily traffic actual.

Another important factor which, he felt, had been left out in the adjustment correction was inadequate surface. For example, a road having a volume of 4,000 vehicles per day with surface composed of 2 in. of road mixed soil processing was subject to correction if the geometric standards indicated that such a road should have a higher type of concrete or asphaltic concrete surface. Another more important adjustment factor, particularly, for Indian conditions, was lack of dust-proof surface. Here it was necessary to decide what was the maximum volume of traffic beyond which dust-proof surface was required.

He did not agree with the Author's suggestion to take long stretches of road for adequacy assessment purposes. It would not be practically possible to run up and down 20 miles and remember everything about safety and then have correct assessment about safety, structure, rideability and other things. The road had to be divided into short sections and, therefore, it was necessary to decide the optimum length of sections. In the Arizona State, they took one mile as the length of a section to be assessed at a time. In no way it would be correct to assume that the average of this assessment would indicate the quality of the road. A particular mile might be way down and the other mile way up. Yet the two miles combined, might pass the adequacy assessment, but it would take the attention away from the section which needed immediate attention.

He felt that probably more important was the adequacy assessment for bridges on our roads and suggested that a study might be conducted keeping in view the following points:

(1) Whether the width was too narrow to allow the opposing lanes of traffic to pass with freedom;

(2) Restriction and overhead clearance which did not allow the passage of high loads;

(3) Inadequate load carrying capacity, etc.

On page 133, Fig. 2, the Author had given "Survivor" curves for three different types of road surfaces. Again, these curves were based on American experience and in no way our roads could come close to the life-expectancy of their roads. He made a reference to Bulletin No. 125 of Iowa State College Engineering Experimentation Station where they put up 18 basic types of survivor curves after long years of experience, and from those which fit in the nearest they calculated the surface life or the total life expectancy of a particular type of road. Similar survivor curves would have to develop independently to suit Indian conditions. As developing of survivor curves took a long time, a start should be made forthwith.

Dr. Bh. Subbaraju desired to know whether the Author had tried this rating system on any village road and whether he was satisfied about the applicability and the suitability of this particular rating system to the village road in our network. A road, running in agricultural area, connecting a village with a small town, would score roughly about 50 points according to the suggested rating. But due to the meagre traffic on the existing road (about 100 bullock-carts and no fast moving traffic), the adjusted rating jumped up to 70. The tolerable value given for classified village roads was 33 and for unclassified village roads 28. This showed that the condition of the road was above average, whereas in fact the condition of the road might be intolerable. Therefore, he felt that suggested rating system was not flawless. As had already been stated, this rating system was started in late Forties or early Fifties in most of the States in America. By that time most of the roads in U.S.A were designed on scientific principles whereas this was not the case about Indian roads. So the suggested rating system without drastic changes in the par values of the various components of the highway would not be applicable in his view to the village roads and major district roads which had predominantly bullock-cart traffic. He therefore, suggested that the system be adopted with the introduction of three more adjustment values, which were (1) more par value for the structural sufficiency, (2) another adjustment for the surfacing, and (3) another adjustment for the traffic. Even though the Author had stated that the destructive effect of a bullock-cart might be taken as twice that caused by a pneumatic tyred traffic, he was not satisfied with that and suggested that in addition to the three adjustment values stated above, one more should be added to cater for the bullock-cart traffic.

Shri G. C. Khanna in his comments stated that on page 133, the Author had mentioned that a concrete road had a total life of 36 years and it would have only a salvage value of 25 per cent after 24 years of life. He thought the representative of Concrete Association should be able to give a better idea. Chandni Chowk road was constructed in 1935, exactly 24 years ago; it had been carrying very heavy traffic and he thought its residual value was still about 80 per cent. Similarly, the Author had stated that a bitumen treated surface road had a total life of 24 years and after 16 years the residual value would be 40 per cent. He thought that this was not based on actual experience. For the last 15 to 20 years no road had been reconditioned in the Punjab and, therefore, he thought that, that value should also be increased. He would like to suggest to the Author a simple method as to how a highway could be assessed on operational basis. The cost of transport consists of two parts (1) vechicle operation per ton mile, and (2) road charges per ton mile. If vechicle operation cost be taken as Re 1/- per vehicle mile on a metalled road, or Rs 1.2 on an unmetalled or katcha road, it meant that 20 per cent more was spent on operation of the vehicle travelling on a katcha road. Taking an average net weight of goods carried by a vehicle equal to 5 tons, the extra cost of operation was about 4 nP. per ton mile. If the road had sufficient traffic to justify that the extra road charges were less than 4 nP., then there was necessity for a metalled road. In working out this, one had to bear in mind the capital cost, the maintenance charges and the residual value of the road. For instance,

A = annual cost of the road,

C = initial capital cost of the road per mile,

R = rate of interest,

S = salvage value of road after, say, 'n' years.

If C is = Rs one lakh, rate of interest = 5 per cent, salvage value of road based on the Punjab experience, Rs 25,000/-, and maintenance cost Rs 2,000/-; the annual cost of the road would be Rs 7,200/- per mile. If the net traffic on this road was 1000 tons per day, the proportion of annual charges of road per ton mile of traffic would be 2 nP. If the traffic was 5000 tons, then the cost of annual charges would be ·4 nP. The relationship between traffic on the road and the cost per ton mile would be given by a hyperbola. For instance, if the width of the carriageway was to be doubled at a cost of about Rs 2 lakhs, then 2000 tons of traffic would justify this. He thought this method could be adopted for assessing the economic aspect of road charges.

He would illustrate this by working out an example of the Punjab road system. There were 4,800 miles of metalled road in the Punjab. The total investment was about Rs 48 crores, assuming it to be Rs 1 lakh per mile. The average intensity of traffic which had been found on the Punjab road system was 1,300 tons per day. Road charges per mile, therefore, worked out to about 1.54 nP. per ton mile. If it was assumed that the road system was entirely unmetalled, then the cost per mile would have been 4 nP. Thus there was a saving of something like 2.46 nP. per ton mile. If the traffic intensity was multiplied with milage × saving × number of days in the year, the net or gross saving would be, say Rs 5.5 crores. Now, on an investment of Rs 48 crores, our annual maintenance charges were approximately Rs 1.5 crores. The total saving to the State by construction of this metalled milage was approximately Rs 4 crores, which gave a yield of about 8 per cent to the State.

Shri H. S. Bhatia suggested that evaluation of our highways could be based on two important factors, viz., the maintenance cost per year and the accident rate per 1,000 vehicles. These two factors would enable us to make an assessment as to how the road had been faring for some time and then evaluation of highways in a more rational manner would be possible.

Shri S. N. Sinha stated that the variations in the ratings between the Village Roads, the O. D. Roads, the State and the National Highways needed to be maintained to some extent to serve as a proper guide for working out the adequacy of the highway system. Another point for consideration was the total assessment values of the various groups. Both "Structural Sufficiency" and 'Situation' had been given a par value of 20. Roads were meant to serve the needs of the areas concerned. It did not, therefore, seem very correct to assess the values of their location. He, therefore, felt that the rating for 'Structural Sufficiency' should be increased to make total of at least 30.

Similarly, regarding Group III, safety, he was of the opinion that the rating for side protections, specially for hill roads, should have been more. This could be easily incorporated by suitable adjustment under the heads traffic interference and constant speed maintenance where the par values could be reduced.

Shri D. C. Chaturvedi stated that the work of carrying out the assessment of highways would involve a lot of labour and time. Field parties might have to be appointed permanently for this purpose. The State P. W. Ds. carry out traffic census regularly on their roads, and it was possible that this work of

assessment might also be entrusted to the same units with some extra staff.

On page 125 the Author had stated that average daily traffic struck from actual per week traffic census taken at least twice a year during preselected period might be taken as a workable basis. In U. P. slightly different system was being followed. The census at each point was taken in 2 instalments. For first time census was taken for 7 consecutive days (between January and March) and the traffic again taken at the same point after about 3 months. This time it was taken for 3 consecutive days. The Author might, therefore, consider the applicability of this procedure for traffic census.

At present, in U. P. P. W. D. history sheets of each mile were maintained by the Engineer-in-Charge of the road. These history sheets contain the following data:

1. Depth of metal.
2. Condition of surface.
3. Length operated on.
4. Nature of operation and area.
5. Cost per sq. yard.
6. Resulting width.
7. Life fraction.

With the help of the above information, it was possible to get indication of the index of the condition of the road. For finding out the index, definite marks were given according to the condition of the mile. Thus for A class mile which was in good condition and would not be renewed even if funds were available, 100 marks were given.

For B class mile which was in fair condition and would only be renewed if there was money to spare, 80 marks were given. For C class mile which was in poor condition and ought to be renewed to keep the road up to a reasonable standard, 50 marks were given, and for D class mile which was in a bad condition and must thus be renewed, 25 marks were given. Thus if a road 55 miles long had 53 A miles and 2 B miles it would have a condition index equal to $\frac{53 \times 100 + 2 \times 80}{55} = 99.3$. By computing these indices, condition index for the District Division or the State as a whole could be obtained.

He would, therefore, suggest that in order to make the assessment easier, the particulars to be collected in the field might be reduced.

Shri K. S. Sankaran stated that he agreed with the Author that the ratings given in U. S. A. might not be suitable to our conditions, but he wondered why the ratings should be divided into four broad sub-heads with two additional correction factors. In the State of Oregon, these two additional factors had been considered and they were subject to heavy criticism. The two factors, viz., traffic considerations and economic consideration, were included in the Capacity and Service and, therefore, there was no need to repeat them. In any rating system, whether AA or Sufficiency Rating System, there should not be any room for personal bias in assessment and the procedure should be straightforward and simple. By increasing the broad heads into four with two correction adjustments, certain factors were repeated, for instance, there was Consistency in Group II as well as in Group III. Probably the best way to proceed in the adequacy assessment of highways was to formulate highway plan surveys which formed the backbone of the structural aspect. The traffic surveys would take care of the capacity and safety. It might be argued, apparently convincingly, that to inunciate these surveys and to wait for the results too, adequacy assessment might be too long a period. So, a short circuit could be made by conducting highway planning surveys taking a representative sample projecting the results for rating. He wished to emphasise that highway plan surveys, viz., road inventory and the allied traffic survey, should be a continuous process and should be operated by special funds.

Shri R. L. Nanda stated that on page 156, Appendix 4, the assessment of riding quality as given was probably by vigilant inspection. It would have been better if such an assessment had been done by using some mechanical device as a common yard-stick to avoid personal error. There were several types of equipment avaiable, one such equipment was Bump Integrator. It could be operated at 20 miles per hour and was a rapid, convenient and satisfactory means of assessing the riding qualities of highway pavements. In some countries like Spain, all the State roads were measured every year over the whole length with the Bump Integrator. This was particularly suited for a survey of the roads in a country or State to enable decisions to be made as to which road needed repairs. And, for this purpose, it was used by a number of American States and in some parts of U.K. In U.K. maximum permissible irregularity was being introduced in the British Standard Specifications and the Official Code of Practice.

Shri T. R. Sehgal stated that whereas the Author had dealt with the road conditions very elaborately, he had not given due consideration to traffic and economic aspects which

cause changes in road conditions. These would help to judge the adequacy not only for the present day but also for some years to come. In order to include traffic and economic considerations, he would suggest that data should be collected under traffic on (1) annual average daily traffic, (2) traffic per day, and (3) peak hour traffic and it should be maintained vehicle-wise, i.e., fast traffic, slow traffic and cyclists. Under economic conditions, the factors like population, type of employment, per capita income of the areas should come.

The Author had given index values to four assessments, named by 4 Ss, as 20, 20, 30 and 30 respectively, but he had not given any measuring rod for giving these particular indices. This might induce non-uniformity in the index values from person to person.

Another point was that in the suggested groupings under the four Ss, there were different subjects which had been mixed up under each head. This was likely to create some difficulty. It might be mentioned that the Author had given on page 129 another set of factors which were :

(1) Physical (surface, foundations, drainage, etc.)
(2) Design (alignment, gradients, width, etc.)
(3) Safety (consistency, intersections, etc.)
(4) Service (traffic, community service, etc.)
(5) Economics (roadside conditions, maintenance, etc.)

It appeared that this grouping was more sound and if these factors were rated for the adequacy assessment, they would bring better and uniform results as each one of them was an independent subject and when a specialist dealt with each of them separately there would be less chances of non-uniformity in rating.

Shri C. L. N. Iyengar expressed the view that there was no fear for the adoption of the method suggested by the Author provided the main objective of this method, i. e., to serve as a numerical index for relative standards of the existing road system in the country, was taken into account. The system did not go beyond a stage of merely assessing the condition of the existing road system, whereas in the case of roads, missing links, etc., there were certain other methods such as saturation coefficient system or cost benefit analysis—which would have to be considered. So far as it pertained to the relative assessment of the condition of the existing road system, there was no doubt that this numerical index method was probably the best guide.

However, the idea being a numerical index, all the extraneous elements which could not be numerically assessed such as personal bias of the various operators using this method of assessment shall be excluded from the Paper which was to serve as a guide.

The Author had given the two motor cars equivalent of one bullock-cart. This was a point which required to be emphasized because not merely did it under-write the obstruction value in a congested traffic but it also did under-write the value of the rural system. The moment the traffic factors were increased to a larger equivalent of bullock-cart, the weightage to the village roads would also increase relatively. The relative assessment would be, therefore, much better.

The second point was about the question of setting up tolerable standards. He thought this had been done rather arbitrarily. Actually, the question of tolerable standards was a matter of relating the design standards to the standards which would meet the needs of the immediate future and this could not be arbitrary. Tolerable standards could be provided for all systems and so also relative standards for each system, but the relationship between these two should remain as such. He considered that the village system or the lower class was still being under-rated by stepping down the par values as remarked by a previous speaker.

Another point was that there had been undue weightage given and some confusion created by just high-lighting one aspect of this rating study by concentrating on the road service life. He thought that for every element before it was actually put into use, a manual would have to be developed to study all the factors. He felt that the same could have been left without controversy to future date when the method was practised and used.

Regarding the selection of control lengths, the Author had proposed that the minimum length should be 5 miles and the maximum 20 miles. That was not the correct position as far as the method was actually operated in practice. Actually, control length was based purely on uniformity of conditions obtaining not for one factor but for all the factors. The moment the uniformity of condition, either from service conditions or structural adequacy, changed, naturally the control length changed. But that was only for the purpose of survey and would not bring in obstruction from any construction contractor because for purposes of contract the road was split up in sizeable lengths.

Shri Fateh Chand * felt that it would be more within the range of practical politics if adequacy assessment was made separately for development and maintenance. For development a formula on the lines of the one devised by the Chief Engineers at Nagpur, would perhaps be more suitable with certain modifications on the basis of experience gained during the past 15 years. In any scheme of Planning, the urgent necessity of providing a cheap all-weather road, whether surfaced or not, which could be negotiated by mechanised transport, within a reasonable distance of every village or agricultural or industrial centre, should not be lost sight of.

In laying down standards the Author had suggested the same cross slope for berms as for road crust. In his opinion, the cross slope of berms should be 1 in 36 irrespective of the type of road crust and the camber given to the latter.

For maintenance, it should be comparatively easier to assess adequacy on the basis of the type of surface, nature and volume of traffic and local rates and conditions.

Shri D. G. Bhagat (Author) in replying to the discussions stated that the purpose for which this Paper was written seemed to be justified by the keen interest it had evoked. As many of the points raised by the speakers covered common ground he would answer only the main points rather reply to each speaker individually.

The first point was that the method proposed by him had been mixed up with the sufficiency rating system adopted in the U.S.A. The latter had three categories instead of four now suggested. In that country proper scientific methods were largely adopted for the design of composition of crusts, alignments, etc., and they were properly co-related with the soil conditions, physical environments and the traffic requirements. Besides, they had evolved a rational and comprehensive system for compilation of inventories of materials. As such, there would seem to be no particular need to assign any specific weightage to the aspect of "situation".

Some speakers had suggested that structural sufficiency and traffic carrying capacity should be the only basis for evaluation of the adequacy of a road. In India, some roads were absolutely inadequate in pattern and structure from the traffic point of view and in some cases roads did not carry the traffic which they could carry with the result that emphasising only the structural aspect or the traffic aspect without suitably linking these with

* This comment was received in writing.

the other corelevant features like geometrics, locations, etc., would not give any comparable results and he could not say whether a brief system based on only one or two peculiar aspects would be worthwhile. Our roads would need a long time before they could be brought to proper standards.

Elimination of factor of situation under the road conditions obtaining in this country would not seem to be correct. It was not clear to the Author as to how a hill road could be dissociated from a road passing through plains or a road situated in a waterlogged area from one in sandy stretches. Obviously a road in a waterlogged area would need greater attention than a road passing through hilly or rolling country and, therefore, to that extent, it would have a lower rated value. He had purposely introduced the 4th category of 'situation' because of the fact that conditions along roads varied not only in each State but even in each sub-division.

One of the speakers had suggested that attention should be confined to only maintenance aspect while another speaker had proposed that maintenance cost should be the basis for designing the priority in which the roads should be taken up for further development. He personally did not think that the cost of maintenance could be the only criterion because the costs varied considerably in different regions, e.g., an earth road in one State took as much as Rs 200 per mile while in the other State it was as low as Rs 50. Even in the case of W.B.M. the rate of maintenance varied from Rs 800 to about Rs 2,000. Besides, the maintenance figures in some States were based mainly on maintaining the carriageway. But the road as a whole must be considered on a unit basis with all its other accessories added to it. The idea behind combining the priority rating, as now suggested, both for construction and maintenance was that maintenance should not be dissociated from the construction aspect. While proceeding with maintenance, efforts should be made to gradually and systematically improve the road also as far as possible simultaneously, and only thinking of maintaining the road surface as an integral basis of policy would not, in his opinion be quite correct.

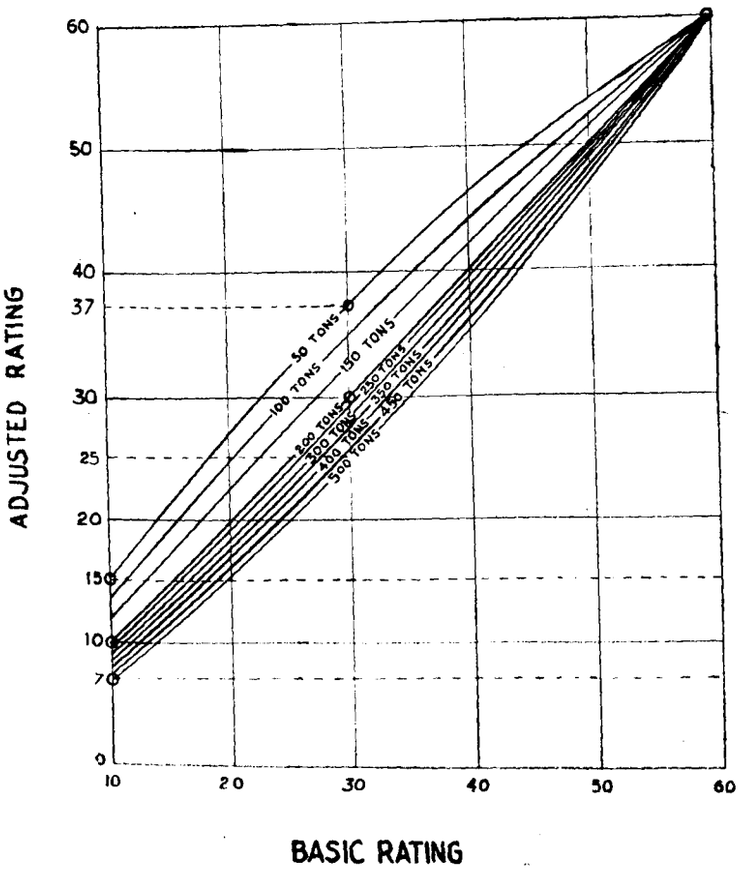
Shri G. C. Khanna had raised a very interesting issue about the economics of road improvements.

The economic factor relating to the comparative costs of various types of surfaces was purposely excluded from the study because he thought that this question was more associated with the construction aspect of the road crust rather than with the evaluation of its current condition.

A pertinent point had been raised about the various curves and other formulae indicated in the Paper. He did agree, as already stated in the introductory remarks, that the adjustment curves for basic rating values given on page 126 followed the trends indicated by Gordon Baird in the U.S.A. But he had made necessary modifications to suit the conditions obtained in this country. If it was felt that the adjustment margin for the traffic varying from 300 to 1500 tons affecting the basic rating of 50 from 37 to 70 was of a very long range, he certainly had no objection if it could be suitably modified on any other rational basis which would equitably suit variations in the traffic data. He personally thought that the suggested adjustment values brought out the factor of traffic more prominently in the evaluation chart than what would be obtained from the normal rating. He, however, agreed that with these curves, the village roads were at a slight advantage, suitable modifications in this respect could be introduced in the curves. (N.B. The Author has subsequently carried out further work in this connection. He is of the opinion that the curves given on page 126 covering the traffic range from 300 to 1500 tons should be applicable only to roads having metalled or a higher type surfacing and normally in this country, upper classes of road consisting of Express Highways, National Highways, State Highways and Major District Roads would come under this category. The roads carrying lighter traffic would come under unmetalled roads and would inculude other District Roads and Village Roads and he had evolved a separate set of curves for working out adjustment values for the traffic range varying from 50 to 500 tons. The adjusted values for a basic rating of 30 vary from 25 to 37 and the maximum par value has been limited to 60 which was what had been considered adequate for other District Roads and these are usuallay unmetalled. The effects of adjustments on the basic rating values would thus be in comparable proportions and not unduly upset them.)

The curves are given on next page.

In regard to the question of life values raised by some speakers, the Author explained that these had been taken from the study carried out by Iowa State College, U.S.A. The basic approach was that the maximum life of a road should be taken about 1½ times the normal working life which could be considered safe for salvage purposes. The periods of life now adopted were slightly different from those shown in the Iowa College curves but these were generally what we normally assumed in India in our road estimates. This, however, was not the final word. A lot of detailed study would have to be done to come to a final decision in regard to the correct assessment of the life of roads of various types of surfaces.



ADJUSTMENT CURVES FOR BASIC RATING VALUES
(FOR UNMETALLED ROADS)

Some speakers had suggested that an averaging system under different classification of roads such as good, fair and bad roads extending to longer reaches should be adopted. Personally, he thought that averaging system should not be applied. Each section having a length determined according to its physical and functioning characters should be considered on its merits. He was, however, completely in agreement that the length of the unit should be reduced even to 1 mile as suggested by one speaker but the question was whether it would be possible to do so with the present staff and the present resources available.

Actually the proposed adequacy assessment study must be followed up further by a countrywide probes and detailed preparation of inventory of road materials, and other fiscal and economic service. But unfortunately, in his opinion, this would, in practice, take a very long time yet.

Some speakers had raised the question of inadequacy of the existing crust and greater weightage being given to that element. The main question to be considered in this respect was that, expecting for a few road crust designs that had been made on proper scientific basis in the recent periods, all our road crusts were by and large inadequate, and if insufficient thickness of our road crusts was to be the main criterion for determining their adequacies, he was afraid that astronomical amounts would be required to upgrade all our roads.

One speaker had suggested that the weightage given to bullock-cart traffic in relation to pneumatic tyred traffic in the proportion of 2 : 1 was too low. The Author was guided in this respect only by the consideration of stress intensities based on the research carried out by the C.R.R.I. He would, however, be glad to pursue the matter further and introduce necessary modifications in this aspect if he was given sufficient information on that point.

One speaker had suggested that the riding qualities of a road surface should be assessed by mechanical contrivances. It would be seen from the rating system that the marks at par value for riding quality were of the order of 4 only. Whether a visual survey was done or a resort was made to mechanical contrivances, he thought, that the difference in results would probably not be very significant as for practical purposes, visual observations of a practical engineer would certainly be pretty close to what would be obtained with the use of mechanical contrivances.

Shri Tejbir S. Khanna had suggested a very good formula for working out the correction adjustment in respect of traffic. The formula advocated seems to be highly mathematical. It had, however, to be seen whether this formula gave widely divergent results from those obtained from the use of curves, and if they did so, he would certainly be, too, happy to take to the new formula.

Shri Khanna had further suggested that the adoption of element of traffic should be based on the traffic volume rather than on the tonnage. He did not agree to this as it would introduce computation factors accounting for different sizes and weights of various types of vehicles going over the roads. The total tonnage on the other hand, gave an easy workable basis

for the purposes of comparisons and the results obtained would probably not be appreciably different from what were likely to be, if the traffic volumes were adopted as the basis.

Shri Khanna had advocated qualifying minimum values for the categories of safety and service. This is a useful suggestion, which might be adopted in due course, after the assessment system had been properly developed in its actual application. Its use in a broad way would also be helpful, particularly in adjusting conflicting priorities.

One speaker had enquired whether the Author had tried to correlate the village road adequacy index as given in the Paper into actual field assessment and whether the par values of various classes of roads as given in Table on page 128 were to be applied proportionately amongst all the elements with different groups. The Author explained that the absolute par values shown in Table on pge 128 against various classes of roads would broadly correspond to what would be obtained by the summation of the par values of the component elements applicable to a particular class of road.

The proportional distribution amongst the component elements would obviously apply to the elements applicable to the road under consideration, for instance, items of B. T., etc., would not be applicable to an unmetalled road and so the question of distribution of par values amongst all the component elements did not arise. The 2/3rds tolerance value was, however, arbitrary. If this was considered on the low side, any other ratio would also do, provided, it fitted in appropriately with the overall picture of the road system and the availability of funds for its development.

Shri U. J. Bhatt (Chairman) in his concluding remarks thanked the Author for his valuable contribution. Actually, he said, adequacy of traffic requirements for all our roads must be assessed, bearing in mind that this was to be looked upon as a tool for planning and not as a substitute for planning. If it was thus used, very valuable results should be obtained. There was a controversy over the weightage on '4 S 's'; that could be varied. Another point was, that the study had been styled as academic because no experiments had been carried out under Indian conditions. He was wondering whether it would not be worthwhile for Chief Engineers in charge of roads and other authorities to carry out adequacy assessment and then pool their knowledge and results and evolve something rational which could be recommended for uniform practice all over the country.

Discussion on Paper No. 208*

" Traffic Survey In and Around Calcutta "

By

S. K. LAHA, A. K. DAS GUPTA & S. CHATTERJEE

Thursday, 8th January, 1959.

Shri R. N. Dogra (Chairman) called upon Shri S. K. Laha one of the Authors to introduce the Paper.

Shri S.K. Laha (Joint Author) in his introductory remarks stated that the city of Calcutta proper has an area of 38.2 sq. miles and because of the situation of the river Hooghly on the west and the low lying areas on the east, the expansion had been possible on the north and south only. A century ago, the city had a population of few thousand people only and this rose to about 1.22 millions in 1941. As a result of the partition of Bengal, the heavy influx of refugees from East Pakistan raised the population figure to 2.7 millions in 1951, i.e., a rise of 1.5 millions in 10 years. Apart from the stationary population, there is further concentration of about 0.3 million people every day from suburban areas. Taking into account the adjoining municipal areas of Howrah, Garden Beach, Cossipore, Dum Dum and Barnagore, which could reasonably be taken within the orbit of greater Calcutta, the population figure might be taken to be of the order of 4 to 5 millions.

The city in the begining had 400 miles of road. The road milage rose to about 460 in 1956. The increase in road mileage is hardly commensurate with the tremendous rise in population.

Along with the rapid increase in population there had been tremendous rise in vehicular traffic. With huge increase in population, negligible corresponding increase in road mileage and the enormous demand of fast vehicular traffic, circulation and control of traffic assumed a gigantic problem. This had further been complicated by the slow moving traffic of hand carts, bullock carts, hand drawn rick-shws, etc.

A thorough study of the problem had, therefore, been attempted in this Paper with the help of a traffic survey to examine it from all possible angles.

* Published at pages 185 to 245 of the Journal of the Indian Roads Congress, Vol. XXIII-Part 2, December, 1958.

The traffic survey was divided into two categories, viz., the internal survey and the external survey, linked with origin and destination. This survey was made first in 1950 and again in 1957 particularly for making a comparative study.

In the internal survey, traffic counts were taken at important crossings of streets and roads. Both fast and slow moving traffic was recorded and the equivalent traffic worked out. Shri Laha further stated that in order to relieve traffic congestion in the city, certain recommendations had been made in the Paper in the light of the study carried out. He would be grateful for further suggestions which members might have to offer.

Shri N. S. Surya referred to the Table at page 199 of the Paper showing the number of vehicles passed in an hour corresponding to speed and the distance between successive vehicles. Actually if results of investigations to find out the spacing between vehicles at different speeds were taken into acount, the number of vehicles per hour would be modified somewhat as follows (for a two-lane road):

20 m.p.h.	— 60 ft	—	1750
30 m.p.h.	— 80 ft	—	2000
60 m.p.h.	— 220 ft	—	1750

This basic capacity would be reduced to a practical or design capacity by such factors as deficient alignment, width of lanes, percentage of trucks, percentage of length with inadequate sight distance and other similar factors.

He further suggested that efforts may be made to obtain other basic data from future censuses which would help the engineers in the geometrical design of highways. In the United States, the following traffic information was invariably obtained before designing any important road. A.D.T. (or Average Daily Traffic), D.H.V. (or Design Hourly Volume), K ratio of D.H.V. to A.D.T., D, directional distribution and, T, the percentage of trucks in the D.H.V. By taking continuous counts over long periods of time, they had found, for instance, that K was 12 to 18 per cent, D varied from 50 to 80 per cent and T was between 10 to 12 per cent. In future censuses, it might be arranged to collect such data here also. It was also worthwhile considering whether we could arrange to get traffic figures for every hour at least at one or two points to have an idea of the traffic in the 30th maximum hour, 40th maximum hour, and so on.

Shri G. C. Gupta stated that the Authors had given the figures of traffic flow, but the procedure by which this traffic

survey was conducted was not given. Similarly, for studying the traffic problems, an intensity was worked out from average daily traffic. The ratio of maxmimum hourly traffic to the average daily traffic was found to be nearly 1:10. This, of course, varied from country to country. A second alternative to get the design traffic was to work on the basis of 30th peak hour traffic. He wanted to know if the Authors had used some of these rational procedures to work out the maximum intensities of traffic.

The Authors had assumed in the Tables given in the Paper that one slow vehicle was equivalent to four fast vehicles. This appeared to have been done on the basis of speeds of vehicles whereas actually the problem was very much different in a mixed traffic. Mixed traffic essentially resulted in overtaking and the overtaking distance, divided by the optimum space for one fast vehicle, would perhaps give a more correct equivalent. However, he requested the Authors to consider this in assuming these values.

Shri A.S. Adke stated that the Authors had given an interesting account of the growth of the city of Calcutta as well as the traffic conditions. Seeing the growth of population in the last 10 years wich was over 15 lakhs and also the growth in the traffic conditions, he could not imagine what would be the position after a few years hence. So it was high time that the engineers started thinking as to how to restrict the growth of cities. In order that these conditions did not arise in the new industrial townships that were being erected, he emphasized the need to take steps to remove the business centres from the city and whenever new industrial installations and factories were to come, they should not be allowed in the congested localities. Of course, this was outside the scope of engineers and as such they could only suggest to the Govt. to see that business and industrial centres did not grow in large numbers in the heart of a city and, wherever possible, such centres should be removed to less congested parts of the city.

Shri T. R. Sehgal stated that traffic was a very highly variable material, the flow varied in different seasons of the year, different days of the week and again different hours of the day. He was not sure if the Authors were correct in basing their recommendations on a single day's count, which appeared to have been selected arbitrarily.

For calculating equivalent fast traffic for different types of slow vehicles, page 197, the Authors appeared to have been guided by the speed factor only. They had obtained a multiple factor of 2 for trams and 4 for bullock-carts, rickshaws, etc. This flow they had utilized in comparing the theoretical and actual capacities of different roads. This seemed to be incorrect and might lead to wrong conclusions, as capacity was not only the function of speed but also of the occupancy of space per unit time. Thus the size of the vehicle was another point which should be considered while applying theoretical basis for the calculations of the capacity. Also, the multiple factor for trams and push-cycles was the same, while it is commonly known that the trams reduce the capacity of road to a great extent. The correct method would be to statistically analyse the effect of different types of vehicles on the speed of fast moving vehicles by, what is commonly known as, multiple regression method and then equate them directly in proportion to the size of the coefficient of regression for each type of vehicle. A fundamental work in this direction had been done by Wardrop in England.

Shri Sehgal stated that the theoretical method given by the Authors to calculate the capacity per lane per hour was strictly applicable to one type of traffic only as found in the western countries. The calculation of capacity of a lane under mixed traffic conditions was quite complicated. Regarding the statement on page 198 that the capacity increases as speed increases up to a speed of 25 m.p.h., but beyond this speed, as the safe distance betwen the succeeding cars increases, the capacity decreases, needed a check in the field and the Authors should have given practical data for some roads in Calcutta in order to prove their point than merely giving a Table on page 199—based again on theoretical calculations.

Shri Sehgal did not agree with the Authors' conclusion regarding determination of average speed by giving range of minimum and maximum speed observations, as this might sometime lead to wrong conclusions as the correct statistical average under these conditions should be the 'mode' value. Mode is that value which occurs most frequently and not the arithmetic mean as taken by the Authors.

Shri C.L.N. Iyengar stated that for calculating the capacity of the lane, reaction time should have been included in addition to the braking distance obtained by the speed and friction factor. The time gap of 4.8 seconds worked out by the Author between successive vehicle could be correct for vehicles going at almost the same speed, but where the speed variations were very large, possibly the time gap would not average out to 4.8 and it might be more, say, six seconds or so. A more practical basis was needed to work out the capacity of the street in its different degrees of traffic like congested condition or free flow condition, etc.

As stated by him previously also, there seemed to be a lot of confusion in regard to the traffic equivalents of different types of vehicles. In the Paper equivalents had been worked out by grouping all the fast moving vehicles together as though they were all forming vehicles of a uniform nature. It had been accepted throughout the U.S.A. as well as in Europe that the commercial truck equivalent of passenger vehicle, in which term we always refer to capacity, was roughly equal to 3, though in various degrees of performance the equivalent might be 2 to 12. Similarly as motor-cycle had been taken as half of a motorcar, for other types of vehicles corresponding figure have to be evolved from certain statistical basis.

Shri Iyengar further pointed out that there were certain observations which appeared to have been made a little at random. Saying that registration of motor vehicles cannot directly indicate the actual number of vehicles on the roads was correct in the sense that it does not help to assess the traffic counts at various stages because of the out-station vehicles which also come in the traffic picture in variable quantities. The registration records have very little value if you want to develop an expansion factor for a particular street, but they have got a high value if you really want to assess the expansion factor on a city or countrywide basis.

Regarding the remark in the Paper that origin and destination data would be of little importance for internal traffic, Shri Iyengar stated that it was a gross mis-statement in the sense that actually some of the investigations showed that a very large relationship existed between zonal interchanges as they were called and the traffic. The type of land use and also the changes in land use give a direct indication of the increasing number of vehicles which were originating in a particular district and were destined towards another district. Some of the surveys in Melbourne and Chicago where these series were put to a very high degree of practice showed that a mathematical formulae could be evolved on the basis of land use to find out the desired data. It was rather premature to judge on the basis of a short count of one or two days in Calcutta that origin and destination surveys had little value.

Shri M. Meeran thought that the Paper was meant to dea with only the procedure of traffic surveys for the city, but h found at the end of the Paper that certain recommendations ha been made with regard to traffic improvement. Fundamentally it was not correct to take up the question of recommendation for traffic improvements for a city only on the study of traffi movements and traffic requirements. Traffic requirements an

planning of traffic improvements, he stated, had to be integrated with city planning as a whole. City planning comprised broadly 4 aspects: (1) population distribution, (2) industrial and commercial requirements, (3) communications, and (4) the recreational facilities and the like. Thus the traffic needs and traffic surveys was only one item and that had to be very closely related or integrated with the other requirements. Therefore, it was not safe to suggest any remedies or improvements of traffic conditions without going into the question of the other three important aspects of the city needs. The end should be to aim at getting remedies to the problems and not just what might be called first-aids. As one of the speaker had pointed out, the solution might lie in the direction of diverting industries from the centrally congested parts of the city to the outskirts. There, again, merely diverting the industries would not give a solution, but the people attending on the industries must also be residents round about the industries.

With regard to the installation of automatic signals recommended for internal traffic, he wondered how the installation of automatic signals was going to improve the traffic conditions. That would only mean replacing a constable at some traffic points by more initial expenditure by installation of signals.

Regarding another recommendation about the orderly movement of vehicles, he asked if it meant channelising the various kinds of traffic by regular lanes in the road or by some other means, as it was not clear what was meant by orderly movement. Regarding the fifth recommendation for improvements of crossings, wherever possible with special attention to pedestrian traffic, Shri Meeran stated that merely having specified definite places for crossing of pedestrians would not give all the benefit and in this connection he suggested that pedestrians crossing must be on grade separation and not on level, i.e., either by overhead crossings or by subways.

The sixth recommendation about diversion of traffic by way of construction of Great Circular Road (in Calcutta) was a matter which had got to be decided on the basis of a comprehensive and integrated planning of the city as a whole and not on the traffic needs alone.

With regard to the external traffic, Shri Meeran did not agree with the suggested provision of elevated railways inside the city. The sad experience of the city of Chicago should serve as a guidance in this matter. It was better to think in terms of underground tubes. If that was not possible, elevated roadways should be considered.

Shri D.L. Gupta felt that all the accidents occurring in Calcutta and the persons involved therein were not fully reported to the police department and his impression was that the number of accidents as the fatal cases were more than those enumerated by the Author. Another thing noted by him in Calcutta was the practice adopted by the fast-moving traffic in overtaking from the left, and very callously allowed by the Police Department. Such a practice, he felt, needed immediate attention and stoppage by careful handling of the situation both by the P.W.D. Officials and the Police Department.

Shri Tejbir S. Khanna stated that the reaction time of 3 seconds given on page 198 of the Paper should not be more than one second. Generally it varied from .75 to 1 second. Further, the Author could have adopted a slightly improved way of making a survey by having full origin and destination survey as pointed out by Shri Iyengar earlier. That would have helped tremendously. Also, the method of recording for 3 hours together should have been changed to 15 minutes or half an hour interval for selecting the highest hours as there was never equal distribution of traffic during all the time and during particular hours as assumed by the Authors.

Shri Khanna added that the Author had said very little about accidents. He asked if there was any scientific investigation of accidents going on in Calcutta ? It would have helped if the Authors could train the Police or their own department people for carrying out scientific investigation of accidents because Police were mostly interested in trying to find out the party at fault, whereas our object was to find what caused the accident; how it could have been avoided; what time of the day; whether it was the road vehicle or road user at fault, the details of the road user, such as his education level, age, sex, income level, and other habits. If efforts were made to find this it would have given a clue as to which group needed maximum education for deciding the priority.

About blind corners, Shri Khanna felt that the main emphasis should be given in trying to remove black spots from the cities. Legislation was required for improving the black spots and to get rid of the blind corners in built up areas.

Regarding conversion of one form of vehicle to another, Shri Khanna said that as pointed out by Shri Sehgal, there were two main factors, the speed and the space occupancy. To find out how much weightage each should be given, needed a lot of research. He further stated that capacity did not decrease after 25 m. p. h. but after 35 m. p. h. and there was no further necessity of research on that point as it was now well established.

Another main point that should be emphasised in the recommendations was about improving the drivers. He proposed that there should be driving schools recognized by the Government and those schools should have necessary equipment such as dual control cars, etc, and before a learner driving licence was issued, an applicant must be examined in Motor Vehicle Act under Schdules 9 and 3, i. e., about the road rules. After he had passed the road rules, then only should he be given the learner's licence. In Delhi, this was not the practice for the time being. If that was done, it would reduce the number of accidents to some extent.

Another big problem was about the relationship between the police and the court. In a number of cases under Sections 279, 304-A and 338 of the Indian Penal Code, no action was taken, either because of lack of evidence or lack of witnesses. The police needed definite training for this purpose.

Shri Khanna stated that in the Motor Vehicle Act, there were only few roads signs and those, too, were obsolete, and suggested that new legislation was required to improve them as had been done in America. The C. R. R. I. was working on that.

Another serious problem commented upon by Shri Meeran also was about the placing of industrial areas with respect to certain other areas. He recommended that all future plans of development of Calcutta should be passed by a traffic expert who would look at it purely from traffic point of view and give his opinion. That would help to solve many problems at the planning stage itself.

Shri Fateh Chand* suggested that traffic census should be taken every year and simultaneously at all stations and crossings at least once in 5 years. The latter could be made possible by requisitioning the services of other departments, particularly educational institutions as is done at the time of general election. The duration may be 3 days only. Weight of commercial vehicles should also be taken by providing automatic weighing platforms. Source of origin and destination should be recorded for external traffic only as suggested by the Authors for fast traffic and card system could be adoptod for this purpose as in several western countries.

Regarding crossing section for Chittaranjan Avenue he suggested a footway of 12½ ft on each side followed by 15 ft slow traffic lane and 2½ ft islands on both sides and a 40 ft central width for fast traffic divided by a white traffic line in the centre,

* This comment was received in writing.

thus allowing 2 lanes for each side for fast traffic. For other roads, the width should be suitably increased according to actual traffic requirements.

Segregation of fast and slow traffic could be done by providing a separate lane or by widening the road sufficiently, which would automatically keep the slow traffic on the left portion of the common road. External traffic should be directed by one or more circular or diversion roads at different points. He did not favour complete prohibition of slow traffic on any road. He agreed with the Authors that provision of automatic signals, regulation of speed, marking of traffic lines, provision of suitable parking and halting places, improvement of crossings and construction of diveraion railway tracks would also go a long way to relieve congestion.

Mobile courts were not recommended by him because these would cause further congestion on the road.

Publicity should be given by leaflets, local newspapers and at meetings not only to traffic regulations but also to the prosecutions made and punishments awarded.

Shri S. K. Laha (Joint Author) in reply to **Shri N. S. Surya** stated that in computing the capacity of a road, two methods were adopted and it was seen that both the methods led practically to the same results. The first was based on the distances within which the driver of a motor vehicle can come to a stop without colliding with another. The formula used for the purpose of finding the braking distance is based on American Standards. The reaction time, which had been taken here as 3 seconds, was a bit on the high side, instead of 1 second as determined by the National Institute of Industrial Psychology, London and corroborated by the Bureau of Standards, Washington. Considering that the control of the steering wheels of lorries, buses and other transport vehicles in our country is done by persons who have much lesser traffic sense and who react rather slowly, liberal considerations had to be given for reaction time.

In the second method for computing traffic capacity of a road, ideal conditions had been assumed first for a thoroughfare uninterrupted by cross-roads, and theoretical values obtained, and these figures were brought down by putting limiting conditions that were actually prevailing on the road.

It had been pointed out in the Paper before presenting the Table on page 199 that the capacity had been computed under perfect ideal conditions, which, of course, did not exist in reality.

It was, therefore, not clear how Shri Surya had arrived at the capacity mentioned by him. As a matter of fact, the safe distance apart between successive vehicles would invariably depend on so many divergent factors such as quality of road surface, conditions of road surface, braking efficiency of the vehicles, wind conditions and personal factors of the drivers concerned, etc.

The suggestion for obtaining traffic informations like average daily traffic, design hourly volume, directional distribution, etc., did not, however, hold good in this case, as the problem was not of designing a particular new road, but of solving the enormous impact of traffic with the existing alignment of roads in the city of Calcutta.

Referring to **Shri G. C. Gupta's** comments, the Authors stated that although the detailed procedure of traffic census for both internal and external traffic was given in the original Paper, that portion was omitted to reduce the length of the Paper. However, a very brief statement had been made in paragraphs 2.3 and 3.1 of the Paper.

In working out the maximum traffic intensities, six hours average from 9.00 to 12.00 hrs. and from 16.00 to 19.00 hrs. had been taken. It had been found that the intensities of traffic appreciably increased during these periods and it was not understood how that procedure appeared to Shri Gupta to be somewhat irrational.

The Authors were absolutely in agreement with Shri Gupta's remarks with regard to the multiplying factors for converting slow traffic to equivalent fast traffic. Really the problem was extremely complicated in a mixed traffic condition. But in the absence of any other suitable method and factual data, they were guided by the speed factors only.

In reply to the points raised by **Shri A. S. Adke**, the Authors stated that urban life essentially differs from its rural counterpart in respect of easy availability of important conveniences. The balance is lost as soon as the optimum capacity is exceeded. It is, therefore, essential to put some limitations with regard to the expansion of city areas. Legislation is required to be enacted and the responsibility no doubt rests with the authorities empowered for planning, both on national and local basis.

Shri T. R. Sehgal was very correct when he emphasised the need of taking census figures in different seasons, in different days in a week and different times in a day to arrive at a dependable figure with regard to the flow of traffic. But with the limited resources available nothing better could be done.

Referring to **Shri C. L. N. Iyengar's** comments, the Authors stated that reaction time had been taken into account in calculating traffic capacity per lane and included in the calculations (page 198). This probably had escaped Shri Iyengar's notice.

Regarding registration of motor vehicles and the actual number now on the roads it was gathered from the Police (Traffic) Department, West Bengal, that though the total number of registered vehicles in Calcutta area was about 84,000, a much greater number of vehicles was actually plying which was due to either duplicate numbers or spurious numbers; the actual figures would have been to the tune of 1,25,000. Nevertheless, the number of registered vehicles as a whole would not directly throw any light on the actual number of vehicles plying on the road. This particular problem had also some effect on the assessment of the number of motor vehicles in the country as a whole. It was absolutely true that volume counts show where the traffic is moving at the present time. This is, however, not a positive index of where it desires to move. For this Origin & Destination of traffic is of basic importance to arrive at a possible new alignment to provide direct routes, to improve the congestion of some existing thoroughfares, etc. But for the City of Calcutta, there was practically no scope for construction of new alignments of widening the existing roads due to obvious reasons of compensations involved and financial implications. As such, O.D. for local traffic would give practically no clue for the solution of the problem. Moreover, there being great difficulties and technicalities involved in the work and with very limited resources at our disposal, a comprehensive O.D. Survey did not seem to be feasible. But for External Traffic the O.D. was considered to be essential and that had been done.

The Authors agreed with **Shri M. Meeran** that traffic congestion and accidents were becoming more and more complex everyday due to unregulated expansion of city suburbs. The real solution of these problems lies in decentralisation of Commerce and Industries, and land-use control for which a Metropolitan Regional plan for the City of Calcutta is essential indicating the stages of developments. Moreover it should not be forgotten that Calcutta is a City where there is very little scope for improving the existing road alignment unless one is prepared to spend a very enormous sum.

Installation of automatic signals—These installations not only replace the traffic Police thereby effecting economy in the long run, but they are able to work on precise and predetermined periods with automatic regularity and to adjust their periods with precision to the volume of the traffic. Automatic

signals are more visible and more easily read specially after nightfall and during rains. It is also found that drivers become more confident and quicker in action when automatic signals are used. Automatic signals on a flexible progressive system affords most satisfactory co-ordination. When the speed, for which these signals are set are advertised at each end of a system (which may vary during different parts of the day) the drivers who watch their speed can be assured of a clear run. This system has an additional advantage that it discourages "Racing". Some installations of this nature are in use in big cities in England and in America with very good results.

Orderly movement of vehicles. This means to remove all possible obstruction of the free flow of traffic, i.e., channelising the various categories of traffic and to remove anything which may induce the drivers to infringe upon the space provided for the traffic coming from opposite direction. For example continuous stopping and starting of transport buses at any point of the road will invariably cause obstruction of free flow of traffic and there will be a tendency on the part of the drivers following these vehicles to bye-pass the buses through the carriageway which is probably not assigned for them, thereby causing possibilities of accidents or of traffic congestion. Tramcars are worst in this respect. The capacity of the road is very much affected where orderly movement of vehicles is not maintained.

The Authors entirely agreed that provision of grade crossing for pedestrians at all places were most desirable but considering the finance involved in such works, specified definite places for crossing of pedestrian was something better than nothing.

The recommendation with regard to the construction of Greater Circular Road had been based not only on traffic requirements but also on other considerations.

Elevated railways were not always favoured but they had been just mentioned as an alternative method, since construction of underground tubes in the city had been ruled out by experts owing to the typical alluvial soil of Gangetic delta, very high sub-soil water level, rain-fall conditions, etc.

There was much truth in **Shri Gupta's** statement that all number of accidents and total cases were not in record, but they had to depend on the figures available from the Police Department, as there was no other practical way to get the figures.

Overtaking of vehicles from the left was a serious offence which could only be effectively dealt with by the authorities

empowered to do so. P.W.D. Officials and Highway Engineers could help only to rouse up strong public opinion in the matter.

The Authors agreed with **Shri Khanna** for taking the counts at staggered periods instead of continuous counts. The method of recording accidents and its scientific investigation with regard to the causes was for the present primarily left with the Police Department and they had appointed a qualified Traffic Engineer to look into it and to suggest possible improvements.

Optimum capacity at 25 m.p.h.—The theoretical optimum traffic capacity per traffic lane stated by a reliable authority is 25 m.p.h. It was not, however, clear how Shri Khanna had said that it was 35 m.p.h. The Authors would like to be enlightened on this point.

As regards driver's licence, it was the recommended practice in Calcutta that no professional licence was given to any driver unless he came through a recognised Motor Training School and before he was allowed a Learners' Licence, he had to know the traffic rules and regulations as well as traffic signs and signals. The tests were rather rigid in this respect. But it should be borne in mind that the psychology of a professional driver for transport vehicles was quite different from others and that gap could not be covered by any amount of instruction.

In West Bengal, the Govt. had established a Police Training School to train up traffic police regarding every aspect of work he will come across during his duties. As regards the delay in reporting and hearing of traffic cases, they had suggested Mobile Courts. In fact, for the last 3 years Mobile Court was tried off and on at various suitable points to make spot decisions regarding violation of traffic rules and regulations, namely speed, overloading, braking efficiency, registration, licence, etc., which gave wonderful results.

Inadequacy of road signs was very much felt in this country. Other advanced countries had gone a long way in this matter. It was certainly gratifying to know that the Central Road Research Institute had taken up this task. The Automobile Association of Bengal was quite active in this respect and was assisting the State in the matter of road signs on arterial roads.

The Authors also agreed in general about what **Shri Fateh Chand** had suggested in his comments excepting on a few minor points.

Weight of commercial vehicles plying in the City could be had from the Motor Vehicles Deptt. wherein the R.L.W's were recorded. But it was not clear why that was necessary in a city of existing roads. Recording of wheel loads and its frequency were necessary in connection with the design of pavements. But such exigencies did not at all arise here.

Considering the types of men employed in driving vehicles, it was very much doubtful if the card system would become at all successful in determining the O.D.

In his recommendation for a revised cross-section of Chittaranjan Avenue, Shri Fateh Chand might have missed to provide spaces for parking vehicles. For this purpose, 18 ft width had been allocated for parking cars parallel to the kerbs as well as space for slow-moving traffic.

The width of a road is a guiding factor for segregation of fast and slow traffic. It was for this reason that complete prohibition was necessary for slow moving traffic during peak hours on important roads.

Attempts to educate both pedestrian and vehicle drivers were made by the Police Deptt. through loud speakers near important crossings at peak hours.

Shri R. N. Dogra (Chairman) in his concluding remarks commended the Authors for focussing attention on a very important subject that should receive the consideration of the traffic engineer as well as the police and administrative authorities. With the organization going on in the country at the present moment on account of economic development, there was a defined need for studying this problem and finding out certain solutions. He thought that a Paper of this nature was not a solution of the problem but merely an attempt to focuss attention from which could emerge various recommendations to form the basis of some sort of plan for the future.

In connection with statistics, Shri Dogra stated that it was a very important subject which was being overlooked in the country not only for roads and traffic but in other directions as well. Statistics in the country, he felt, were not being collected scientifically and accurately nor maintained and utilized properly. Taking that all the traffic statistics required a period of at least 5 to 10 years before they could yield any results, he stressed that it was time that they start collecting the statistics and try to put them in records.

In the end, he thanked the Authors for having brought this very important subject before this august gathering and the various speakers who had contributed to the discussion.

Discussion on Paper No. 209*

"An Investigation of a Concrete Pavement Failure"

By

DR. BH. SUBBARAJU & Y. C. GOKHALE

Thursday, 8th January 1959.

Shri K. V. Ekambaram (Chairman) while calling upon the Authors to introduce the Paper stated that investigation of a concrete pavement failure is important as with all round increase in traffic more and more concrete pavements are likely to be laid. Generally the opinion prevailed that concrete roads being the costliest type of roads nothing would happen to them at any time. Investigation of failures, therefore, provided several lessons to be learned and profitted by.

Shri Y. C. Gokhale (Joint Author) in his introductory remarks stated that this Paper described the systematic investigation carried out to find the probable causes of failure of the 4 in. thick and 12 ft wide cement concrete pavement laid on Belgaum—Khanapur road in Mysore State. The particular road under reference runs alternately through red and black soil regions. The concrete slabs laid in the red soil regions were still in good condition while the slabs on the same road laid in the black soil area had shown signs of distress by way of central longitudinal cracking within a short period of 2 to 4 years. The cause of the failure had been attributed to the excessive swelling and shrinking properties of the black subgrade soil. A salient feature of this investigation had been the determination of flexural strength of concrete from the beams cut out from the actual road slabs. Based on theoretical consideration, stresses induced in the slab due to wheel loads and temperature differentials had been calculated and, as a logical step forward, crack expectancy period for the pavement had been computed. It was fully recognised that several assumptions had to be made in the calculations. But it should be borne in mind that every assumption required to make only revealed the gap in the existing knowledge of the subject. These gaps could only be filled up by continuous experimentation and observation of performance of concrete pavements designed and laid according to the existing theoretical methods.

* Published at pages 247 to 278 of the Journal of the Indian Roads Congress, Volume XXIII—Part 2, December 1958.

The Author then mentioned some typographical errors that had crept in the text.

(1) Page 259, para 6.2 (b), for edge loading, in the equation instead of 'C' (capital C) it should be 'b' (small b).

(2) Page 259, add the words "lb per sq. in." after the explanation of 'sigma i'.

(3) Page 260, para 6.3, for "5×10^{6} per °F.", it should be "5×10^{-6} per °F".

(4) Page 266, first para, last but one line instead of "Stimulates" it should be "simulates".

(5) Page 266, last line, words "per inch" should be added after 'lb per sq. in.'

Dr. A. S. Adke stated that the cross-section given on page 248 showed some typical section assumed by Government of Bombay for constructing number of roads in Bombay State. The concrete width of the road was 12 ft and on either side of the concrete strip, 4 feet wide metal width was provided and the same was treated with asphalt surfacing. A number of such roads were proposed for concreting by the Bombay State, and Miraj-Sangli-Islampur road, which was 35 miles in length, was one such typical road. This road passes through different soils varying from black cotton soil to murrumy soil. At certain places it was having embankment and at certain places it was passing through cutting. Wherever the road went through murrumy soil or through cutting, there were no cracks formed and the concrete surface stood well even though the thickness was only 4 in. In places, where the road went through embankment or black soil, there were many cracks formed. In order to avoid such cracks, following precautions were taken:

1. The embankment of black soil was covered with murrumy soil on all sides to avoid the contact of moisture and consequent cracking in embankment. On such embankment soling and metalling was laid and properly consolidated in each layer. After allowing traffic for a month or so, the concrete slab was laid. This had stood well.
2. Where the embankment was heavier, i.e., more than 4 to 6 feet, in height, light reinforcement of $\frac{1}{4}$ in. bars spaced at 6 in. distance both ways were provided in the concrete slab. That had also stood very well. The additional cost was about Rs 6 to 7 thousand per furlong.
3. More expansion joints were provided.

Dr. Adke then laid emphasis on proper drainage and suggested that entry of water into the subgrade and the embankment should be avoided. The Authors had suggested a number of remedies but due to uneven settling of the base, the cracking of the surface was occuring without fail. Therefore, it was better to have good and sound base and where it was not possible, provide necessary reinforcement as stated above.

Shri N. H. Taylor suggested that when an investigation into a failure was made, it should be done with an open mind. After data had been collected on the site and laboratory tests had been completed, possible reasons for the failure would occur to the investigators. It was essential at this stage, before any reasons for the failure were formulated, that the investigators return to the site to make sure that any assumptions made were correct and to collect any additional information which might assist in completing the investigation.

The Paper revealed that the concrete road was laid on a macadam road crust from 13 in. to 25 in. thick. After the failure, the concrete was removed in various areas and what was described as "subgrade bearing tests" were made. Of course, what was being tested there was not the subgrade. Although the tests were to determine Westergaard's "modulus of subgrade reaction", what was really being tested was the strength of the base, or the macadam road crust, with its underlying soil subgrade. It was, therefore, somewhat confusing to find in Table 4 that the subgrade reactions thus determined were related to the subgrade soils below the macadam road crust and particulars were given of the moisture content etc. of these soils. The results of the subgrade reaction tests were particularly interesting because the cracked areas had rather low results of 175 to 396 lb per sq. in. whereas in the sound areas the subgrade reactions were considerably higher, i.e., 309 to 546 lb per sq. in. The Table also showed that cracked areas were associated with black soil in the subgrade while sound areas were associated with red soil in the subgrade. Since the tests were made on the macadam crust and not on the subgrade soil, this relationship between the measured subgrade reaction and the type of soil required some explanation.

It appeared to him that somehow the soil from the subgrade had become part of the macadam crust. It was probable that when the road was remetalled, soil from the roadside was used as blindage and that during dry weather soil had been taken from the sides and spread over the water-bound macadam to keep it in order. This would go on year after year so that the macadam crust was really a mixture of stone with soil from the subgrade, the soil being red in the red soil area and black in the black soil

area. When an excessive quantity of soil from the subgrade was used in macadam, engineers were lifting the subgrade to the surface.

The Authors were quite right in saying that there was no great significance in the variations in the subgrade reaction, as no result quoted was sufficiently low to account for failure. The variations recorded would not be reflected by any great variations in stresses induced in the concrete slab, except perhaps at the corners. If the corners of the slabs had broken, the failure could have been attributed partially to low subgrade reactions. As the cracks were longitudinal right down the centre, failure had been attributed quite rightly to the differential volume changes of the black soil.

Shri Taylor stated that he could not quite follow the method suggested for measuring what was described as pore pressure. These measurements had been made in a C.B.R. test mould. Above the soil had been placed a proving ring and water was introduced into the soil. The load on the ring which followed the swelling of the soil would be measured by reference to the deformation of the ring. Thus what was actually measured was the reaction from the proving ring and a very flexible proving ring would indicate a very small pore pressure while a very stiff proving ring would indicate a very high pore pressure. When it was desired to measure the moisture content of the soil during the test the proving ring was removed. Surely at that time there was no pressure on the soil or from the soil. It was not possible to have a great upward pressure from a mass of expanding soil under a concrete slab. The upward thrust would only approximate to the weight of the slab and the slab would be lifted until the swelling ceased.

Whilst he agreed with the Authors that failure was probably caused by differential movement of the soil under the slabs, Shri Taylor thought that they were mistaken in blaming swelling pressures at all for the failure and observations showed that failures were most likely to occur after the monsoon when the soil was drying and shrinking. Drying and shrinking would occur more rapidly at the edges of the road and support could be removed from edges of the road. This effect would be most pronounced at dusk after a hot day when the cooling of the slab tended to lift the edges of the slab. Under these conditions, the passing of a heavy lorry as illustrated in Fig. 6 could crack the centre of the slab. Whatever might be the mechanics of the actual failure, he considered the real cause was the laying of a thin rigid slab on what was thought to be a solid crust but what was really a mixture of road metal with soil from the road base.

In these circumstances a flexible asphaltic concrete surfacing would have survived.

Among the precautions to be taken in future, the Authors had not mentioned increasing the thickness of concrete road slabs. The report by the Road Research Laboratory, Harmondsworth, on slabs of various thicknesses laid at Oxton, Nottinghamshire, England, indicated that every plain concrete slab of 3 in. and 4 in. thickness, whatever might be the thickness of the base, had failed not because of any defect in soil but because of age. His suggestion was that in addition to making sure that the bases to receive concrete roads were solid, engineers should also satisfy themselves that the thickness of the slab was adequate.

Shri P.L. De stated that in the last para on page 256, it was mentioned that for the measurement of swelling pressure the soil was compacted at the natural moisture content which was 2.6 per cent for the red soil and 3.2 per cent for the black soil. This was not very clear to him, because again on page 273, para 7.4, the moisture contents of the subgrade soils at the time of test were shown to be different. He requested the Authors to clarify that point. Moreover, moisture contents of 2.6 and 3.2 per cent seemed to be very low for compacting such types of soil. Though the densities attained were not very high, 90, 100 and 110 lb per cu. ft., still he felt such a low percentage of moisture for this type of clayey soil was insufficient. If such a low moisture content was used, enormous pressure would be required to compact the soil to the required density.

It would be very useful if the change in moisture content shown in Fig. 4 were compared with the variations of the actual moisture content of the subgrade at different seasons. This could bring out how far the laboratory tests for the swelling pressure were actually developed in the field, since the Authors had assumed that due to the change in moisture content the swelling pressure was developed in the laboratory and the same change in moisture content might have developed similar swelling pressure in the field. It was not known whether actually in the field so much variation in the moisture content had taken place in the subgrade soil.

Under suggestions given on pages 276-77, para. 9.2, one of the suggestions for new construction on expansive soils was removal of such a soil. This was, however, not possible in the present case because it was an old road already constructed. In any case, it would have been interesting to know the thickness of this type of soil.

Shri N.R. Srinivasan referring to page 249, Table 1, stated that it had become a general practice in our country while

judging daily traffic intensity over a concrete road, to include the total tonnage of all types of vehicles moving on the road, often starting from the number of bicycles. For a mere traffic census, such a procedure might be all right, but when it was with a view to examine the effect of this traffic on the structural soundness of a road, the inclusion of the total tonnage of the smaller vehicles with small individual weights, had no meaning. The current practice in advanced countries was to take into consideration only the commercial vehicles. Collins had stated that the effect of private cars on the structural soundness of the road was negligible. In our country where thin slabs 3 in. or 4 in. thick were generally employed till now, it might perhaps be desirable to take into account only pneumatic tyred vehicles with an individual weight of more than two tons and iron tyred vehicles of 1 ton and more. Even though in the present Paper, exclusion of columns 2 and 6 in Table 1 merely reduced the daily traffic intensity from 1300 tons to 1100 tons, as a principle, the procedure suggested seemed desirable.

The second point was about the swelling pressure test. Though the Authors seemed to be conscious of the limitations of that test, it might still be pointed out that the values obtained might be much larger than what they might actually be in the field due to the unidirectional swelling in the vertical direction in the test under the conditions of lateral confinement. Though the test was said to give a relative idea of the pressure developed in the black and red soils, it made a great difference if the actual as also the differential pressures at the centre and edge of the slab were much smaller than those given in Table 12 and Fig. 6.

It also appeared that data on the actual moisture content of the soils at the centre and the edge of the slab, atleast at the time of investigation, might have been more usefully given instead of giving the assumed values of 20 per cent and 12 per cent respectively.

The third point was regarding laboratory data that could be of some use in similar investigations. Hardly any reliable data was available regarding the relations between the flexural and compressive strengths for our materials. Practically there was no data on strengths of any kind beyond one year. Investigations of that nature should be carried out in future on sufficient number of samples so as to yield results that could be analysed statistically so that reliable conclusions were reached.

His next point concerned the interesting observation of the extension of the longitudinal crack right into the metal crust. If that was because the metal crust and the slab keyed on to it behaved as a composite section, one failed to follow why in the

stress calculations etc., no allowance had been made for the additional structural strength offered by the 13 in. — 25 in crust.

Dr. H. L. Uppal stated that a method for measuring the swelling pressure of soil at different moisture contents had been suggested in para 5.2.2 at page 256 of the Paper. A similar method had already been published in the Proceedings of the 3rd International Conference on Soil Mechanics and Foundation Engineering. It would be interesting to know how the method proposed by the Authors was an improvement on the already published one.

On page 274, while drawing the conclusion, it had been said that high swelling properties of the black cotton soil seemed to be the principal cause of the failure of the pavement. Unfortunately, the data given in the Paper did not prove that conclusively. The swell pressure of a soil is a function of two things.

(i) The range of moisture contents at which the tests are carried out; and

(ii) height of the specimen.

If a black cotton soil at one time of the year is very dry and then gets saturated at another time, the swell pressure would be higher than if the range of moisture variation was small. Again, as the depth of soil layer increases the swell pressure also increases, as it is an accumulative effect. Since the laboratory tests had been carried out on samples of same height and same range of moisture content, without any regard to the range of moisture and the depth to which each type of soil existed in the field, it would not be correct to conclude that black cotton soil had higher swell pressure than red soils, on the basis of reasons given above.

Shri K. L. Sethi stated that the thickness of the metal crust varied from 13 in.—25 in. He, therefore, wanted to know if there were any slabs over 13 in. metal crust which had cracked and on 25 in. metal which had not cracked and vice-versa.

Slabs in mile 7/4 and 8/7 had cracked within 6 months of concreting. It would have been better if they had also been investigated.

With the present available means of construction, it was known that there was great variation in the strength tests of cubes and beam samples taken during the construction work or cut from the slab and that variation could go even up to 25 per

cent. Sometime the concrete in the same slab varied from portion to portion. So it would be somewhat unjustified to compare the actual strength with that theoretically calculated when a huge number of " ifs and buts " had been used.

It had been stated that there was a very steep moisture gradient in the subgrade soil, starting from the centre of the slab and going on either side. Moisture content was determined from samples taken from a test pit, but nowhere test pits were made in the same line. He thought that if a few samples had been taken in the same line, and if they had indicated that such a steep moisture gradient existed, it would have been a very excellent observation.

Shri G. C. Gupta stated that on page 262 the Authors had stated that flexural strengths, which were a basis for the present study, were worked out from the values of compressive strengths with the help of relationships given by the Road Research Laboratory, U.K. These relationships were not rigid and varied from mix to mix. Besides, the moisture content of concrete greatly affected the flexural strengths as had been worked out in the P.W.D. Research Institute, Lucknow. Moreover, whatever be the relation, the results were always liable to a variation of 15-20 per cent from the established relationships. It was, therefore, not known as to how much reliance could be placed on the indirect way of working out the flexural strengths.

On page 276 while describing the remedial measures, the Authors had said that the foundation region of the concrete pavement might be enveloped in an impervious layer right upto the equilibrium moisture depth. In the case of black cotton soils of M.P. & Bombay where that problem existed in an extreme measure, the depth of equilibrium moisture was about 15 ft. He was doubtful if it was at all practicable to treat the soil for water proofing upto 15 ft depth.

The cracks had perhaps been caused by the shrinking action of the subgrade soil. The concrete was bonded to the base and shrinking with enormous force had caused cracks in pavement due to tension. If the pavement is separated from the subgrade by interposing a frictionless layer in between the pavement and the subgrade perhaps it might be possible to arrive at a correct solution.

Shri Y. K. Chougule stated that the Authors in their concluding remarks felt inclined to attribute the failures of the concrete pavements to the shrinkage of the soil in post monsoon periods and consequent uneven supports offered by the subgrade. If that could be taken as the main cause, there should have been

a number of cracks, crosswise also, because the spans of the intermittent indeterminable supports that could be possibly offered by the shrunken subgrade were bound to be greater lengthwise than crosswise. Normally, however, it was seen that there were mainly longitudinal cracks. The field observations noted by the Authors in para 3.3, page 253, indicated that the bitumen poured in the cracks had travelled nearly 10 to 12 in. deep in the metal crust.

In his opinion, that observation should lead us to think whether the failure might not be due to the tearing action of the soil in the process of its shrinkage. It was general experience that the fields crack in post monsoon periods so much so that the cracks extend even upto 10 ft below the surface. The tremendous adhesive force was known to be responsible for the cracks in building which had foundations on other stratas than black soil, but were surrounded from inside and outside by black soil. Therefore, mere shrinkage in volume and lack of proper support under the slab might not be the only cause of failure.

If these considerations were taken into account the remedies suggested by the Authors in para 9. 1. 1, page 276, would not be able fully to meet the situation. Firstly, the reliability of making the foundation region impervious particularly in low banks would be doubtful, as it would not be possible to envelop the portions below the surface adjoining the banks. Consequently, only covering the banks with impervious material would still leave scope for the foundations or the subgrade to draw its requirements of moisture by capillary action in rainy season and the swelling would be there. The swelling in that case would not only develop cracks under the slab but also on the sides of the bank. Besides, the cost of treating the sides would be prohibitive.

Dowel bars had been used to prevent the two slabs on either side of the centre from being separated. It would be seen that the longitudinal cracks were beyond the dowel bars. In his opinion, therefore, it would be worthwhile examining whether use of some light reinforcement in such black cotton soil regions should not be considered. There would be some increase in cost and difficulty of obtaining the required steel no doubt. But it would be worth the trouble and additional cost in case the remedy proved to be successful.

In case non-availability of the reinforcement ruled out this remedy, a foundation slab of weak proportion coated over with bitumen to act as lubricant between the wearing slab above it and the foundation slab below it might be helpful to prevent

cracks in black soil regions. Any cracks developed due to black soil would be restricted to the foundation weak concrete slab only and the wearing slab would mostly remain unaffected due to the protection offered by the lubricant layer.

Shri N. Amanullah pointed out that the Authors had calculated the maximum combined stresses in a 4 in. thick concrete pavement by corner and edge loadings as 721 and 759 pounds per sq. in. respectively. The estimated flexural strength at 28 days life was given as 640 pounds per sq. in. If that was taken to be correct, then the concrete pavement should have started failing soon after construction due to fatigue. However, actual failure started after about 2 years. That should lead us to think that the pavement thickness was not adequate.

The physical analysis given at page 253 showed very little difference in the plasticity characteristics of black cotton soil and red soil. This was supported by the Geological survey of India's classification. It was, therefore, not properly understood how the swelling pressures were varying so much. Moreover, the depth of the soil profiile as given by the Authors was also different and, therefore, the swelling pressures as determind in the laboratory were not very realistic and did not give the correct picture of the actual swelling pressures in the field. The Authors had claimed that a method was developed by them for measuring swelling pressures but two Papers had already appeared in the 3rd and 4th Proceedings of the International Conference on Soil Mechanics about the use of exactly similar type of apparatus. In those Papers it had been concluded that swelling pressures measured by their apparatus could not give a correct idea of the actual swelling pressures developed in the field.

It was further felt that the conclusion of the Authors in attributing the failure to swelling presures in the black soils seemed rather illogical due to the fact that the maximum swelling pressure shown on page 274 was 0.75 ton per sq. ft. which was about 12 lb per sq. in. and which was very very low and hence incapable of cracking the concrete pavement.

The dry bulk density of the red soil had been found to be less than that of the black soil. This factor had a pronounced effect on the overall structural strength of the subgrade and, therefore, if the failure was due to the weak subgrade, then the pavements above the red soil should have also failed.

If the Authors had recorded the condition of the flexible pavement on the other portions of the same road it would have helped in drawing a logical and balanced conclusion.

He did not agree with the suggestion made by the Authors that the foundation region of the pavement be enveloped right up to the equilibrium moisture depth. The equilibrium moisture in black cotton soil was only at the point of its water table and normally the highest water table observed in such regions was about 15 to 20 ft below the surface. He wondered how one could go up to a depth of about 45 ft or so to provide a treatment of primer or asphalt.

Shri K. K. Nambiar stated that he was generally in aggreement with the lines of analysis of the problem made by the Authors, but it was not correct to adhere too rigidly to certain assumptions which the Authors had made with regard to the calculations. The road was running through black soil and red soil alternately and it was stated that in the case of cracks on the concrete roads, the crevices were found to be extending deeper than the concrete, far deep into the water-bound macadam which varied from 13 to 21 in. That phenomenon of cracks in the water-bound macadam itself should have been noticed ever before the concrete was laid and care could have been taken to design correspondingly thick concrete slab.

Certain assumptions which the Authors had made in the Paper had not been properly accounted for. For example, the whole calculation of the stresses was made on the assumption that there was a residual moisture content of 20 per cent in the center of the slab whereas it was 12 per cent at the end. How they had arrived at these figures had not been explained. Was it purely a guess work so that the results they expected to find could be obtained by assuming these figures. If so, to base the life expectancy of concrete roads on these assumptions might not be perfectly reliable.

With regard to the remedial measures suggested, he did not think there was any hurry about creating a joint in the centre of the slab expecting that it might crack in course of time and that this joint might localise the cracks that might eventually develop. In view of the several questionable assumptions and approximations made in this Paper, it was not necessary to open out longitudinal joints in these 12 ft slabs. Another remedial measure that had been suggested in the Paper was to put in non-expansive type of soil over an expansive soil. If the water-bound macadam which was about 20 in. thick could not help, he did not see how a small layer of non-expansive type of soil was going to help.

Shri K. F. Antia stated that the Authors had made some recommendations without justifying the same. One of the recommendations was treatment of soils with lime. There was

nothing mentioned in the text nor any reference given on which this recommendation was based. Some of the members might know that this was based on Dr. Uppal's Paper, but some reference should have been made to that.

It seemed to him that two types of investigations had been carried out, one in connection with the strength of normal concrete pavement, and the other in connection with the swelling effects of black cotton soil. There seemed to be some lack of correlation between the two. This correlation was desirable and further investigations should be carried out.

It was interesting to note that there were successive waves of red and black soils. It seemed to be rather unusual to have two furlongs of red soil followed by black soil. It would be interesting to know a little more about this formation and its causes.

Shri Antia mentioned that it was possible to strengthen a concrete pavement with overlays without great difficulty and that this had been tried out successfully in America in the case of airfield pavements.

Shri C. L. N. Iyengar stated that the analysis was very revealing in that it confirmed the cross-sectional non-uniformity of support to be the cause for cracking, though the question as to whether this was due to swelling pressure or constructional deficiencies, could not be as easily explained as in the Paper. Certain assumption had been made for the load positions on the road to have constituted the worst bending condition. It would have been better if only a transverse placement study of moving vehicles had been made when passing in both the directions instead of just assuming that the traffic was not large enough in volume to cause the worst condition under passing traffic.

The rational formulae which had been employed for the calculation of the load stresses were those of Teller and Sutherland in modification of Westergaard's formuale. Of course, the limitations of these formulae had been further explained by Gerald Pickett and Ray and they had modified these formulae to correct for inconsistent values obtained, viz., that stresses in thin slabs supported on highly resisting subgrades were lower than those for thicker slabs on the same subgrade. Modification by Pickett and Ray gave values which were much nearer to those actually measured in the field.

Regarding the failure of the concrete pavements assumed for crack expectancy, in the Table on page 271, the stress assumed as a percentage of flexural strength appeared to have

been based on 2 years' strength. Actually, it was conventional for all those fatigue calculations to be based on 28 days' strength and the number of repetitions before failure estimated on that basis.

Another aspect which he had observed on many lengths of concrete roads subjected to longitudinal cracking, which was also supported by observations abroad, was that longitudinal cracking in single lane concrete pavement could be definitely ascribed to the loss of support on the edges either caused by fine grained soils which had a tendency to pump up under free water or when affected by frost action. Here, in most of our roads the side widths permitted the collection of free water as the general shoulder levels at the sides were higher than the concrete pavement which in turn reduced the support at the edges more severely than if a cross drainage had been properly provided.

The question of overlays had just been mentioned in the Paper but sufficient explanation had not been given as to how it was going to be designed over the fractured pavement, and whether it was necessary to strengthen the pavement at the present stage or at a subsequent stage. According to him immediate construction of the overlay was not necessary and sufficient service life of that pavement could be obtained before overlays were constructed.

Also, there was a recommendation for sub-dividing the pavement in narrower widths in case of future construction. This observation was too premature in that the pavement though initially it might not show the disadvantages of the sub-division by cracking, however, the number of joints increasing would add up to the cost of maintenance and also, unless the bars were provided across the longitudinal joints, movements which were feared due to swelling pressure in the soil would lead to their opening up, adding to the problem, even if they were constructed beforehand.

Shri S. R. Mehra stated that he was in agreement with the line of thought suggested by Shri Taylor. As a matter of fact, during the course of his discussions with the Authors while results were being analysed, this idea did crop up, but for some reason it had not found its place in the Paper. In the case of concrete pavement over flexible base of whatever thickness it might be it is possible to imagine that when drying up of the subgrade was taking place, drying was more towards the edges than towards the centre, on account of the excessive shrinkage that takes place in such heavy clayey soils. There might be a position where the subgrade soil at the edges was fairly low while the subgrade soil in the centre was in contact with the base of the concrete pavement, and, as such, if a load came, particularly on a single carriageway, it might cause a tensile failure in the pavement. This was a line of thought and he felt that along with other suggestions put forward it would be useful to have actual field experiments under controlled conditions carried out and tested with a view to prove things one way or the other.

One thing in which he did not agree with Shri Taylor was that according to Shri Taylor's way of thinking if one provided sufficient thickness of a flexible base under the concrete pavement, the effect of recession of the subgrade would be nullified. The flexible base, having no flexural strength, will lend hardly any support to the concrete slab, under the above condition, unless of course the base was so thick that it extended beyond the sphere of influence of moisture change and consequent shrinkage. That was the very idea which the Authors had put forward in suggesting that some short of vertical moisture resisting membrane might be introduced up to the depth of influence at each end of the pavement. What that depth of influence was going to be in actual practice, it was difficult to say. But he personally thought that it might be possible to avoid damage by protecting the top 3 or 4 feet. In any case, this was a matter on which no one could take an ad-hoc decision and further concentrated research work was called for and it was intended to take it up systematically at the C. R. R. I. on that basis.

Shri D. C. Chaturvedi stated that in Fig. 1, it was shown that 4 in. cement concrete slab was laid over 2 in. macadam or lean concrete. However, from para 2.1 it was noted that the thickness of old crust varied from 13 in. to 25 in. This had created some confusion.

The basis for selecting the various test locations on the concrete slab for investigation, viz., at the corner, in the interior or at the edges might be stated. It was assumed that the portions selected for taking out the slabs for exposing the subgrade had no cracks at all; otherwise, it would have been difficult to take out beams for flexural strength.

The Authors had not mentioned in the Paper the time when these investigations were carried out and it was, therefore, difficult to analyse the causes in the light of the results obtained.

In para 3.3 on page 253, it was stated that differential movement up to 1 in. was noticed. It was presumed that the

movement was in the vertical direction and thus there was a step formed between the cracked portions.

The Authors might indicate whether any bond was noticed between the concrete slab and the old water-bound macadam while removing the slab for test purposes. Also whether there was any disturbance caused on the metal road crust by removal of the cement concrete slab for carrying out the plate test.

In paras 5.2.1 and 5.2.2 measurement of swelling and swelling pressure had been referred to. In this connection he would refer to an interesting Paper on "Foundations in Shrinkable Soils" by K. J. Vogl (Technical Paper No. 329 of Ministry of Railways, Govt. of India). It had been stated therein that the shrinkage limit depended upon the absorption capacity of the clay fraction and also on the ratio of the clay to the silt and sand fraction of the soil. It would have, therefore, been useful if shrinkage limit of the soil had been determined. The swelling capacity of a soil depended on the water binding power of the clay fraction and that could be measured by means of the Enslin apparatus which gave the percentage of water absorbed by dry sample. For clays that percentage was higher than for sand.

The natural moisture content of soils was found out to be 2.6 and 3.2 per cent respectively. He desired to know when that moisture determination was made. The moisture content of the subgrade soil given in Table 4 was higher than those values. The results in Table 4 showed that the dry bulk density of the subgrade soil was more in the cracked portion than that in sound portion. He requested the Authors to enlighten him on the significance of those results.

In the calculation of load stresses by Westergaard formulae, no impact factor had been taken in the wheel load which in his opinion should have been done.

In para 6.5 it was stated that no better data was available regarding the relationship between the strength at various periods and also between the flexible and compressive strength. As far as he remembered the Central Building Research Institute, Roorkee, and other Institutes had carried out investigations in that respect and data should be available with them. In U. P. they had adopted the relationship between flexure and compressive strength as found out in the laboratory investigations reported in his Paper * submitted last year.

* Page No. 203 - "Study and Investigation of Performance and Failure, of Road Pavements in Uttar Pradesh" H. G. Verma & D. C. Chaturvedi Journal of the Indian Road Congress, Vol. XXII-3, December 1957.

The calculations given by the Authors for the crack expectancy brought out a new approach to the problem. However, so far as the present investigations were concerned, they did not help much. The investigations carried out by the P. W. D. Research Institute, Lucknow about failures of concrete pavement on G. T. Road also had revealed that 4 in. thick concrete pavement might not give serviceable life for 30 years or so.

It would have been very interesting if the moisture variation in subgrade had been studied in different seasons. The moisture content at saturation had not been mentioned in Table 5. The Authors might kindly say if the subgrade was liable to get saturated. The Authors had mentioned on page 274 that the black soil required more time to get saturated. He had not been able to follow how that factor would give steeper moisture gradient in a shorter period in the case of black cotton soil than in the case of red soil which had been attributed to cause higher differences in the values of swelling pressures at the centre and at the edges.

The suggestions given by the Authors for improving the road were not very definite. He liked to know what definite suggestions were given to local P. W. D., for improving that road. Also he would like to know how the suggestion given in para 9.1.1 (i), viz., enveloping the foundation region of the concrete pavement right up to the equilibrium moisture depth with an impervious layer, could be put into practice.

Shri Fateh Chand* stated that the Authors had not mentioned whether a blanket coat was provided under the original road crust and what the thickness of the expansion and contraction joints of the concrete pavement was. His comments were, therefore, based on the assumption that no sub-base or blanket coat existed and the joints were sufficiently thick and effective for the calculated stresses caused by expansion, contraction and shrinkage of the slabs.

To his mind the chief cause, if not the only cause, for the failure of the concrete slabs, over black cotton soil, was the development of cracks in the subsoil due to low formation level and water table in the paddy growing area coupled with capillary action. Such cracks were not uncommon in the black soil at the end of the monsoon due to contraction caused as a result of less moisture content. It would have been helpful if the original road crust had been opened at certain points to see if any such cracks existed at the points where the failure had taken place.

* This comment was received in writing.

The theory of hydraulic gradient from centre towards the edges did not appeal to him because such gradient existed practically on all the roads but no such failure had taken place on stable granular subgrade. Whether or not the thickness of 4 in. was sufficient for concrete roads was a question which was not correlated with this failure. In his opinion that thickness was sufficient for the nature and volume of traffic in that particular case. As the Authors themselves had realised, the data and assumptions on which the calculations were based did not take into consideration several unknown factors and the value of 'k' adopted was also disputable. According to these calculations, the chances of such failure should be more soon after construction rather than 2 years afterwards when the concrete had acquired greater strength. Similarly the calculation of 8½ to 14 years life of concrete pavement was not supported by actual facts and figures. Several pavements of 4 in. thickness, constructed over stable granular subgrade, had been rendering good service for about 20 years or more. Experience showed that the life of a concrete pavement depended to a very great extent on the fact whether or not it had got an unyielding subgrade under varying conditions of temperature and moisture.

In his opinion, 4 in. thickness should hold good for highways carrying only moderate traffic intensity. The remedial measures suggested by him were:

(1) On existing concrete roads, moisture should be prevented from entering or staying for any length of time in the subsoil.

(2) In new roads (i) the formation level should be at least 2 ft above the H.F.L. under normal conditions and more in special cases such as in black cotton soil or in paddy growing areas which remained waterlogged for long periods, and (ii) when the water table was less than 10 ft below the formation level, a subgrade or blanket coat of sufficient thickness of some hard granular material like sand or gravel, must be provided over the subsoil.

Dr. Bh. Subbaraju (Author) replying to the suggestion made by **Dr. A. S. Adke** that reinforcement of ¼ in. dia. round bars at 6 in. centre to centre was the only remedy, said that nowhere in the world now, concrete pavements are designed with reinforcement for structural stability. The reinforcement used was only to minimise the cracking due to temperature and various other reasons. In this connection he mentioned that recently in the C.R.R.I. they had designed the concrete pavement for the Heavy Electricals, Bhopal, for their heavy duty

road transporters weighing 180 tons. Each wheel would be carrying 7½-ton load. The subgrade was of black cotton soil. On investigating the desirability and economy in the design of the concrete road to carry the above load and reinforce it to counteract the effects of black cotton soil, it was found that the cost of reinforcement alone would be Rs 14 lakhs per mile for a 30 ft wide road with 12 in. thick pavement. Whereas the final design suggested, without reinforcement worked out to about Rs 10 lakhs.

Shri Taylor had stated that the 'k' value obtained was not of the subgrade but of the base for which the Author preferred to call it as a composite 'k' value of the base and the subgrade.

Several members had commented that the method adopted for measuring swelling pressures was not correct and they could not interpret these results in the field. It was clearly mentioned in the Paper that the values that were obtained were not the absolute values but only comparative values as the Authors wanted to present the difference between the red soil and the black soil. Whatever technique they had used in the absence of any standards, the same technique was adopted in both cases and so he did not find any objection at the present stage of knowledge to the method that they had adopted.

Regarding remedial measures, some members had commented that the Authors had recommended removal of black soil wherever it was economical and had asked how it was possible under the existing pavement. He clarified that the recommendation was made not for the existing pavements but for new construction.

Some members had asked about the alternative red and black soils, whether they were found only in the embankment or the natural terrain also consisted of these two soils. The answer was that the natural terrain consisted of black and red soils alternately.

Regarding crack expectancy, **Shri G. C. Gupta** had said that the calculations were applicable to ordinary soils but not to expansive soils. It was not the aim of the Authors to calculate the crack expectancy in the case of the black soils. They had already cracked. The crack expectancy attempted in this Paper was for the concrete slabs which were remaining in sound condition now on the red soil. Here, unless prompt action was taken they would come to grief in 8 to 10 years' time depending upon the thickness of the slab. It is, therefore, necessary to take action on the remaining slabs lying on the red soil before these slabs also cracked.

Shri Y. K. Chougule had commented if the failure was due to swelling and shrinkage, why there was only longitudinal cracking and why not cross-wise. For which it was stated that in the presence of differential shrinkage of the subgrade soil from edge to centre and thus losing base support more at the edge than at the centre as explained in the Paper, due to the double cantilever action created by the wheel loads of a passing vehicle, the cracking should be expected only longitudinally but not cross-wise.

Some members had asked if 5 ft cut-off bituminous envelop was practicable. For which the Authors stated the method can be adopted wherever practicable and if the depth of influence of the moisture variation is too excessive, then other methods may be resorted to.

In the recommendations it was suggested to overlay an expansive soil subgrade with non-expansive type of soils. **Shri Nambiar** had asked if the existing 15 to 25 in. thick water-bound macadam was unable to prevent the swelling effects, how could swelling effects be stopped by simply providing a non-expansive soil layer. Here, by non-expansive soil was meant something like moorum. He stated that swelling pressures could be minimised, because due to the porosity that they were providing on the top, there was room to accommodate the expansive soil, thus minimising the swelling pressures. They could not compare the existing water-bound macadam of 25 in. thick which was unable to minimise the swelling pressure with the moorum layer that was recommended.

Regarding strengthening cement concrete pavements with cement concrete overlays, he agreed that it was a question of design whether the overlay could be either of cement concrete or some other material whichever is more economical.

Shri Iyengar had stated that some more locations might have been tried for tests. Even with the number of slabs that they had already cut in a public road he did not know how the Chief Engineer of Mysore felt about it, and if he had tried to cut more, possibly he could not have been allowed to do so.

Regarding Shri Iyengar's comment about Teller and Sutherland's formulae not being nearer to reality as against the formulae by Gerald Pickett, to his knowledge every formula has its limitations and it was a matter of opinion which formulae to adopt as knowledge on this subject was limited at the present stage.

Referring to **Shri Mehra's** comment regarding shrinkage he stated that he was extremely sorry for not including in the Paper any sketch. This was because they had not done any shrinkage

testing to put it in the form of a sketch. Detrimental effects were not only due to swelling but also due to shrinkage. Some members had commented that they had drawn a sketch imagining 20 per cent of moisture content in the centre and less at the edge. Again, it was clearly stated that the sketch was drawn just to demonstrate the difference in the two cases. As mentioned earlier, they had never mentioned in any part of the Paper that the swelling pressures that were obtained were of absolute value.

Some members had said that the Authors had not suggested increased thickness for the pavements. On page 272 they had proved from the calculated stresses that the existing thicknesses that were being adopted on the highway system were inadequate. In the recommendations they had not mentioned this point of increase in thickness. The main emphasis was laid on the indeterminate stresses which were created by the swelling and shrinkage of these expansive soils. Regarding the increase in thickness of cement concrete slabs these were going to be designed according to the 'k' value, the wheel loads and temperature differentials that they are going to have.

Shri K.V. Ekambaram (Chairman) in his concluding remarks referred to the point raised by Shri K.F. Antia whether black and red soils could alternate as described in the Paper. Generally, in the black cotton soil valleys one always gets red soil deposits brought from the hills and in that terrain these soils were met together.

With regard to this Paper, it was certainly good for the engineers to take interest in the cracks and failures of road surfaces because studies of such nature would produce success. In the proposed 20-year plan, out of Rs 5,200 crores probably one-third would be spent on upgrading the road crusts both with concrete and bitumen. It was quite possible that they might spend one-third of that to put in concrete pavements all over. It was true that any failure in concrete pavement would be certainly very strongly criticised, for after spending so much money people generally expect that a concrete road was going to last permanently. So it was very necessary to study failures of concrete pavements very carefully whenever they occurred. In this connection he had to make a suggestion that wherever they were laying a concrete pavement, boards should be erected on the roadside giving details like date of construction, the proportions of concrete used, some information about the nature of the subgrade, etc. The erection of these boards would give particulars about the construction details which would be very useful. In Madras they had done that on N. H. Nos. 4 and 5.

Discussion on Paper No. 210*

" Brick Pavement in Highway Construction "

By

D. C. CHATURVEDI & J. C. TAYAL

Thursday, 8th January, 1959.

Shri S. R. Mehra (Chairman) called upon Shri D. C. Chaturvedi one of the Authors to introduce his Paper.

Shri D.C. Chaturvedi, (Author) in his introductory remarks stated that the possibilities of using bricks for providing a dustless surface on major road, as well as for providing low cost roads in the villages had been examined in the Paper. Although the experiments had been made over a stretch of 1½ miles, which might not be considered sufficient, the results given in the Paper show clearly that the possibilities of using brick pavement in India were great. But the quality of bricks to be used in road construction shall have to be of a very high order.

The behaviour of the experimental portions had been observed regularly and recent inspection of the lengths had brought out the following informtaion which might be of interest to members.

The portions on which premix carpet had been laid both on flat bricks and brick-on-edge were behaving in an excellent way. The surface was quite uniform and free from any depressions. This was, therefore, the best specification which could be suggested at the moment for bituminous coat on brick pavement.

Surface dressing had been done both by tar and bitumen. It was observed that the treatment with Mexphalt had given better results than with tar. In the case of bitumen, the brick surface was less exposed and a uniform bituminous mat had formed and was adhering well. In the case of tar, the surface had been more exposed as already stated in the Paper. It had further been observed that surface dressing with Mexphalt over transverse bricks had given better results than in other bonds. By providing surface dressing, further wearing out of brick surface had altogether stopped and no deterioration had been noticed so far.

* Published at pages 377-433 of Volume XXIII-part 3 of the Journal of the I.R.C., December 1958.

The brick pavement laid in cement and sand mortar was behaving satisfactorily in comparison with other unpainted brick surfaces. Excepting those bricks which were not hard the bricks were intact and had not been crushed. The surface was smooth. The concrete overlay, however, did not prove successful as already stated in the Paper.

In the other lengths, viz., brick pavement laid over 3 in. sand cushion, brick pavement with joints filled with bitumen and also brick pavement left unpainted so far, the surface was showing signs of wear specially in the case of those bricks which were not very hard. Some of these bricks had got crushed.

It had been noticed that when brick pavement was laid, specially in mile 28, the bricks used were uniform in colour (deep copper colour), but when these lengths were observed recently, the colour of the bricks which had either crushed or had worn out on top, was not the same, indicating that such bricks were only fully over-burnt on the surface but were not so inside. That pointed out to the necessity of burning the bricks thoroughly at the desired temperature which might not be possible in ordinary Bull's Kiln. Down draft kiln or Hoffman type kiln might be suitable where better control over temperature and duration of firing could be exercised. The behaviour of these surfaces, however, indicated that if bricks possessing strength upto 7,000 to 8,000 lb per sq. in. were used and protected by a bituminous coat, the pavement could take up fairly heavy traffic. For laying brick pavement without surface treament, vitrified bricks capable of withstanding more than 10,000 lb per sq. in. pressure should be used.

It would be interesting to note that in Holland and in Germany vitrified bricks or clinker, as those were called, were used for light to heavy traffic. From the information available, it was found that such bricks were laid on sand bed or cement mortar bed. Where 2 layers of bricks were to be used, a layer of sand 2 in. thick was necessary between the two layers. Blinding was done with sand. When joints were to be filled with bitumen, the pavement was brushed to open the joints about 1 in. deep. These joints were then filled with tar or bitumen and a layer of sand or fine stone chips was then put over the filled in tar or bitumen.

Shri R. L. Nanda : The Author had stated that the various specifications of brick pavement had been laid between September 1957 to April 1958 and surface treated only in June-July 1958. This meant that the field performance had been studied only for a few months before writing the Paper. It was not reasonble to draw any conclusion or judge the superiority of one specification over the other within such a short period.

It had been recommended that in waterlogged areas flat brick followed by a layer of 1½ in. sand and brick on edge might be suitable. It was feared that this specification would not serve the purpose as brick on absorbing moisture from the water-logged subgrade would get weakened and crushed under the wheel load in due course.

If a layer of sand had been recommended below the brick depending upon the mean diameter of the particles, there were reasons to believe that it would cut down the capillary rise of moisture.

The Author had satisfied himself by testing the brick metal by dry aggregate crushing test. It would have been safer if wet aggregate crushing and wet aggregate impact tests had been performed for assessing their suitability. That point was discussed at the ECAFE Seminar on low cost roads and it was finally agreed that soft aggregates should be tested in wet state rather than in dry state.

Shri H. S. Bhatia stated that the most important thing in the burning of bricks was the need of temperature of about 1,500 deg C. to produce bricks with a compressive strength of about 8,000 lb per sq. in. Such a high temperature was essential for the proper fusion of alumino-silicates in the soil. In Bull's Kiln, such temperature cannot be achieved. As the Authors had suggested they could not at the present moment think of using Hoffman type kiln involving high initial investment, and skilled maintenance was not easy at present. It might be possible to achieve the required degree of fusion normally possible at 1500° C. by use of 0.5 per cent of Felspar as a flux and burning the soil at 1,000° C.

On page 387 of the Paper, the Authors had stated that the C. B. R. value of the subgrade increased more in the course of time more under the brick pavement compared to that under the concrete pavement or flexible pavement. There was no reason for it as the over-burden pressure was the same in both the cases. This point required elucidation.

On page 417 of the Paper, the Authors had stated that in samples 779 and 780 there was large variation of compressive strength, in one case about 10,000 and in the other about 5,000 psi. The physical properties of the soil were, however, more or less similar. The Authors had not explained why such a discrepancy had arisen. Apparently there was nothing wrong with samples Nos. 779 and 780. The difference being the position of the samples in the laboratory furnace at the time of burning. It is known that even in an ordinary laboratory

furnace there was a difference of temperature of about 100-150 degrees C. from one apartment to another when the temperature in the centre was about 1,000 degrees C. If the place of the samples had been the same, those two samples would have given same compressive strength.

On page 383 of the Paper, the discrepancy of the compacted strength in the field and in the laboratory had not been explained by the Authors. He felt the size of the block was of great importance. There was already a Paper on the subject by Dr. H. L. Uppal of the CRRI. Mr. Clyde E. Kesler had also done a lot of work on this subject and some interesting Papers had been published in ASTM Journals.

On page 390 of the Paper, the Authors had compared the behaviour of different stretches of brick pavement laid over 7½ to 8 in. thick kankar base. For studying the behaviour of pavements, the same must have a balanced design or balanced thickness to permit comparison in the riding quality or the settlement. He personally felt that the thickness of the base (about 7-8 inches already provided) was on the excessive side and in fact that was the total thickness required in most of the secondary roads laid on alluvial soils in Northern India. It would have, therefore, been better if C.B.R. or plate bearing test had been tried on the subgrade and on the basis of that the total thickness of road pavement given to permit a fair comparison of the behaviour of the different portions of the road.

On page 398 of the Paper, the Authors had suggested that the brick surface laid over freshly compacted kankar was worn out earlier. One could certainly understand that so far as the settlement of the road pavement was concerned the subgrade or the base played a very important role, but the wearing quality of the surface had no relation whatsoever with the base strength or the base compaction. Therefore, he felt that the wearing out might have been due to other reasons and was not due to different types of bases provided.

Shri K. L. Sethi said that on page 389, the Authors had pointed out that due to extra burning the compressive strength and the density of the bricks had increased. It was feasible and understandable that the compressive strength increased with extra burning, but so far as density was concerned, it was not feasible. Density being mass upon volume mass remained the same and there was no volumetric change after a temperature of 500 to 600 deg. C. The Authors might remove this confusion.

The Authors had also felt that the extra burning had no marked effect on the Los Angeles abrasion aggregate crushing

value and water absorption. If it was taken for granted that the extra burning increased the strength, then the properties enumerated above should also improve. He was of the opinion that the Authors should have tested some good road metal for these properties and compared brick aggregate in terms of percentage of those metals. If good metal was not available, at least they should have tried the road metal available in the region.

On page 388, para 3.8.4, the cost of bricks had been given as Rs 30 and Rs 28 per 1000, but while calculating the cost of the pavement on page 402, para 8.1, they had taken the cost of bricks as Rs 45 without assigning any reason. This required clarification.

On page 398, para 5.5.6, a very interesting point of brick pavement on sand cushion had been mentioned, and the Authors had pointed out that due to the traffic movement the sand below the bricks got consolidated and, therefore, settlement of the bricks occurred and had suggested the replacement of the bricks from time to time. Replacing of bricks on such a cushion would be costly and difficult as in course of time similar type of bricks might not be available. In this connection he invited attention to a Paper by Shri Mehra and Dr. Uppal regarding the importance of subgrade compaction in the economic design of flexible pavements published last year in the I.R.C. Journal. If, instead of giving a sand cushion they had tried to put a compacted soil base, probably that would have reduced maintenance to a considerable degree and would have provided a very good base.

Shri A. V. Karnik stated that the Authors had given instances of work done in Holland, but as far as he knew, in Holland they were finding laying of bricks costlier than bituminous or concrete pavement. The work done there had been mostly of double brick type and for base course.

In the Paper, the Authors had brushed aside soil stabilization on the basis that it required quality control or it required a mobile laboratory. He considered that in a place like U. P. possibly soil stabilization would have been cheaper than the use of brick not only as a base course but also as wearing course especially when it had to be covered with a black top. So, he would like the Authors to clarify whether soil stabilization was being considered along with brick surfacing.

About surface dressing, the Authors had found that $\frac{1}{2}$ in. or 3/8 in. chippings did not adhere well in surface dressing on the brick pavement. That might be possibly due to lack of affinity of stone to brick. They had suggested the use of $\frac{1}{4}$ in. or even lesser size of chippings. Even the use of smaller chippings on

the brick pavement, especially under bullock-cart wheel, might not give any good results because they were likely to be crushed under the iron tyred wheels. He suggested the use of very fine premix with chips from $\frac{1}{4}$ in. down to 200 in the form of a thin carpet, as it would form one mass with the harder base such as concrete or brick and give better life.

The Authors had tried rather an expensive treatment of using bitumen sand mortar underneath the brick. There again, he felt that if they had tried a lean mix and if they had laid the bricks under the lean and loose mix, they would have got better results.

The Authors had used 80-100 bitumen for filling the joints of bricks and had obtained bettter results. That again worked out to be a more expensive treatment. In France, they were using a bitumen emulsion for jointing of the stone setts to brick setts which worked out to be cheaper. But they could not use the same emulsion in India because of the climatic conditions. Emulsions with the base of 60-70 or 80-100 could be used quite successfully in filling the joints.

The Authors had stated that kankar base was quite hard and might be adequate. In Rajasthan, he remembered, some work had been done previously where the bituminous carpet was laid on 7 in. kankar. He suggested the Authors to try out laying $1\frac{1}{2}$ in. thick carpet straight on the kankar base and see if it gives good results.

Shri R. N. Kapoor stated that the Rattler wear test which was usually specified to judge the wearing qualities of the paving bricks could not be done by the Authors due to the non-availability of that equipment. In order to have some idea about the wearing qualities of bricks, it would have been better if abrasion test by means of Dorry Abrasion machine had been carried under wet conditions and compared with some standard materials.

The Los Angeles test performed by the Authors on the brick metal is not essentially a surface test. Dorry abrasion test was carried out by the Road Research Laboratory, London for assessing the surface quality of the material like concrete, etc. and he would recommend that test.

While drawing the Authors' attention to Table 1 on page 416, where the physical characteristics of soil were given, Shri Kapoor stated that taking other characteristics into consideration the values given under the heading sand retained on 200 mesh seemed to be too low. It was just probable that there might be some discrepancy. At the end of that very Table were

also given the particle size and analysis in the case of four soils. Taking one case the percentage of sand was given as 42 while the sand retained on 200 mesh was only 1.12. He failed to understand the difference between these two values. He requested the Authors to throw some light on the point.

Shri R. N. Dogra stated that bricks had been used in many countries for pavements, but they were now being given up. The reason was two-fold. Firstly, brick was a porous material and water which was one of the very damaging factors in any road-pavement gets through not only the joints but through the material also. Hence, he felt the Authors had found the necessity of putting a surface dressing or a carpet on top of bricks. No amount of fillers used in the joints were likely to help because the body of the bricks itself is porous and, therefore, water gets through in spite of the bitumen filling. Actually, the bitumen filling was quite unnecessary because it did not do anything at all in the pavement.

The second disadvantage of that type of pavement was that the distribution of load was only on a few bricks. It did not depend upon any interlock anywhere. The difference between water-bound macadam and any other type of pavement was that in the former there was a certain amount of interlocking taking place and there was the distribution of stresses. Shri Dogra recalled that in the earlier days there was a live discussion on the question whether flat bricks should be used as soling or brick-on-edge. It was suggested that flat brick should be used for greater distribution of pressure. Anyway he thought such material as did not have bonding qualities was not a suitable material for road construction.

It had been suggested in the Paper to provide mortar filling. He remembered as long ago as 1935 or 1938 when Shri Mehra was in-charge of one of the Lahore Divisions, they had tried an experiment at Amritsar with bricks and a frog was provided on either side and the joint was filled with cement mortar which provided the interlock. That did help, but it still suffered from the same defect because it was not a moisture-proof pavement and they had eventually to put a carpet on top of it. With a carpet on top it stood very well. He felt that unless and until the bricks provided were of high quality as in Holland which required special burning in different types of kilns, different types of fuel and high temperatures, it was not worthwhile considering the use of bricks.

Shri Swaroop Singh observed that it had been said that bricks were porous; that was perfectly correct. Bricks as manufactured in this country were generally hand-moulded and

they were manufactured and used in the most indiscriminate way. In places like Dacca in Pakistan, bricks were manufactured with mechanical means and were burnt with oil fuel in the most modern type of kiln, and the cost of production there was less than the cost of production by hand labour in the ordinary type of Bull's kiln used in this country. When stone ballast was not available in the alluvial plains and the cost of importing ballast was very high, the only material that could be used was bricks. There was no reason why bricks of superior quality could not be manufactured and used as had been suggested in the Paper.

Shri D. C. Chaturvedi (Author) in replying to the discussion stated that as the Paper was written in October, 1958, the pavement had been under traffic for about one year and that was considered quite a sufficient time for drawing some conclusions.

Specifications suggested for waterlogged areas had not been tried by the Authors but it was felt that if good quality bricks were ussd, there were no chances of the bricks getting weakened and crushed after absorbing moisture. The suggestion of **Shri R. L. Nanda** for providing a layer of sand below bricks was very much appreciated as it would be helpful in that case. But so far as the thickness of the sand layer based on mean diameter of the particles was concerned, it had been found in the laboratory that such a thickness of very fine sand might not stop capillary rise of water.

About testing of brick ballast in wet and dry state it was felt that soft aggregate might give somewhat higher values during wet state, but standard specifications prevalent at present specified only dry test. Further, overburnt brick-metal, in the opinion of the Author, was not a soft aggregate but an aggregate which could be called a substitute for stone metal. However, they had started testing all types of aggregate in wet state also to see the comparative behaviour. It was very interesting to note that in the case of kankar, they had in some cases found lower values when they tested it in the wet state. That was rather surprising, because they felt that kankar under wet condition would absorb water, crush and give higher values. They were still continuing the test and they might be able to say something about that in future.

Shri H. S. Bhatia had rightly said that in the Bull's kiln the required temperature for vitrifying the brick could not be attained. The Bull's kiln was set up because that was the only kiln which could be run by local 'mistries' and, in that type of kiln, the only way to improve the quality was to increase the duration of firing. Although they could not obtain bricks of 10,000 to 12,000 lb per sq. in. strength, they were successful in

obtaining 8,000 lb per sq. in. strength. They had in mind to produce vitrified bricks in the near future. In Khanpur project near Delhi, which was being organised by Ford Foundation, the strength of bricks being produced from Down-draft kiln at the moment was not very high but the problem was likely to be solved if some more experiments were carried out. The suggestion of Shri Bhatia to use 0.5 per cent of Felspar for lowering the fusing temperature to 1000° C. or so will, if possible, be tried in the laboratory.

The statement that C. B. R. value increased under the brick pavement, was taken from a certain report regarding brick roads in Holland. It was not difficult to visualise the reason for this. As had been pointed out by some speakers, the transmission of load to the subgrade was through individual brick and hence the intensity of load (pressure) transmitted to the subgrade was more in the case of bricks than in the case of water-bound macadam. This might cause the C.B.R. value to increase with the course of time.

Regarding variation in strength between two samples (779 & 780) they had always placed the bricks in the same apartment of the furnace and fired them under the same conditions as they were aware of the variation in temperature in the furnace from one apartment to another. The probable cause for this variation might be the different mineralogical composition of these soil samples. The Author agreed with the views of Shri Bhatia that difference in strength between field and laboratory fired bricks was mainly due to the difference in sizes of bricks tested. The Central Building Research Institute, Roorkee had published a Paper* on the subject and the relation between the strength of laboratory size and field size bricks was established.

The necessity of carrying out Plate Test of C. B. R. test on these portions was not felt as the road was already under modernization programme and a coat of stone metal ($2\frac{1}{4}$ in. compacted thickness) was to be put in over the existing kankar surface. It was, therefore, decided to observe the comparative behaviour of brick pavement on this surface. It would, however, have been useful to calculate the thickness of pavement based on C. B. R. values.

One of the reasons why the brick surface over freshly compacted kankar, wore out earlier may be that the bricks might have become somewhat uneven due to compaction of kankar under traffic, leading to more wearing.

Shri K. L. Sethi had expressed some confusion about increase in density of bricks by extra burning. The Author had

* "Bricks from Alluvial Soils" by L. C. Jain & B. C. Ray Choudhury, C.B.R.I. Bulletin, Vol. 2, No. 1, April 1954.

not mentioned anything about density in the Paper. It had, however, been observed that the size of straight overburnt bricks was slightly smaller than that of first-class bricks and that might explain the decrease in water absorption.

As regards results obtained on brick metal it had already been stated that all brick metal was obtained from the misshapened overburnt bricks whether the duration of burning was normal or higher. The selection of bricks was made by visual inspection and, therefore, to the Author's mind, the same quality of brick was selected whether burnt in one apartment or another as they had achieved the same degree of vitrification. That was why the effect of extra burning was not very much marked in the case of brick metal.

In the P. W. D., Research Institute, Lucknow, many types of stone metal and brick metal had been tested and the results are available in the annual reports and also in the Paper on "Use of Overburnt Brick for Low Cost Road Construction" discussed in the ECAFE Seminar held in New Delhi during January 1958. The difference in cost of bricks given on pages 388 and 402 of the Paper was due to the cost of transportation of bricks from kiln to the roadside.

The Author agreed with Shri Sethi's suggestion that the use of compacted subgrade below brick pavement would reduce the chances of settlement of brick surface and thus reduce the cost of maintenance. The Author felt that this specification was worth trying in case of new roads.

The Author agreed with **Shri A. V. Karnik** that brick roads were costlier than other types of roads in Holland but still they preferred brick pavement in many cases because subgrade conditions were very bad in Holland and concrete pavements were liable to settle and crack. The brick pavement could be relaid if it settled.

The Author did not discourage the use of soil stabilisation. Soil stabilisation had its own utility. They were carrying out soil stabilisation on some roads in U.P., but it had to be stated that the use of soil stabilisation required more control in the field than brick pavement. In U. P. the soil sometimes varied from one quarter furlong to another and they had to do a lot of blending and that was why in some cases soil stabilisation became costly. Under such circumstances, brick pavement might be economical. As rightly pointed out by **Sardar Swaroop Singh** stone metal in U. P. was available only in the Himalayas and Vindhayan ranges and in the whole of the Gangetic plain there was nothing but kankar or brick.

The premix carpet used on brick pavement had stood very well. In other portions which were still unpainted they would like to try different types of bituminous treatment, e.g., painting with smaller size stone chips, etc. They might also try the thin premix carpet as suggested by Shri Karnik.

The Author also agreed with Shri Karnik that the sand bitumen mix should not have been compacted. This had already been stated in the Paper. The percentage of bitumen used was the same as specified in American specifications.

Filling of brick joints by bitumen was done on a small length and they were not happy about this specification. The Author would not recommend its use as it had proved costly. The suggestion to use emulsion could be tried in future investigations. The suggestion of Shri Karnik to use 1½ in. premix carpet over kankar surface was also worth investigation. It might, however, prove costly where the existing thickness of kankar was less than 7 in. or 8 in. and another coat of kankar was to be given before putting the premix carpet.

Dorry's abrasion test as suggestsd by **Shri R. N. Kapoor** could not be done as the machine was not available. But as far as known, abrasion test by Los Angeles machine gave a good indication of crushing and abrasion resistance of aggregate and that was why this test had been adopted by many authorities for testing the suitability of road metal.

Shri R. N. Dogra's contention that the use of bricks in road pavement was being given up in other countries might be true but in a country like India, where the road system was lagging behind, it was necessary to build low cost roads and brick pavement offered one of the solutions specially in the alluvial regions where good quality brick making earth was available in plenty. The fear that brick when used in the road pavement would absorb water and get damaged was not justified. The percentage of water absorption was fairly low for such bricks and the Author felt that there was no likelihood of bricks getting damaged on this account. The filler was used not to waterproof the joints but to give some cushioning between the bricks.

It was agreed that the distribution of load in the case of brick pavement was through individual brick and not by interlocking. As stated before, this would help in increasing the C. B. R. value of subgrade. It was found in the experimental lengths laid that those bricks which were not very strong got crushed but it was difficult to take them out as they had set themselves firmly in the pavement.

Shri S. R. Mehra (Chairman) in his concluding remarks stated that brick was one of the most handy construction material, whether it was for masonry or whether it was for use on roads, and any effort towards making brick a usable economic material for low cost road construction would be contribution in the right direction.

There were two very serious defects in the use of brick. One was that it had no dispersion capacity of any denomination. There were independent bricks taking the load and transferring the load as it was on to the base. Therefore, bricks could be used not as a pavement for dispersion of load but only as a surfacing material to take the surface wear from traffic. Still a sufficient thickness of moisture resisting base to carry the intended load would have to be provided.

Secondly, brick in India had very small wearing resistance and in order to make it sufficiently hard it had to be burnt at very high controlled temperature and the soil also had to be very well controlled. It had been stated that the brick roads in Holland were more expensive than concrete roads. It was not only now but to his personal knowledge, it was so as far back as 1936-37 also. The only reason why brick roads had been used in Holland so long was that it was a national industry and they did not want to let it die a natural death. That was why they permitted some of their roads to be constructed with bricks although the concrete road was cheaper.

Shri Swaroop Singh had just said that in Pakistan they had been able to produce particularly hard wearing bricks in oil-fired temperature controlled kilns at costs lesser than bricks produced by manual labour. If it could be done in Pakistan, there was no reason why it could not be done here because the conditions were more or less similar. Even though personally we had doubts about that, he thought that was a matter well worth pursuing and it would be very useful if Sardar Swaroop Singh was to provide the necessary information to the I. R. C. It would be a good thing to go into that question and the C. R. R. I. would be very interested in making a deep study of it.

Mention had been made about work being done by the Ford Foundation in Khanpur village. But a visit to the work about 3 or 4 months ago had revealed that they had no figures of cost or anything else available there. They themselves thought that it was going to be quite expensive. But even so, he felt that the material was very good and likely to have good potentialities. Every effort should, therefore, be made to see if bricks which are usable as surfacing material could be produced.

About surface treatment of bricks, the Chairman stated that a brick pavement was provided on an already sufficiently thick foundation and putting a bituminous surface on top of that meant that the road would not remain a low cost road any more. On the other hand, he did hope that the idea of surface treatment of a brick paving did not go on to the cases where in some of the States, particularly in U. P., they had used brick paving as a road edging. Instead of putting edging on the road in the form of a brick-on-end, they were putting 3 to 4 ft wide berms of brick which, in itself, was a very commendable practice. But it had this very great danger of some economy enthusiast coming along and saying that the brick was doing well under traffic and let it be surface treated to widen the road. There had been plenty of failures of that type and, therefore, caution was necessary.

With regard to the technique of surfacing itself, it might be worth trying to give a coat of bituminous primer and then doing surface treatment, because it was known that the soaking of brick in bitumen primer not only increased its own resistance to wear or resistance to load on the surface, but it also increased its adhesion to surface treatment very considerably.

Discussion on Paper No. 211*

"Investigation of Failures of a Bituminous Road"

By

C. G. SWAMINATHAN & S. A. SWAMI

Friday, January 9th, 1959.

Shri N. Durrani (Chairman) called upon **Shri C. G. Swaminathan** (one of the Authors) to introduce his Paper for discussion.

Shri C. G. Swaminathan while introducing the Paper stated that results of the investigation of the surface cracks on a bituminous road near about Delhi had brought home the importance of such investigations. Although the overall thickness of the pavement over the 40 mile stretch varied from about 10-15 inches, the structure of the road, as such, consisted of a kankar soling, over which there was macadam course with black top. The intensity of traffic over the stretch was about 3,000 tons per day. The soil in general was silty. The ground, weather and climatic conditions were more or less the same. The investigation was conducted during February and March. Although the general conditions were the same throughout the 40 mile stretch, some of the sections had shown signs of cracking extensively whereas this was not the case in some other sections. This naturally led the Authors to investigate the causes for it. In the past, many of our roads were not designed according to the present day concepts of scientific principles. Therefore, whereas the road stood successfully the traffic of those days, the roads of today are expected to carry much heavier wheel loads and much faster traffic. Therefore, according to Shri Swaminathan in an investigation of failures, the first thing one had to see was whether adequate thickness of crust was provided or not, and afterwards to go into the causes of different types of failures. Consequently the first part of this Paper dealt with the thickness aspect, while the second part dealt with the causes of various types of failures.

The field investigations conducted consisted of cutting a trench longitudinally along the road right through the structure. Since the adequacy or inadequacy of the pavement alone could not cause failure, analysis of the properties such as density, moisture content of the soil, etc. were carried out together with an aggregate impact value of the stone, series of field tests such as

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field C. B. R. and plate bearing, etc., on the subgrade soil. Further as far as this investigation was concerned the Lab. C. B. R. value with a saturated condition for the entire 40 mile stretch showed inadequate thickness, but quite a few miles were sound. That was the very reason why they had to go about various test data collected to try and get a tool or yardstick with which to distinguish the sections which were sound from those which were cracked, based on pavement thickness analysis.

The conclusions were not universal at all, they were broad in nature and there are limitations. The test site being only 40 miles in length was limited. As there was always some empirical relationship between Lab. C. B. R. and k value, it was found that a relationship could exist between the field C. B. R. and plate bearing test. In order to take into account the repetitive effects of wheel load, McLeod chart suggested a repetitive type of plate bearing test. That type of test would be rather cumbersome and, as it had been shown by some of the western workers that the total permanent deformation after 10,000 applications of load might be considered equivalent to a total deformation of the same for a single load, it was thought that some sort of correlation if possible between the non-repetitive plate bearing and static plate bearing test should be obtained. He was not aware of any other chart which could straightaway give the required thickness of the pavement based on static plate bearing tests. It had been reported that homogeneous slab with subgrade having a k value equal to or less than 125 lb per sq. in. per inch fell into the category of poor subgrade. Their analysis had shown that the value less than 370 fell in the category of poor and very poor soils.

Lastly, it was also found during the investigation of the failure that the values based on field data were much less conservative than the laboratory data and in case of an investigation of a failure to be conducted the field data such as a plate bearing as shown in the Paper might be preferable.

Passing on to the second phase Shri Swaminathan observed that during the investigation it was found that cracks had developed in many stretches even though the overall thickness was found to be adequate. The failure was obviously the result of macadam or the soling. As an example he added that normal stone metal, viz., quartzite, when in good condition usually gave a value of about 17 or 18 aggregate impact. But the very same stone metal excessively weathered would give a value of 35 or so. So, whenever there was a concentration of the weathered aggregates in any localised spot, it was obvious that they might be got crushed and some sort of subsidence had taken place. Similar occurrence was also possible when a highly or excessively clayey binder was used as blindage. The engineers from the southern

part of the country might be aware that an unsurfaced water-bound macadam had given excellent service behaviour but failed when surface-treated. Some sort of clay binder on untreated water-bound macadam was required to supply the cohesion and stability by entraining sufficient moisture. But the very same moisture was detrimental when not allowed to evaporate by providing a bituminous black top, causing thereby the softening of the macadam resulting in subsidence.

Finally, one or two typographical errors need to be corrected in the Paper.

(1) On page 452, Table 4, in the column "Plate bearing 'k' value for settlement" it should be .05 and not .50" as printed.

(2) On page 454, last para, the reference given was '5' and not '4'.

(3) Page 470, last para, instead of 34/4 it should be read as 34/3.

Shri C. D. Harris pointed out that Shri Swaminathan had in his introductory remarks stated that the failure might be due to faulty macadam but no tests had been carried out on the macadam. With the type of failure described it would have seemed the obvious first objective to test not only the thickness of base course but the quality of the base course materials. The other fault to which the failure could be attributed was weathering of the binder. Since the road was surface dressed with bitumen in 1949 and in 1952 it was surfaced with tar and samples were taken for testing, he wanted to know whether the Authors had been testing tar or testing binder mixture of tar and bitumen. If it was the latter, it seemed possible that some softening points were perhaps not out of line, the only one which stood out was 28/4 where the Authors had not associated failure with the weathering of the bitumen but due to inadequate thickness. If comparative figures were available from sound sections it would be a better guide. He, therefore, felt that certain sections which had failed due to inadequate thickness might be due to a faulty macadam. During heavy rains, perhaps coupled with faulty drainage, water got into the macadam leading to failure.

Shri D. C. Chaturvedi mentioned that apart from the various tests carried out in the subgrade soil, the grading analysis of the subgrade soil should also have been done.

For testing the subgrade under saturated condition, ponding was done and after dewatering, the top 1 in. layer was removed.

He felt that this procedure might have disturbed the subgrade. It was, therefore, better to adopt the procedure recommended by Shri Srirangachari in his Paper on "Design of Road Bed" published in Vol. XII-Part 5 of the Journal of the I. R. C.

He expressed doubts about the field and laboratory C. B. R. values. He presumed that laboratary C. B. R. values were those which were obtained on the sample compacted in the laboratory to same density as in the field. He suggested that undisturbed soil samples should be taken out in C. B. R. mould from the site and tested for C. B. R. value at the site itself. Thus it might be possible to obtain values comparable to field C. B. R. value. He requested the Authors to clarify the point.

Shri Srirangachari had given certain curves for design of thickness of pavements based on North Dakota Cone Tests. The Authors should have used those curves at least to verify the applicability of those curves in the present investigations.

According to Shri Chaturvedi the group classifications of soils should have been given in the Tables 7 and 8.

He observed from Table 12, that Aggregate Impact Values of some kankar, stone or bricks had been reduced in wet state. Similar results had been found on abrasion test on kankar samples. He requested the Authors for an elucidation on the probable reasons for these results.

The Authors had stated that materials used were reasonably sound but cracks occurred due to non-uniformity of construction or non-homogeneity of materials in the base and or wearing courses or due to ingress of moisture. The bases on which those observations were made might be clarified and also as to whether the compaction of material in base and wearing course was determined in different lengths and also as to whether the quality of material used was checked at different places. Ingress of moisture in kankar or stone W.B.M. might not produce such harmful effects, as it had been observed that even in wet condition the test results were not on higher side indicating that quality was not adversely affected.

It has been stated that a bitumen coat was given in 1949 and a tar coat in 1952. Shri Chaturvedi did not understand how the extracted binder from the road surface could be only tar. It must contain some amount of residual bitumen also. Thus the results of tests obtained on extracted binder could not be relied upon.

Shri A. K. Deb pointed out that the Authors had drawn on the work done by Dr. Norman McLeod in order to use the C.B.R.

Test for getting the repetitive effects of load in relation to pavement design. It is only an indirect method because in order to get the effect of repetitive loads, Dr. McLeod used the medium of plate bearing tests only. He had the occasion to use the same work of Dr. McLeod in arriving at a specification for roads in black cotton soils in the last ECAFE Seminar on Low Cost Roads in Delhi.

Investigation of the kind which had been carried out by the Authors was very helpful because they had given valuable data in so far as they correlated the K values obtained in the field with the field C.B.R. values. Also, they had arrived at tentative conclusions such as that K values less than 370 lb p.s.i. per inch were poor and very poor subgrades and K values higher than 625 p.s.i. per inch should be considered as good and excellent subgrades, though the work was of a very limited scope.

Shri Deb referred to page 475, wherein it had been mentioned that if the design was based on field data, either K values or the C.B.R. values, the design thickness was likely to be less conservative than if it was done on laboratory C.B.R. values. He pointed out that the field CBR values and the field K values had been taken on a subgrade which had been subjected to wheel loads for a considerable length of time. When a pavement was being designed in the first instance, that high value was usually not obtained. The field values that were obtained when an embankment had been freshly laid and tested were likely to be less than what were likely to be encountered if the field values were taken after the subgrade had been subjected to wheel loads stresses for a number of years. Hence if the design of embankment is made on field C.B.R. or K values when the subgrade has been freshly laid, it is likely to be quite conservative.

In arriving at the different causes for the failures of the pavement, the Authors after eliminating the possibility of inadequate thickness had straightaway gone to the subsidence of the base course or sub-base material only. Also, waterlogging and weathering of the binder had been taken into consideration. Another factor to be taken into account was the possible differential subsidence of the embankment itself. In the Paper the Authors had mentioned that the subgrade when subjected to saturation had slumped. He felt that if the C.B.R. values had been taken a little deeper, say 6 in. or 1 ft below the top level of the subgrade, that would have given an indication whether the possibility of differential subsidence of the subgrade was also a reason for causing such failures. It was true that the load stresses would be lesser and lesser below the subgrade level, but such tests if carried out would have given an indication of the possibility of differential subsidence of the subgrade all the same.

The Authors had concluded that hair-cracks were possibly due to differential densification of the subgrade. In the next para it was stated that under the kankar base they did not get this. He felt that kankar must be considered more flexible than brick soling under which the hair-cracks did not appear. It seemed that the differential densification of the subgrade was not the main reason. Hair-cracks were probably the initial shrinkage cracks when the subgrade was first prepared. After the pavement was constructed, there had been some moisture movement under the pavement in the vapour phase, and those shrinkage cracks were the easy seats available for moisture to settle down and that was the reason why the cracks were showing black lines.

Shri N. Amanullah found that Plate Bearing Test had been tried on a 12 in. diameter plate and those values had been correlated to a field C.B.R. in order to use McLeod's curves. He wanted to know why straight C.B.R. determination was not made directly on the subgrade at 5 or 6 places and average taken for the purpose of using McLeod's curves. Co-relations mentioned in the Paper had got their own limitations and hence could not be freely used.

The C.B.R. values taken were at O.M.C. whereas the natural moisture content in the field was much less than the O.M.C. Density had a pronounced effect on the C.B.R. values and if the natural moisture content was low and less than O.M.C. then naturally the density would also be low. The ignorance of this factor had actually brought in a tremendous difference in the two values. No mention had been made about the densities at which the C.B.R. tests were tried. Only the laboratory C.B.R. values were to be used for determining the proper thickness required over a subgrade as all the curves are based on laboratory C.B.R. valves.

He found that the Paper was silent about the natural moisture content and the density of the subgrade which were the major factors affecting the C.B.R. values.

As regards Table 4, he personally felt that it was essential to indicate the moisture content before and after saturation.

Referring to Table 6, Shri Amanullah stated that the thickness required for mile 31/3 was 6 in. for a C.B.R. value of 11.2 and for mile 42/5 it was 14 in. for a C.B.R. value of 13.0. He wanted the Authors to clarify this.

Referring to Table 4, Shri Amanullah stated that at places where the K values were very low, the cracking of the portions were

justified. But for miles 34/3 and 40/4 for which the K values were high and the in-situ C.B.R. also high this was not justifiable. For these portions it would be observed that the laboratory C.B.R. values after saturation were very low and if that was taken into account, the failures could be easily explained.

As regards miles 42/5, 60/7, 59/1 etc. the soundness could be attributed to the proper drainage thus eliminating the full saturation of the subgrade.

Referring to Tables 7 and 4 he stated that for mile 54/2, the moisture at saturation, density, nature of soil, C.B.R. value, K value were quite up to mark and as such that portion should behave quite alright and the cracking might be limited to the surface carpet only and not beyond that. That was a point for further investigation.

As regards the correlation of plate bearing test result, he found that it had been done with a 30 in. diameter plate. Normally 30 in. diameter plate were used for airfields and in roads 18 in. diameter plates were used. Hence correlation with 18 in. diameter plate results would be more appropriate.

Shri H. H. Campbell stated that during the last 3 months he had the opportunity of covering about 5000 miles by road. Nearly all the road failures he had observed, in his estimation were due to either drainage, or hogging used in water-bound macadam or compaction. The photographs of the cracks in the various stages of deterioration of the surface really show that the failures were possibly due to inadequate drainage, to bad hogging used in the water-bound macadam or compaction whereas more emphasis had been given to the weathering of the binder.

Shri G. C. Gupta stated that a relation had been established in the values of plate bearing test and the C.B.R. tests. According to him both these tests were merely empirical and had different test procedures which gave rise to widely different resistances. In the C.B.R. test what came into play was a peripheral shear resistance, a point resistance and effect of surcharge. The proportions of these were also dependent on the nature of the soil. In fact, the point resistance and the effect of surcharge played the predominant part. In the plate bearing test, the proportions of various resistances were quite different and the test was governed fundamentally by different characteristics. He was, therefore, not at all hopeful of establishing a definite relationship between the two.

He agreed with Shri Amanullah that the plate bearing test could have been easily avoided in this case. There was a definite established procedure for finding out the values of field C.B.R.

and it would have been much better if the Authors had worked on the field C.B.R. values which could conform to the standard procedure.

He expressed concern that even after 10 to 12 years of road research in the country the engineers were working on the basis of C.B.R. curves established in the U.S.A. The loading repetitions in the U.S.A. were quite different from ours and it was high time that the premier institutions like the C.R.R.I. should chalk out a programme and draw up our own C.B.R. curves.

Dr. I. S. Uppal stated that he had the opportunity to visit several times the work done by the staff of the C.R.R.I. near Karnal and he knew the keen interest taken by them in this investigation. However, as already mentioned by Shri Gupta, he found that the proper gradation of the soil had not been given in the Paper. He added that the very fact that in some of the sections the C.B.R. was fairly high but still the surface had cracked though no settlement was apparent, showed that something was wrong not only with the thickness of the crust but with something else also. Recently he had an opportunity to test some roads where after only 1 to 2 months of surfacing they had disintegrated. He had investigated the cause and found that the soil used in the stone metal contained a lot of sulphates, whereas the actual soil in the subgrade did not contain so much of sulphates. He enquired from the Authors if they had taken care to see whether the soil actually used in the stone metal for making the water-bound macadam did contain sulphate or not. In his view this point was worth investigating because surface cracks could also be due to the sulphates coming from the soil used in the water-bound macadam.

Shri C. G. Swaminathan replying to comments stated that it had very rightly been pointed out by **Shri Harris** and quite a number of other speakers that the blindage material that was used in the water-bound macadam, should have been analysed and tests conducted on the metal itself and also to see if the blindage soil contained sulphate content or not.

Shri Harris as well as **Shri Campbell** mentioned that perhaps undue importance had been given to the weathering of the binder. They also said that when the first coat was with bitumen and the second with tar, it could not be said that it was tar only. When the material was taken out from the base it was actually extracted with pyridine; as near complete solubility was obtained only with pyridine. Hence it was considered to be tar. As regards the consistency and the reason attributed due to hardening the B.S.S. suggests the maximum value of the softening point should not be over and above 52 which was equivalent to 67 deg. E.V.T.,

the idea being that if it was higher than that consistency it was liable to crack due to tensile stresses. In this analysis they had shown that all of them possess the value of E.V.T. much higher than that.

Replying to **Shri Chaturvedi's** comments, he stated the investigations were carried out in the months of February and March immediately after the winter rains. Shri Chaturvedi and **Dr. Uppal** had suggested that some grading should have been done on soils. The Authors, however, felt that just the sand content and P.Is would be sufficient for an investigation of this kind.

Shri Chaturvedi had also said that removal of the slurry would have disturbed the base. He was afraid, he did not agree with him. He thought this practice was adopted by Mcleod and by Shri Srirangachari in the Paper "Design of Road Beds" referred to by him. He also stated that laboratory C.B.R. values were obtained on lab. compacted specimens, since getting undisturbed soil samples was not an easy job.

Shri Chaturvedi had also asked about North Dakota Cone test. In this investigation they found that N. D. Cone did not always give very consistent results. That was why they carried out the plate bearing and field CBR tests. He thought in the Paper referred to by Shri Chaturvedi it was also mentioned that in the case of macadam bases N. D. Cone test gave erratic results. Therefore, they did not attempt to correlate their figures with the figures referred to in that Paper.

Shri Chaturvedi said that classification of soils should have been done. He felt that Fig. 12 on page 461 should suffice.

Regarding moisture of the aggregate, he did not think the wet aggregate impact had anything to do with what had been said while referring to the subsidence of the macadam stone. The subsidence of the macadam is as a result of ingress of moisture and as stated by him in his introduction and as remarked by other speakers, it had no effect on the stone but only on the clay binder.

Regarding **Shri A. K. Deb's** comment that CBR test did not take into consideration repetitive traffic loads, he stated that was exactly why they went over to McLeod's chart since McLeod's charts were based on repetitive bearing test values. They wanted to correlate the static plate bearing k values with the repetitive bearing values and then to use McLeod's chart for investigation.

He knew that the values given by them were not definite, especially when there was such a wide range of factors not only

in the methods of testing but also in the fundamental principles involved in the test itself. When they have half a dozen of such empirical procedures, as somebody else also remarked, it was really a tough job to attempt to have an exact rigorous mathematical co-relationship between the data. The object was to suggest that further investigations might be taken up in this line and when sufficient data is collected, perhaps a sort of general relationship could be obtained. Since the field C.B.R. values and k values had been taken on a subgrade which had been subjected to wheel loads for a considerable length of time (a factor which may not be obtainable at the time of design) the values for the lab. C.B.R. are less. It is true that at the time of design, as high a factor of safety as is reasonable should be taken into consideration but then this factor of safety is exceedingly variable depending on the nature of the soil condition etc. It may even be said that there is no single factor of safety for the lab. C.B.R. value. So, it is but obvious that when an investigation of a failure is undertaken, that test which is likely to have the least factor of safety and would give the minimum thickness required should be chosen. And this information as can be seen from the Paper is clearly brought out only by the field test data. And this was what is meant when it is said that the thickness as dictated by the field data is less conservative.

He had also mentioned about possible differential subsidence of the subgrade and had referred to mile 50/2. Actually, as soon as they ponded the test site, it slumped, indicating clearly water-logging and no C.B.R. could be done on it.

Regarding hair-cracks, they attempted to give only an explanation and he did not think it was the final answer at all. Perhaps, differential densification was the reason or, as he explained, it might be due to shrinkage cracks. They actually wanted some comments on this aspect so that they could learn.

Regarding the point mentioned by **Shri Amanullah** as to why plate bearing test was done on a 12-in. diameter plate and not on 18 in. diameter plate, there is no doubt that the bigger the diameter of the plate the better. When one went on increasing the diameter of the plate, the total reaction that was required would be rather high. With a 3 or 5 ton truck, they thought 12 in. diameter plate would suffice. When there was Stratton's empirical relationship and when the relationship was given up to 30", they thought they could make use of that for any required diameter.

He had also asked why straight CBR was not done. But they had actually done straight CBR. As a matter of fact, they had correlated the 'K' value of the static plate bearing test to the repetitive type through the C.B.R. data.

He had also mentioned that density had pronounced effect. It was true and they have been given in the various Tables. As far as laboratory examples were concerned, they compacted them at the optimum moisture and then saturated and tested them.

He had referred to the two sound sections, viz., 31/3 and 42/5. The existing thickness was 13, whereas from the McLeod's chart it was 6 and 14. He thought the soundness of the sections was obvious. Many of the anamolies would become clear if the data are interpreted through the field C.B.R. instead of the Lab. C.B.R. values.

Regarding **Shri Campbell's** remarks that they should have stressed the importance of drainage and also about compaction, the stretch that was taken by them for investigation was only 40 miles and except over a length of 2 miles which were nearly waterlogged, the rest of the portions were fairly on an embankment of 4 to 5 ft. They assumed the same conditions of drainage in the entire stretch and, as he had stated earlier all the conditions were more or less similar, i.e., intensity of traffic, climatic, soil types, etc. Only certain portions had failed and certain portions had not. So they had to go in for this investigation.

Shri Gupta had also said that K and C.B.R. were empirical and there was fundamental difference between them. He agreed there could not be a definite relationship between them. Even if there was, that portion of the curve, between the clayey and the sandy soils, as could be seen from the Fig. is tricky. As the K value increased, the C.B.R. value increased through a smooth curve, but a linear relationship in the range of good subgrades, at higher values of K and C.B.R. It was only a very tentative and workable sort of relationship.

He agreed with Shri Gupta that C.R.R.I. should chalk out its own C.B.R. curves. Actually, the work had been taken in hand in the C.R.R.I. under the guidance of Shri S.R. Mehra and Dr. Bh. Subharaju.

Shri N. Durrani (Chairman) thanked Shri Swaminathan for a very good Paper and the lucid way in which he had covered all the aspects. He also thanked the various engineers who took keen interest in the discussion and brought out several other useful points.

Discussion on Paper No. 212*

"Landslide Investigation and Treatment in Assam"

By

G.C. SHARMA

Friday, 9th January, 1959.

Shri G. R. Nangea (Chairman) requested Shri K. Barua, Chief Engineer, P.W.D., Assam to introduce the Paper on behalf of the Author who could not attend the Session.

Shri K. Barua in introducing the Paper on behalf of the Author who had intimated his inability to attend the Session stated that Assam having about 30 per cent of its area hilly, ranging to an elevation of 8,910 ft had a considerable number of hill roads. With the hill roads particularly in an unfavourable terrain and perhaps undesirable soil conditions and having the heaviest rainfall in India, there was tremendous trouble and the problem was much more serious than could be normally imagined. Sometimes within a couple of hours the road was blocked by hill slides thereby paralysing the lifeline of that area; sometimes the duration ranged from couple of hours to couple of days and weeks, and in certain cases from 4 to 5 months. That could not be helped. That trouble was experienced more particulary, on Dimapur-Imphal Road which was popularly known as Indo-Burma road during the second World War. The trouble had been aggravated because of the fact that the road had to be widened during the war to make it fit for two-way traffic. The hill slopes were necessarily cut steeper and in the process a certain stability which had been obtained during the course of about 50 years was disturbed. During and after the widening of the road they were having more difficult slips than before. Similarly, on the road from Gauhati to Shillong there had been slips but gradually these were getting less in number. Similarly, on another road starting from the railhead Mayani to Mokokshung, one of the headquarters of hill districts, they had lot of trouble and the causes were innumerable. One of the most important was the unstable hill face. Some of the hill faces contained shale mixed with boulders which had been found one of the most difficult materials to deal with. It was very hard when dry. But when torrential rains fell, it became soft and flowed down. The hill tribes' practice of burning vegetation to produce manure for cultivation considerably increased the run-off. As a result of this, rainwater flowed with greater velocity and dislodged more and more of shale.

Another cause was the cultivators bunding water and preventing functioning of drainage system. They let out water whenever not wanted, i.e., during the monsoons. This water in addition to the rainwater created further trouble.

Another trouble was that the season when the roads were blocked coincided with their cultivation season and, therefore, it was difficult to get sufficient labour for clearing the slips, even partially to restore communications. Bull-dozers and other equipment were also used without much success due to the conditions prevailing there.

Besides those usual troubles in normal times, difficulties had to be faced in time of emergency. The Assam P. W. D., took a number of measures to prevent slips.

It had not been possible for the Author to deal exhaustively with such a complex problem. The intention of the Author was to focuss the attention of the road engineers naturally interested in hill roads, so that further studies and investigations could be made and it was possible to get the benefit of the work done and experience gained in other parts of the country.

Shri R. R. Goel pointed out that in Annexure 1 on page 518 a statement had been given showing expenditure incurred in dealing with some landslides on Dimapur-Imphal Road. The statement had two columns for each year. It was not clear whether these two columns showed figures of expenditure on original and repair works. The total for each mile given in the last column was excessive as the figures were as much as Rs 1,21,640 for mile 42. It would be of interest to know the average cost of construction of that road per mile. In the U. P. the average cost of a hill road was Rs 50,000 per mile and naturally when figures as high as Rs 1,21,640 for repairs of a mile of road were mentioned, that raised the query whether the specifications adopted for repairs were proper and economical. When repairs to monsoon damages were taken up, the general tendency was to build up heavy retaining and breast walls using cement or lime mortar lavishly. Those walls cost huge amount of money. One had, therefore, to be careful while deciding upon the nature and the design of such walls. His personal feeling was that in most of the cases, heavy masonry walls should not be

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constructed and they should allow the normal process of clearance of the hang-off of the slip in the natural course. When sufficient quantities of loose materials had come down, the slope of the hillside would ease off to normal and it was at that stage that they might provide retaining walls on the valley side and breast walls on the hillside. During the course of the rainy season they should strengthen the road gangs to keep communications open. His own experience in U. P. was that this method worked well and was very economical. In situations where it was not possible to open the road due to too much of slips they provided coolie wallings or crib-wallings. In such situations, normally, good foundations for walls were either not available or were at a considerable depth, requiring heavy cost. Crib-walls, therefore, were the right answer as those could be built quickly and economically with the help of local trees available in the vicinity.

On page 512, para 5.2.3, the Author had stated that "where landslides occurred due to flowage, jungle wood spurs were constructed in series at intervals along the slope of the hills." As wood was not a cheap item and payment for all wood obtained from the forest had to be made, such spurs must be very expensive. However, he requested the Author to furnish sufficient details of design and cost so that those might be tried elsewhere also where feasible.

Again, in the same para, the Author had stated that where the slides took place due to erosion of river in gorges, series of boulder sausages were made which raised the river bed and stopped landslides by backwater pressure. That statement, continued Shri Goel, might be true only where the terrain was very flat which was not a normal feature of the hills. Normally water flowed at a terrific speed and must cause scour at the foot of the sausages. It was not understood how that method could raise the bed level unless too many sausages were built which again meant a lot of money. In U. P., the practice was to build bed-bars at suitable places where rock foundation was available and where there was no risk of scour. That helped in breaking the head of water and thus reducing its velocity. The method had worked well and stabilization of the hillside of the town of Nainital and the connecting Ballia Ravine was an example.

Again, at the end of para 5. 2. 3, the Author had stated that "the measures adopted by his department gave good results and there were no severe landslides during 1957 and in 1958 until the time of writing of the Paper." He would like to know the result of observations during the 1958 rains. The Author's statement

of no trouble in 1957 was not borne out by the figures included in Annexure 1 at page 518 which showed very heavy expenditure on the miles referred to in the year 1957-58. The Author might kindly elucidate.

On page 512, para 5.2.4 regarding methods of treatment, the Author had outlined 22 measures, out of which one or more could be adopted to solve each particular problem. Most of these methods were, however, very expensive and to his mind the only practical methods were the ones mentioned by him earlier.

On page 513, para 5.2.5, the Author had stated that "the surface erosion might be minimised by fixing wooden poles diagonally across the face of the cutting to divert the flow of surface water and check the downward movement of soil particles". It would be too much to expect the wooden poles to be of any help in providing stability against such heavy earth pressure or to divert the flow of water to any desired direction. That might mean only an unnecessary expenditure. He however, requested the Author to inform if he had already tried that method with success anywhere.

In Plate V, design of retaining walls, the top of retaining wall had been kept at 2 ft 6 in. and bands of C.R. masonry in C.M. 1:4 had been suggested at the base, in the middle and at the top. The bottom width had been adopted on the basis of the formulae

$$B = 0.4\,H + 1 \text{ ft for heights upto 20 ft}$$

$$\text{and } B = 0.4\,H + 2 \text{ ft for heights above 20 ft}$$

For heights above 20 ft, the masonry would become excessive. The practice usually followed in the U.P. was to keep the top width 2 ft, face batter 1:3, and back vertical. The top 12 ft portion of the wall was kept in random rubble dry masonry and the portion below that built in mortar, leaving sufficient number of weep holes to reduce hydrostatic pressure from the back. That method had worked well. Normally back cutting was adopted when a retaining wall higher than 12 ft was not required. If the situation was such that a higher wall was unavoidable, a toe wall might be given at the foot of the retaining wall. By treating monsoon damages in that way he had found that he could repair the damages in about a quarter of the amount required otherwise by adopting traditional methods of constructing heavy retaining walls.

The batter of retaining wall upto 12 ft height had been kept 1 : 4. As stated by him earlier, they kept the face batter

1:3. He would like to know from the Author if the section provided by him had stood the test of time so that they might use that elsewhere quite freely. The purpose of boulder filling all along the height was not understood. The U.P. practice was to provide hand packed stone filling at the back of the wall instead of earth, so that the pressure on the wall might be reduced. The usual area of filling was as per sections shown on Plate V and was never according to Plate VI. Taking the filling right upto bottom would mean unnecessary cutting of the hillside and, therefore, weakening the same rather than adding to its strength.

Shri G. C. Khanna observed that the Paper dealt with the subject of "Landslide Investigation" in a very detailed and thorough manner. The theoretical aspect of landslides had been discussed in great detail and would prove of great benefit to the Engineers in-charge of hill roads. The methods of treatment suggested in the Paper were similar to those adopted elsewhere where hillslides were very frequent.

On page 491, the Author had given a method of drawing a slip circle; the method was practicable only if the slip was less than 45 degrees; if the angle was more—say 60 degrees—then this method was not applicable, because the point D would lie outside the circle. This theoretical aspect might be examined again by the Author and he might kindly elucidate this point further.

A large number of slips occurred on road in Kangra District of Punjab. The treatment of some of the hillslides cost a large sum of money. Even if the work was done with all care there were failures. He particularly mentioned a slip near Kotwali Bazaar at Dharamsala in Kangra District. The road at this place had been giving trouble for the last 10-12 years. Series of retaining walls, and catch-water drains had been built every 3 or 4 years, but these retaining walls slided and the road settled. The construction of retaining walls, pucca drains, etc., had cost the Government a tremendous sum of money, but every alternate year or so the hill side slipped and caused damage to the road. The soil was like plum concrete with a clayey binder, which had hardly any shear strength when wet. Though the catch-water drains carried away a large quantity of water, some water percolated in the soil which became saturated and hillslides occurred.

The Geologist of the Bhakra Dam was consulted to find out whether cement grout could be injected. The advice given by him indicated that if there was a regular fissure in that rock,

only then the cement grout would be effective, but if the soil was like plum concrete it would not be possible for the cement grout to penetrate into the soil. He would like to get the advice of the Author on the treatment of this hill and also would like Shri S. R. Mehra, Director, Central Road Research Institute to advise on the treatment of this reach of the road.

Shri T. K. Natarajan stated that it was not clear whether the landslides which had been described constituted a block slide, or a rock fall, or soil fall, or whether they were in the nature of wet or dry earth flow.

In the broader perspective of a general approach, the problems of landslides were identification, recognition, prevention and control. Firstly, a method had been described on page 490, developed by A. M. Ritche, known as the slip circle method for determining the centre of rotation of a slump. In this connection he referred to another alternative empirical method.

If there had been an appreciable offset with regard to a positive reference point such as the edge of a pavement or something like that, one of the methods by which the centre of rotation of a slump could be obtained was as follows: Suppose the points C and D were known, C representing the edge of the pavement prior to sliding and D the same edge of the pavement after sliding had taken place. If those two points could easily and accurately be determined, the crown A of the landslide was known and the foot B of the landslide could be determined either by observation of the tension cracks which might have occurred or by direct boring. When ABCD was plotted and a perpendicular bisector of those two lines, AB and CD was taken, they would have to intersect at point O which gave the centre of rotation of the slump block, since the rotational paths of most of the segments of a slump were concentric circles towards a common centre and the depth of the slide could be directly determined from the diagram by scaling off.

Further, he would like to say a few words about the significance of cracks in any landslide investigation. It should be very interesting to know if any study of the cracks had been made by the Author during the landslide investigations. The ability to recognise minor cracks or minor displacements in the surface deposits could furnish very accurate knowledge of the cause and character of the movements which, he thought, was an essential prerequisite to correction. He wanted to know if any evidence of stretching of the ground surface was noticeable. That was not clear from the Paper. He should like to distinguish stretching of the ground surface from soil creep, because the former involved

deep seated movements, whereas soil creep was of superficial origin. The phenomenon of stretching was most commonly observed in non-cohesive materials which could not form or retain minor cracks readily. The best evidence of stretching consisted of small cracks that surrounded or touched some rigid body such as a root or a boulder in an otherwise homogeneous materials. These cracks formed because tensional forces tend to concentrate at or near the rigid bodies. In cohesive materials, such as had been found in this investigation, there were some cracks which were known as "en echelon" cracks and which developed in the surface soils before other signs of rupture took place. They were particularly valuable tools in the recognition of potential or incipient landslides.

Since the investigation described presumably concerned itself with cohesive materials, some information on the significance of cracks would have been very valuable.

In Annexure 6, a cross-section of the ground surface after the sliding had taken place was dealt with. This represented an assumption that there had been no change in the shear resistance of the clay before and after the sliding. For that assumption to be valid, he thought it must be clearly ascertained that the sensitivity of the clay had been very low. Of course, reference to Tables 5 and 6 on page 507 would indicate that the moisture content was consistently closer to the plastic limit than to the liquid limit. Even at 100 per cent saturation, the moisture content was much lower than the liquid limit. Those seemed to be evidences of a low sensitivity. It was, however, not clear if the sensitivity had been determined by any direct means in that investigation.

In the methods of stability analysis in Annexure 6 on page 526, calculations were given for evaluating the factor of safety for saturated conditions arbitrarily choosing a ground water table line. He would like to know why the values of ϕ and C for saturated conditions as given in Table 6 had not been used, but instead the Author had used an angle of internal friction of 25 degress and cohesion of 1,512 lb per sq. ft.

Turning to Annexure 8 on page 535, regarding drainage solutions, Shri Natarajan referred to the following statement: "if a drain is now installed in line 8 below the slip surface so as to lower the ground water table to coincide with the position of the slip surface, intergranular force will be eliminated." He thought it ought to read "seepage forces or neutral porewater pressure would be eliminated" and not "intergranular force," because intergranular forces were favourable as they always contribute to stability.

The Author had worked out the factor of safety of 1.2 using a value of $\phi = 10$ degress. If, for a moment, it was assumed that $\phi = 0°$, the cohesion worked out to be 840 lb per sq. ft. for a safety factor of 1. This showed that, if a particular soil did not have an angle of internal friction of even 10 to 20 degrees, there would be no use of installing a drain. It was not clear whether the calculations on page 535 merely illustrated how to evaluate factor of safety with regard to remedial measures, or whether they were to be taken as a set of factual data which were actually used in the analysis of landslides in Assam.

Two factors were difficult to be determined with regard to installation of drains. These were: (1) drain spacing, and (2) the prediction of the water table or the peizometric surface after the drains had become effective. At the present stage of knowledge only trial and error methods had to be resorted to and, therefore, field observations were needed. For example, in clay soils a drain spacing of as close as 10 to 25 ft, perpendicular to the direction of movement, might be necessary, whereas for drainage of permeable layers, a 25 ft to 50 ft spacing might be adequate. Complete interception of all water, of course, would call for a system of drains that was suited to geological conditions rather than one that followed a set geometric pattern. He requested the Author to give information, if any, on these points.

Shri P. N. Srivastava mentioned that on page 515, the Author had stated: "the slopes may be stabilized by spraying heavy grade oil to seal the water passages through pores to decrease the capillary tensions and seepages." He liked to know in which mile the Author had tried that method and what were the results obtained.

Similarly, on page 516, the Author had suggested that they could grout cracks and cavities with cement or other mortar and seal them. He would like to know the method of sealing adopted and the results that were obtained in due course of time. Shri Khanna had already pointed out that it was very difficult to seal big cracks, though small fissures could be closed, especially in stratas like conglomerates where the soils were very deceptive and full of boulders. He would like to know from the Author the method he considered suitable.

In his opinion, the failures on hill roads might be due to the original defective design, particularly with regard to drainage. Shri Srivastava related his experience regarding Mussourie road in U.P. That road, so far as he remembered, was constructed in 1922. In 1937, a big slip occurred near a bridge. At the back of the bridge there was a hill 1,000 to 1,200 ft high.

For 15 years after construction there was no trouble with the road, but suddenly a portion of the hill fell out in 1937. Then they tried to check the slip by putting in cribs. Every year they used to put logs and then fill with boulders and make the cribs. They found there was a tendency for the raising of the bed of the river and in about 5 years' time, the bridge which was 45 ft high remained only 15 ft high. In 1942, they had started the construction of another diversion. The bed of the river was rising by more than 4 to 5 ft every year. There was nothing wrong with the alignment; it was correct. He would like to know the remedy in such cases. Of course, diversion was the answer but the cost was prohibitive.

Further, the Author had mentioned difficulties which had arisen and which had disturbed the regime of the rock of the hill road while it was being widened. They had similar trouble on the Mussourie road. That road used to be only for one-way traffic. In 1945, they tried to make it for two-way traffic. They started cutting the hill sides and he personally noticed that if they cut indiscriminately and changed the type of side rocks, there would be trouble. He would like to be enlightened if the Author had any suggestion to make while widening the road.

On Gulabkoti-Joshimath road in Garhwal district of U.P., it was suggested that to avoid all those types of blockages they might have a rock gallery. The rock gallery kept the traffic going on road without being obstructed on account of the various slips. He would like the Author to consider the possibility of incorporating that in one of his suggestions.

In U.P. they had classified the various types of rocks and hill cuttings into various categories. Before they undertook work on any of those roads, they first decided the type of rock and then all the remedial work was done according to the classification of the rocks.

Shri H. S. Bhatia pointed out that Ritche's assumptions were more or less for deep slips which were found in high embankments and not in hillslides. He felt that boring logs should have been fixed at a number of places and the path of the slip circle investigated properly. There was no point, in fact, in making assumptions that the slip circle should pass through a definite path. That might be quite true theoretically but was not correct in practice.

A very interesting slip had taken place near Oxbridge in England. Any amount of analysis would not lead them anywhere because the boring logs showed that the actual path of the slip circle was one foot away from the anticipated path. The analysis of the slip did not give a factor of safety of one at the time of failure. Therefore, he thought that this aspect was very important and as soon as a failure took place, several boring logs had to be taken to find the actual slip circle before analysis could be taken up. In his opinion a dozen of borings would be able to give with a reasonable degree of accuracy, the path of the slip circle.

Shri Bhatia agreed with Shri Khanna that the length of the hill slips was about 10 times the depth. In an embankment failure, that was about 5 times. The Author's assumptions were correct for embankment failure.

Coming to the laboratory procedure, which was quite important, the Author had rightly touched on the theoretical side more especially dealing with pore water pressures. This was, indeed, a subject which needed careful consideration. He felt that an answer for all the slips could be found if they carefully examined the entire problem from the point of view of apparent shear characteristics minus pore water pressure. When dealing with pore water pressures, they could normally get to the real value of C and ϕ which gave the answer for failure. In his opinion, the Author had touched only the apparent values which would not lead them anywhere. Of course, they got certain value of the factor of safety which had no meaning in actual practice. He could not also understand how the Author could get any value of the angle of internal friction when the tests were performed under completely saturated state and under undrained conditions. They had to work on, what was known as $\phi=0$ analysis. It would always be found that while trying triaxial tests under undrained conditions when complete saturation had taken place, there was no reason why any value of the angle of internal friction was obtained and, therefore, to put it down in most of the analysis did not seem correct.

As regards geological formations in Assam most of the geologists had said that the formations belong to archaean group. This group of rocks was formed when the earth's crust did not support any life. Further there had been a certain amount of overburden pressure on these formations and, therefore, it could be presumed that the soils underneath were to a certain extent over-consolidated. Because, the knowledge in the field of soil mechanics in India had not advanced to that extent they could not say to what extent the soils of our country are over-consolidated. However, he thought, it was very important for that particular investigation to find out what was the total over-consolidation load, as this aspect of the problem might change

the complete basis of the analysis. In that case a drained test in triaxial apparatus was required to be done arriving at certain conclusions why the slip had taken place. Care should be taken in such test that no pore water pressure was allowed to develop, and that would give the real values of C and ϕ which would give the proper solution of the problem.

Regarding remedial measures, it was indeed very important to study a particular slope with reference to the analysis on the basis of which drains could be provided.

If it is observed in the field that pore water pressures is not rising more than what was anticipated in the laboratory then the slip was bound to get stabilized. Therefore, Shri Bhatia was of the opinion that such type of investigation should have been done with elaborate methods and equipment and taking several more observations to get really useful data. In such an investigation, the Central Road Research Institute might also have been approached to give the necessary assistance.

Shri V. R. Vaish stated that the problem of landslides was so great and the annual expenditure that was being incurred in connection with them was so considerable that further detailed study of this problem was essential and he would suggest that the Central Road Research Institute could take up the study of that problem.

In a new road under construction in the north, they had come across several serious problems connected with landslides. In a portion where they were cutting a rock hill-face for providing the road, one night in April when there was only slight rainfall a portion of the hill, 200 ft long, 100 to 400 ft high and about 10 ft thick, slided. The volume of materials that slipped was approximately 500,000 cu. ft. After that slip had taken place, it was revealed that there were layers of clay between the various layers of rock which itself had many cracks. That slip had probably occurred due to removal of support of the hill-face by cutting of road. It had taken 6 months for the removal of that slip as there was a large quantity of big stones that had to be removed. As the road was still under construction, the time taken did not matter, but in a road open to traffic, such slips could create difficulties. Surprisingly enough in the adjoining 100 ft length, where the conditions were exactly similar, they waited for the slip to occur during the monsoons, but no such slip took place at all.

On page 515, it had been recommended in para 7 that the slopes might be stabilized by spraying heavy grade oil to seal

water passages. In case of hills, treatment was not likely to be effective at all. He would like the Author to enlighten if that treatment had been tried by him anywhere and, if so, with what success.

Shri D. G. Bhagat felt that if the hill face was sliding, any superficial stabilization was not going to be very helpful. They must intercept the water at all stages. It was quite likely that in the higher regions there might be cracks and water finding its way through those cracks, going right behind the subsoil terrain and going out into the valley below. The best way would be to intercept the water from getting into the soil by percolation. Catchwater drains were, of course, one of the solutions. But that would only take the surface flow at certain points. It could best be done by putting in subterranean drains. Those drains could certainly be controlled by putting in pipes with open joints and each joint should not be closed completely but should be covered with shingle so that no finer materials go in. It would be preferable if perforated pipes were used. Of course, the point naturally arose at what depth the pipes should be laid; for that a good geological survey or pore study was required. But at whatever depth the pipes were laid, it would be helpful and some water certainly would be taken away, thereby reducing the hydrostatic pressure on the soil. In Photo 8 of the Paper, the Author had shown some pipes receiving the subterranean water from behind the face. Of course, they had got to be cautious that the pipe was laid to certain drainage line and they must avoid water saturating the soil as much as possible.

Shri J. Mukand stated that protection was not of much use when the water pressure was building up from the inside. It was alright when they were dealing with a small localized problem, but when there were miles and miles of road in the hills to look after, they had to find out some economical method and not a system of underground drains. His experience was that if one tried to work with nature, then they could solve the problem much more easily as well as economically. As for erosion caused by water flowing down the hill, it could be reduced if the velocity of water was checked. The scour had a great effect in promoting landslides. As the water fell on the top of the hills it flowed down, especially on the steep gradients it developed velocity of flow. By the time it came to the bottom of the hill, the velocity was so high that it started eroding and eating away the embankment. So, the first attempt should be to reduce the velocity of flow, and that could be done with the help of nature by having a system of contouring and supplementing it by planting vegetation. They could throw grass

seeds or plant some shrubs which had root, going deep into the soil. That helped to stabilise the soil. It not only worked economically but also helped to change the nature of the soil of the subgrade. A system of bitumen sealing had been suggested. He could not understand how bitumen sealing could help in this case. Rather, that was bound to aggravate matters because bitumen would tend to seal in moisture which was inside. When the sunshine was bright, the tendency was for gas to form under the surface of the ground and build up pore pressure. The attempt should be to relieve the pore pressure rather than to increase it by sealing it in from the top.

Shri K. L. Bhanot in his written comments brought to the notice of the Author that the sketch given on pege 523 of the Paper was slightly misleading. Each one of the slices into which the slip-area had been divided had its weight indicated by the right-hand side vertical line in the corresponding triangle of force which must not be obtuse-angled. If the present sketch be taken as it is, the sense of the tangential forces shall just be reversed, tending to further stabilise the slip area. In a nut-shell, he only meant to say that the slip circle in the Figure should have its tangent line at left-end dip downwards rather than upwards as in the present case, and the force-triangles for the slices 0-1, 1-2 and 2-3 corrcted to that extent.

Shri K. Barua Chief Engineer, Assam stated that he would endeavour to reply as many comments as possible and the rest would be passed on to Shri Sharma for detailed replies.

Shri Goel had asked about the cost of construction per mile. He would put that as Rs one lakh per mile. About the table that he had commented regarding 42nd mile, it was not the cost of maintenance per mile, it showed the tremendous amount of money that they were spending in the 42nd mile slips.

About crib walling, they had used that method quite a lot in their hill road construction.

About jungle wood spurs, the cost was not the criterion because it was for labour they had to pay while the wood was available at site. Also, they are using boulder sausages for breast walls and not for retaining walls.

Regarding cement concreting certain hill places, in fact under instructions from the Ministry of Transport and Communications they did some guniting work on a certain road and they got considerable success.

Regarding **Shri Srivastava's** comment about rising of the bed, they were also facing the same trouble in numerous cases. Very often they took resort to clearing the beds as much as possible to find the water they required.

Regarding his comments indiscriminate cutting of hillsides while widening the road, of course they did that but it was consistent with economy. After the road had found a certain amount of stability and when that was disturbed, that took again a considerable time to regain stability, but in the process they experienced the slips.

Shri Bhagat had mentioned about buried drains. Actually, they had done that but not exactly as he had mentioned and they had met with success.

Shri Mukand had suggested about vegetation growing, as previously mentioned by him, they had done that work extensively and with very good results.

Shri G. C. Sharma (Author) who unfortunately could not be present during discussion, sent his written replies to the points raised by various speakers. In reply to the points mentioned by **Shri R. R. Goel**, the Author stated that the expenditure figures shown in Annexure 1 were both for repairs and original works in certain miles during the period 1953-54 to 1957-58. The original works included the construction of boulder sausages, buttresses, retaining walls, catch water drains, benching of slopes and plantation of vegetation. On the other hand, the repairs included removal of spoils, making temporary diversions for traffic, repairs to existing drains and other structures and repairs to the existing surface of road. There was no suitable alignment to divert the slip area as the whole area was susceptible to the land slides. Thus, the economic consideration in terms of rupees did not come into the picture. From the past experience it was observed that there was no likelihood of stabilising the areas by natural processes since the slides occurred many years back and still continued in a vigorous manner. Of course, where possible, small slides had been cleared by manual labour and costly methods of treating them avoided as far as practicable. Wooden crib walls were provided but these were frequently damaged and as such there was no other recourse than construction of boulder sausages which could be built even when the foundation conditions were poor.

As regards construction of jungle wood spurs to prevent flowage, Shri K. Barua had already given a reply. Such spurs were constructed with 4 in. to 6 in. diameter jungle wood timbers

hand driven to a depth of 4 ft to 5 ft below ground, placed compact and tied with horizontals one foot apart. Series of such spurs were constructed in slopes at an interval of 30 to 40 ft according to the nature and magnitude of slides. Jungle wood trees were available in nearby forests without any royalty except cutting and bringing them to the site.

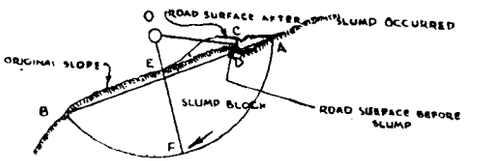
The construction of boulder sausages in beds of rivers to stop slides due to erosion was adopted in miles beyond 81 towards Manipur where the road passes through a valley as explained in para 4.6.7 and the rivers in which such measures were adopted are flowing almost in a flat terrain. The conclusion arrived at as mentioned in para 5.2.3. referred to measures taken by providing jungle wood spurs in slopes and boulder sausages in beds of rivers. As already explained, there were landslides big or small almost all over the road starting from mile 12 to 125 and the expenditure shown in Annexure I was only for landslides which occurred in miles 34,40,41 and 42 and not for the whole road in a particular year as anticipated by the speaker. Besides, no measures were taken to control slides in miles 34,40,41 and 42 by constructing boulder sausages in beds of rivers as no river was flowing in those miles where landslides had occurred.

As regards fixing wooden poles diagonally across the face of the slope of the hill to prevent surface erosions, the method was actually adopted and found to be quite successful. Such poles were driven in the same manner as in wooden spurs as explained in the previous paragraph. The face of the spur was filled up with brushwood to prevent percolation of water. Once the surface water was diverted from flowing along the slope downwards, soil erosion would naturally be prevented. Such wooden poles were not fixed to stabilise the slides as mentioned by the speaker. For stabilising the slide area, the method of driving piles as given in Annexure 7 might be tried when the condition demanded.

The typical sections of retaining walls as shown in Plates V and VI were the standards followed all over Assam by the Public Works Department, and they had stood the test of time quite well. Another speaker **Shri V. R. Vaish** had also admitted that such retaining walls constructed in his area served the purpose satisfactorily. The reason of providing boulders in back filling was mainly to reduce the pressure and weep holes were also provided to drain off free water and thereby decrease the hydrostatic pressure.

In reply to points raised by **Shri G. C. Khanna**, the Author stated that the slip circle method was suggested in

case other positive methods mentioned in the top of page 490 of the Paper could not be adopted due to any other reason. The method devised by Aruthur M. Ritchie was applicable only to slides of the slump block types to estimate their maximum depth from the ground surface to the surface rupture. Another method known as "Concentric Circle Method" might be suggested when certain positive references such as edges of pavements etc., were known. Then the approximate position of the centre of rotation could be found out as explained below:



C and D are two points accurately known from the edges of surfaces and before after the slumps occurred. The point A is ascertained from the tension cracks from which the slides start and also the point B at the foot of the slides. Draw graphically two straight lines bisecting AB and CD and crossing each other at point O which is the centre of the rotation of the slump block. The maximum depth of slide EF can then be measured to scale from the graph.

Both the methods, viz., "Slip Circle" and "Concentric Circle" could be applied to slumps only made of several individual blocks. In most cases, the slump block tended to lie at a tangent to a common shear plane. It was not known to the Author whether **Shri T. K. Natarajan** had explained a similar method as mentioned above.

Regarding the trouble in Kotwali Bazaar, it appeared that troubles arose not due to surface water as many pucca catch water drains and longitudinal drains were constructed to drain off surface water to prevent percolation and thereby decrease the pore pressure in soils. The nature of soil was also such that it started giving troubles just after rains. Thus, it was apparent that water was the main potential agent contributing and aggravating the slides in that particular region. The suggestion made by **Shri D. G. Bhagat**, seemed to be quite logical and reasonable to prevent saturation of soils and reduce the hydrostatic pressure as explained in Annexure 8. As that was a case pertaining to subdrainage and not the surface drainage, the

following methods were recommended: (1) Horizontal drains (as shown in Photo 8) in deep excessive soil mass where ground water exists (2) Drainage trenches in relatively shallow soil mass with ground water present (3) Tunnels in deep extensive soil mass with some permeability (4) Vertical drain wells in deep slide mass with ground water in various strata of soils, and (5) Continuous siphon used principally as outlet for trenches or drain wells. Vertical and horizontal sand drains might well be suggested for experiment in a smaller scale. Portland cement grout injections were used successfully for cementing coarse sand and gravel but were generally considered less effective with finer grained soils. Bituminous emulsions having lower viscosity might be tried which would penetrate into pore spaces of finer grained soils. The process was not recommended where the ground water might remove the emulsion before setting occurred. Any of the methods as suggested above might be tried.

Replying to **Shri J. Mukand,** the Author stated that the importance of ecological treatment to prevent landslides was explained in para 5.2.5 and perhaps no more details would be necessary. In case of bituminous sealing, the process depended on the nature and moisture conditions of soil types. If the slides were due to surface drainage and soil was porous and of granular type, bituminous sealing would be helpful which would reduce the shearing stresses and increase the shearing resistance. The method could be tried in winter and dry weather when the soil strata was completely dry and the moisture content remained to the minimum.

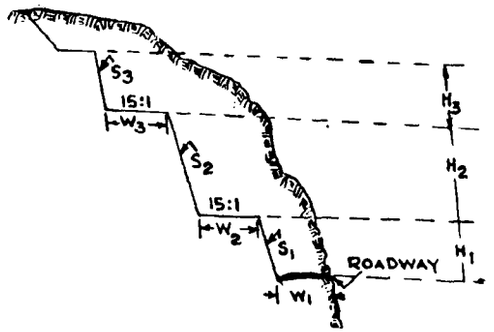
In reply to the point raised by **Shri V. R. Vaish** and **Shri P. N. Srivastava** regarding stabilization of soils by spraying heavy oils to seal water passages, the Author stated that though it was not actually tried, it was one of his suggestions. The process might be tried when the soil in the hill face contained fine grains and trouble arose due to percolation of surface water and increase of pore pressure. It was one of the methods of slope stabilization.

Regarding Shri Srivastava's comment on widening of existing roads in areas susceptible to landslides, the Author stated that the excavation method as mentioned in para 6. 1 and illustrated in Plate VII was designed to increase the stability of the area by reducing the forces which caused movements and at the same time reduced the movement causing stresses. While adopting the excavation method, it would first be necessary to ascertain whether the landslides were due to slide, fall, flow or the slipping plane—inclined or straight—and failure developed at the toe of the slope. Falling rock fragments due to rock falls and rock

slides might be removed; but to prevent further damage to any road structure, benching or flattening the slopes would be a permanent cure. The proper design of slopes in rocks depend on the geological characteristics of the rock itself. There were three main principles in designing slopes of excavation, viz., (1) by giving uniform slope from the drain line to the top (2) straight slopes at varying angles, and (3) straight slopes separated by horizontal benches. The choice in the above methods rested with the designer who might recommend any of them on study of the rock formation and its disintegration in a particular region. No clear-cut method could be suggested for use as a standard. However, the Author happened to inspect some of the measures taken by the West Virginia Highway Department to prevent rock slides during his stay in U.S.A. The following were the design procedures for slopes in cutting of different types of rocks followed by them and might be tried in India where such types of rocks were met in widening.

Type of rock	Height between branches		Width of benches		Back slopes (horizontal & vertical)	
	*H*1 in feet	*H*2, *H*3 in feet	*W*1 in feet	*W*2, *W*3 in feet	*S*1 in feet	*S*2, *S*3 in feet
(i) Heavy cutting in shales & sand stones	5 to 20	20 to 30	0 to 30	20 to 25	½ : 1	½ : 1 to 1½ : 1
(ii) Heavy cutting in sand stones	10 to 30	30 to 40	0 to 20	20 to 30	¼ : 1	¼ : 1
(iii) Heavy cutting in shales	10 to 25	20 to 30	0 to 30	20 to 30	1 : 1	½ : 1 to 2 : 1
(iv) Heavy cutting in sand stones underlain by shales	10 to 30	20 to 40	0 to 25	20 to 35	¼ : 1	¼ : 1 to ½ : 1
(v) Moderate cutting in shale & sand stones	10 to 40	20 to 40	0 to 20	20 to 30	½ : 1	¼ : 1

The excavation method might also be tried to treat slides and flow which were made up mainly of soil as shown in Plate VII. Removal of heads or unloading was a reliable technique. The theoretical analyses should be adopted as explained in Annexure 9 for proper design.



As a reply to the queries made by **Shri T. K. Natarajan,** the Author stated that the brief descriptions of landslides and subsidences with their probable causes on Dimapur-Imphal Road were furnished in para 4.6 as far as practicable. As the Paper was of outline nature, full and detail particulars were not incorporated. Broadly speaking, rock fall, soil fall, under fall, rock slide, block glide, under slide, soil flow, debris flow, sand or silt flow, dry or wet flow under flow were the main types of landslides one might encounter on bedrocks and soils which could be identified after thorough observations for a number of years from their movement and geological, soil and hydrologic conditions. From the past records available, it could be stated that the slides which occurred on Dimapur-Imphal Road would fall under the category of rock slides and also wet and dry flow of debris, earth, and earth mixed with rock fragments and shales.

The nature of cracks and movements was explained by the Author in paras 5. 1. 4 and 5. 1. 5 of the Paper. It was observed that the cracks which appeared in mile 64 slips were of "en echelon" type as described by Terzaghi and mentioned by the speaker. Such cracks appeared in the surfaces before the rupture of the sliding block took place and they were approximately parallel to the axis of movement. It was also observed that the cracks at the root of the slide were almost normal to the axis of movement.

As mentioned in paras 1.3 and 4.7, full scale laboratory analysis could not be made due to want of a road research or a soil testing laboratory within the State but this was expected to be done in future studies. It was not known to the Author what the speaker meant by sensitivity of clay. If he meant "Sensivity" as defined by Terzaghi and Peck as the ratio of soils unconfined strength in an undisturbed condition after remoulding, the Author would say that due to want of laboratory facilities available in Assam, that could not be done though he realised its importance.

Regarding the evaluation of factor of safety for saturated condition in Annexure 6, the water table line was arbitrarily chosen and the calculations were not necessarily for saturated conditions. Even the dry density was taken as 130.5 lb per cu. ft. from Table, 5.

Referring to the drainage solution in Annexure 8, the term "Intergranular force" was taken loosely for the "Hydrostatic pressure" and hence the statement furnished in Annexure 8 should be taken as correct.

The calculations made in page 535 of the Paper represent an illustrative example how to evaluate the factor of safety with regard to the remedial measures. The benefit of installing a drainage structure could not be derived if the angle of internal friction was not between 10 to 20 degrees to have the full influence of drainage.

The object of installing the horizontal drains was to remove the water by diversion, to lower down the water table line in sliding masses and also to drain off water from the pervious strata. Sufficient drillings should be made to determine the existing water table and water bearing strata of the soil mass.

As regards removal of water from the ground, that could be estimated through experience and also by close observation of the time taken for water to flow into the drilling holes. Permeameter test in the field and undisturbed soil sample tests in the laboratory would give the permeability of the soil strata. Observation wells might be tried to measure the water tables and piezometer for attaining hydrostatic pressure. As Shri Natarajan pointed out, no definite procedure except trial and error could be suggested for spacing of horizontal drains due to different local geological conditions.

Replying to the points raised by **Shri H. S. Bhatia** for value of $\phi=0$, the Author stated that Fellenius seemed to be the first to assume that the angle of internal friction for a sliding mass of saturated clay was zero. Since then, the method was widely used. Perhaps it was not known to the speaker that Skempton, later on, proved that in cases where the rate of loading of the soil mass was slow enough, ϕ was not equal to zero and the assumption that $\phi=0$ was no longer valid. Skempton had also shown that the $\phi=0$ analysis would not lead to a correct location of the actual failure surface nor would it give a theoretically correct factor of safety if the test values of

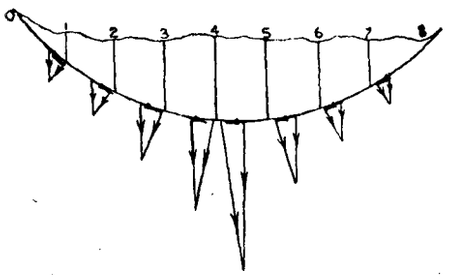
cohesion were applied to the actual failure surface. In the case of the value I for the safety factor, the laboratory values of "ϕ" and "C" cannot always give the correct figure due to irregularities in the soil, difficulties in obtaining undisturbed soil samples, problems of laboratory technique and probably due to the effect of hydrostatic and seepage forces. Slopes in nature have beer known to be stable even though the factor of safety was computed as 0.75. This would indicate that the shearing resistance was only 75 per cent of the shearing force. If the factor of safety is less than 1 or greater than 1 for an unstable slope, it appears certain that some factors have been disregarded. In this particular investigation, the hydrostatic pressure or seepage force was the main contributing factor for the variation of results.

Regarding the geological formations and overburden pressure, the Author stated that the reports submitted by various geologists who were deputed to investigate the landslides in Assam did not point out such reasons which activated the process of landslides. It was not understood how the investigation to find out the overall consolidation to stabilise the natural slope would help in dealing with landslide problems. A more positive approach would be to ascertain the inherent characteristics of the soil and rock materials. Inherently weak materials like sedimentary clay, shales, decomposed rocks, rocks composed of soft minerals such as mica, schist, tale and organic materials have low shearing strength. The intergranular forces which increase the shearing strength are reduced due to (1) Pore water pressure (2) Buoyancy in saturated state (3) Capillary tension in moist soil, and (4) Seepage pressure. These should be considered rather than overall consolidated load or overburden pressure as mentioned by the speaker as increase in the shearing strength of the soil mass to resist landslides seemed to be the correct approach to the problem.

The Author in his reply to **Shri K. L. Bhanot** stated that he was right in pointing out the wrong directions of forces in the sketch on page 523. This happened while copying from the original one and unfortunately escaped his notice. The actual cross-section of the slip area had not been shown in the sketch referred to. The sketch drawn without scale was just an example to show the process of solving the forces. Shri Bhanot's attention was invited to Fig. 3 at page 491 wherein the method of drawing the slip surface had been clearly and correctly shown. In the present sketch (Fig. 9) the forces should have been drawn as shown in the sketch on page 829.

Shri G. R. Nangea (Chairman) in his concluding remarks stated that he should expect Punjab, U.P., Bihar and other

States which had certain lengths of Himalayan hill roads to come forward with their experience and the remedies for avoiding heavy slips.



Many speakers had suggested that the C.R.R.I. should have been associated with the research side of the problem. The Director, C.R.R.I. had mentioned to him that they were already taking keen interest in that and certain amount of work had already been done. He would very much appreciate if all the States who had considerable lengths of hill roads would associate themselves with the C.R.R.I. so that the results that they obtained or the remedies that they suggested were really useful.

The Chairman then thanked the Author and Shri Barua for a very interesting Paper and also the various speakers who took part in the discussions.

Discussion on

"General Report on Road Research in India"*

Friday & Saturday, 9th & 10th January, 1959.

Shri U. J. Bhatt (Chairman) in his opening remarks said that one of the most important things that the Indian Roads Congress had done was to focuss attention on research and its application. In most of the messages including that of the Prime Minister emphasis has been laid on the need of building roads economically by using local materials. While due to higher traffic volumes and intensities paved roads had to be built, attention was also to be focussed on the low cost roads, and unless there was effective research and its application, these objects could not be achieved.

The Chairman then called upon Shri S. R. Mehra to introduce the report for discussion.

Shri S. R. Mehra in his introductory remarks said that, as usual, the report was divided into two main groups, viz., design, construction and maintenance, and traffic and traffic safety, which was according to the international classification. In addition, there were sub-groups on rigid pavements and flexible pavements, etc., under both the main heads, and the idea was that each sub-group should be taken up one by one for discussion.

Two points for discussion emanated from the introduction of the report, viz., functions of the laboratories and application of research. This was a short account bringing out the necessity for giving careful thought to these two aspects of research.

Applied research, Shri Mehra said, meant solution of practial day to day problems which were applicable to the actual execution of work. He felt that unless the results of current research were applied in actual construction, further problems could not possibly emanate and there was danger that research work might become more and more hypothetical and less and less useful in practice. To make this possible, two conditions must be satisfied, viz., (a) and (b) in the report.

Regarding (a), it was true that the States which had laboratories felt that they were meant to control work, but so far

* Published at pages 553-572 of the Journal of the Indian Roads Congress, Vol. XXIII-3, December 1958.

these laboratories had no direct responsibility in the way of controlling the quality of materials and work carried out in the State.

Regarding (b), if the work of testing and control was given to the State laboratories, they would start doing useful work immediately, and during the course of this useful work, they would also come across lot of small difficulties which become problems for further research and the solution of which would again benefit the State for which the laboratory was meant. This would gradually raise the status of laboratory and the level at which its research work would be carried out.

Shri Mehra said that our fundamental outlook on research in so far as it related to State laboratories had got to be re-orientated. There are two ways in which research could start. One was from the top, by setting up research institutes and taking up problems and starting to solve them. In the state of research now existing in this country and the present state in regard to utilization of known and existing methods of design and technique, it would be impossible for many State laboratories to find sufficiently useful research problems if they started on research from the top. On the other hand, if they were associated with actual work they would come across many research problems and from there grow into bigger and stronger research laboratories.

FUNCTIONS AND APPLICATION

Shri R.N. Dogra felt that though some of the States had research laboratories, full benefit was not being taken because of the fact that the laboratories had no responsibility with regard to the actual control of the work in the field. In his opinion, in many instances they were not associated with the construction work in the field and, in places where they were associated, their advice was not always accepted. If the laboratories were to be of any use, they must be given a certain amount of responsibility in the construction. Shri Dogra said that in other countries, for instance in Holland, where a laboratory was run by the department itself, it was not only associated with the design and specifications of all major road projects, but the final bills of the contractors, etc., were not paid till the laboratory had certified that the work had been carried out according to the specifications and to the standards laid down. He felt that some sort of standards should be laid down before any road works were accepted by the Government and it would always be desirable that the person responsible for checking whether the work done was acceptable or not should not be the person responsible for the construction, and in this way control laboratories would be able to play a very useful role. This might be a controversial

point; many of the Chief Engineers might not like it or might not like to accept it, but he felt that if standards were to be raised, some sort of independent authority must be brought in. This had been accepted by most of the organizations, in the Army as well as in the Central P.W.D.

Shri K.K. Nambiar stated that we should lose no time in getting all the States to move in the direction of establishing State laboratories.

At present, dearth of these laboratories was inhibiting the adoption of new methods and new techniques of road construction in the country, as for instance, soil-cement construction. There were many engineers who were keen on adopting this technique due to its being economical and possessing other properties not easily supplanted by other materials. But as there were not sufficient laboratories for testing the soil samples and making the design, this technique was not catching on.

With regard to control work referred to by Shri Mehra, their experience had been that a centralized laboratory in the capital of a big State could not attend to all the control work. There should be a few field laboratory units with testing equipment, etc., to do this work in addition to some mobile laboratory vans equipped with testing apparatus. Of course, all the work would be co-ordinated and controlled by the Central State laboratory.

Shri Sujan Singh agreed that the research work which was being done in the country was not being adopted in practice. Unless that was done, all the amount of money being spent on the laboratories would not be worth it.

He also suggested we should try to have quality control and this work could best be done by the State Laboratories.

Shri U. J. Bhatt remarked that many of the States had excellent laboratories and he would like his colleagues, the Chief Engineers concerned to give their experience. He felt that if the Chief Engineer was research-minded, he could control both the design organization and co-ordinate the work with the laboratory.

Bombay State proposes to establish a road research laboratory almost immediately in close co-ordination with the Central Road Research Institute.

Shri K. V. Ekambaram did not agree with some of the remarks offered by Shri Dogra. He did not know how other State laboratories were working, but the State laboratory in Madras was working under the Chief Engineer. As remarked that if, the Chief Engineer was research-minded, he could make

good use of the laboratory, exercise good control over the various field units, and also make good use of the results in the design of pavements, etc., certainly Madras was working in that direction, otherwise, there was no use of a big central laboratory and no purpose also if no basic research was done. He would call a State laboratory a magnified field laboratory. He was of the opinion that the State laboratory should confine itself to controlling the work in progress in the State and ensuring their proper execution. Possibly certain State laboratories might have been working independently and that was the reason for the remarks offered. However, the Madras Research Station was working in the right direction.

Shri J. Mukand said that research was a subject by itself and they should not burden the research workers with field work in the nature of control as suggested by Shri Dogra. In a country like India, which is a subcontinent by itself, he did not think it was possible for one laboratory to exercise control on the works in the country. He felt that it was not necessary to have a number of research laboratories at various places, the Central Roard Research Institute could do the research work along with a few other State laboratories. But they needed thousands of field laboratories to feed the information to the Research Laboratories and minor problems could be solved there as, he felt, the more centralised this work the more would be the delay. To implement or to bring into use the results of research work, two things were required badly, one was field equipment and the other field staff. He thought the Central Road Research Institute could help them in giving necessary guidance in training of the personnel and the procurement of the necessary equipment at reasonable rates as they wanted to set up a number of field laboratories and start functioning them.

Shri G. C. Khanna stated that there was a large scale road programme in the Punjab but they did not have sufficient staff to carry out the field tests. Then there was the time factor involved in associating the laboratory with field work. Therefore, he felt that either they had to increase the staff of these laboratories to such an extent that all roads were properly designed after field investigations or they had to leave special problems to the field staff. He wanted to know from Shri Mehra whether there were any targets which could be laid down for completion of field work. Control could come later when they had mastered the field tests.

Shri S. R. Mehra explained the position regarding availability of staff for these laboratories and time factor, etc. He quoted an instance in the Punjab itself when they were faced

with the problem of providing 4,000 houses for the refugees at 12 different places, and in the absence of coal for burning bricks, they decided to do the work in stabilized soil using only 2½ per cent cement. They had to rig up 40 field laboratories to work under the Central laboratory in Karnal and in a matter of one month, all the 40 field laboratories were placed in position with their staff having been trained in the testing methods. With regard to the time element involved, he did not think very detailed type of testing work was involved so far as design was concerned. What needed was to get a general idea of the bearing value of the soil in various reaches and to give the thickness which would be adequate and the manner in which local soils and materials could be incorporated into the design of a road. The impression that the association of a laboratory with the design of a road was a time consuming factor and likely to hold up work, in his opinion, was not correct.

Shri R. N. Dogra referring to his earlier remarks stated that he did not mean that the persons who were engaged on research would actually have to leave their research and go out into the field. Anybody who had had anything to do with laboratory organization would know that the laboratory was always divided into various sections, one of them being a control section whose entire job would always be to look after the control part of it. The rest of the research is carried out by other sections which should be equipped suitably for carrying out research. As such, it did not interfere with the work of the research problems that were being posed to the laboratories.

Regarding the time factor involved to do the preliminary soil investigation, etc., he thought that generally they know well in time as to what lengths of roads were to be constructed in the next year, at least approximately, and this investigation should not take very long and should be so arranged that it could be done beforehand. The only thing that was lacking in his opinion was co-ordination between the laboratory and the others, and with a little judicious organization, he thought, these two problems could be solved.

One of the main problems, mentioned by Shri G. C. Khanna and others, was personnel. The Central Road Research Institute could get the personnel because their scales of pay were attractive and, therefore, they were able to take away staff from the State laboratories. The Indian Roads Congress could help in trying to advise the Governments that the scales of pay of all research laboratories should be on a uniform basis, so that there was no tendency of migration of the scientific staff from one laboratory to the other.

Shri P. L. De stated that in West Bengal, in addition to the Roads and Buildings Research Institute at Calcutta, there was a proposal to set up Divisional Control Laboratories, in all the construction divisions and already several such divisional control laboratories were being set up. During constuction of soil stabilized roads, site testing units were set up for the control work.

Regarding the dearth of technically qualified staff, West Bengal had started a scheme for training the departmental Assistant Engineers and Overseers in the fundamental principles and practices of soil stabilization and already about 50 officials had been trained who would be in charge of the divisional laboratories.

Regarding the authority of the research institute to enforce the implementation of the findings of the research in the actual construction work and to exercise control, Shri De mentioned that in West Bengal several findings of the Research Institute had been implemented in construction, and in the case of concrete works for bridges, buildings, etc., even the final payment to the contractors was subject to satisfactory test results of the concrete tested in the Research Institute.

Shri D. C. Chaturvedi stated that so far as testing and control part was concerned, already many laboratories were doing that work but it was difficult to visualize the 'design' part to be done by these laboratories. He enquired whether these laboratories were expected to carry out design of structures and whether the 'design' work implied design of admixture of stabilized soil by means of laboratory tests or design of cement concrete mixes, etc. This point needed clarification.

As regards application of research, Shri Chaturvedi wanted to know the result of the proposal for earmarking a certain percentage of the funds allotted to works in States for carrying out experiments in the field. If that proposal was put into practice, he felt, lot of experiments based on laboratory research could be carried out in the field and it would be possible to give out the results with confidence for application in the actual works on a large scale. Unless this was done, it would not be possible, in his opinion, to apply results of research in the field to the extent desired.

Shri Tejbir S. Khanna mentioned that there seemed to be four main reasons for difficulty in implementation of research results, e.g., (i) to fully comprehend the value of research work and its results; (ii) to effect the results of research which sometimes involved organizational changes; (iii) there was no incentive for the application of research results; and (iv) every

new thing generally created a reaction in the human mind and unless this new thing was to one's personal liking, the reaction often channelized itself in the form of opposition to the new idea.

He further suggested the creation of a 'Research Implementation Committee' in the Indian Roads Congress to study the problem in its various aspects and to suggest means for overcoming the obstacles.

RIGID PAVEMENTS

Shri P.J. Jagus stated that in the introduction to the report, emphasis had been rightly placed on the importance of applied research in the various research laboratories in our country, specially during the period of the next few years. In order to take up this challenge, it was desirable to take stock of the problems based on our past experience for which satisfactory solutions were not yet found. In this context, the importance of a close co-ordination between the State departments and the State research laboratories (wherever they existed) and the State laboratories and the Central Road Research Institute could not be over-emphasised. Such close contacts and co-operation would not only help in the factual realisation of the problems but also in their correct appreciation, assessment and a rapid and more effective solution. Inter-laboratory collaboration would also minimise the over-lapping or duplication of research in the different institutions.

Shri Jagus felt that the emphasis on technological and basic research problems in the report was rather disproportionately high, though it was gratifying to note that leading research workers in the field were getting vigilant of the situation and were wisely inducing a directionality towards applied work in the laboratories.

Shri Jagus referred to para 2.2.2 of the report under rigid pavement section, and wanted to know what was the age at which concrete was subjected to tracked vehicle traffic, and what was the stone used in the setts under (i) and (ii) and whether of the same compressive strength as the concrete.

Further, regarding grouted concrete construction being uneconomical, he felt that the essence of economy was saving in multiple handling of materials and quantity of mixing. In the 20 experimental lengths laid with grouted cement concrete, the saving worked to about 15 to 20 per cent as compared to premixed concrete. A general statement regarding its unsatisfactory performance as made in the report did not do justice to this method of construction, as excellent performance had been

obtained in some of the most heavy traffic roads constructed with this method.

Regarding admixtures in para 2.3.1, Shri Jagus stated that it had long been appreciated that slump and workability as measured by Wigmore needles were not reliable indices, besides being inoperative for low water-cement ratio. On the other hand, a study of the extent to which ease and speed of compaction of concrete could be increased by admixture would be more appropriate. He cited earlier experiments conducted at Mehsana where Lissapol *N* was used for the first time in the pavement with no increase in the slump at all. A rough test of the time required for compaction and finishing of the pavement from the starting of the compaction showed that there was a saving of as much as 15 to 20 per cent in time by the addition of this admixture. Regarding the use of another reagent, Dehydol-25, as mentioned in the report, it was not indicated as to what was the range of workability obtained with this particular admixture.

Regarding use of pozzolanas, para 2.3.2, Shri Jagus stated that the very fundamental basis of thinking of surkhi as pozzolana had to be modified slightly. He did not like the use of such unscientific terms as 1st class bricks, 3rd class bricks etc., as it neither reflected the qualities of the raw materials nor the degree of burning. It was high time that they started talking about what was the basic material that was used and what was the degree of burning and, then, whether it was active pozzolana or inactive pozzolana.

Referring to para 2.3.7 about some work on the joint sealing compound to take jet blasts, Shri Jagus felt that there was a pressing need for developing an indigenous expansion joint filler for use in concrete construction in the country, as expansion joint fillers which were partly or wholly imported from abroad were not available at all. This need was very urgent and they should try and evolve a synthetic or natural expansion joint filler of non-expansive type. In the alternative, he suggested the use of suitable type of soft wood with the help of the Forest Research Institute as a stop-gap arrangement.

Referring to research work on prestressed concrete pavement, Shri Jagus stated that there were certain other very important and baffling problems to be tackled, the principal one being that of subgrade restraint for prestressed concrete specially in view of the resistance to elastic deformation of the pavement when the jacking forces were applied. He informed that under the collaborative research work between the C.A.I. and the C.R.R.I. they had taken up this particular aspect of the problem and were going to handle it shortly.

Shri D. C. Chaturvedi mentioned that though the grouted concrete experiment carried out on Lucknow-Varanasi Road, had developed numerous cracks and settlement, and the Road was in a very pitiable condition and he did not think that the process was defective because on another small stretch of experimental length with Checol on the Sultanpur Road it was behaving better, but comparing the two, it did not have as much bearing resistance as that of premix concrete. He wanted to know what specifications were being suggested by the C. R. R. I. for the experiments which were to be carried out by the Roads Wing as mentioned on page 6 of the report.

Shri Chaturvedi stated that they had found that the use of Lissapol *N* no doubt improved the workability of concrete but a certain loss in the strength was noticed. Other laboratories also had found that the use of Lissapol *N* gave lower strength, with its use the water-cement ratio could be reduced, thereby compensating to some extent for the loss of strength.

Regarding the statement of the C. R. R. I. that with the use of surkhi more water was required, he suggested that if a mixture of coarser and finer surkhi was adopted, perhaps that difficulty might not be there because the loss of strength due to finer surkhi might be compensated to a certain extent.

Regarding the research being carried out at the C. R. R. I. on Indian cements, Shri Chaturvedi enquired if they were using one type of aggregate for the cement from one factory or they were adopting different types of aggregates from various geological formations like granite, sand stone, etc.

Regarding membrane curing of concrete, Shri Chaturvedi stated that liquid membrane had been adopted and found quite alright in the field, though it had been found that plastic membranes also gave better results, but from economic point of view he was doubtful whether plastic membranes could be adopted on a large scale in this country.

Shri K. V. Thadaney described his experience of an experimental stretch of cement-grouted road (250 ft length of one 12 ft width of a 24 ft wide road) laid along Coimbatore-Trichy Road in Madras State in 1951 and stated that the suface produced showed appreciably no difference between its wearing quality and that of the adjoining premixed concrete surface. During his last inspection in 1957 he had found that the surface of the road was quite satisfactory except that as it was laid with construction joints at 66 ft intervals instead of 33 ft as in the adjoining width of premixed concrete, there were sympathetic cracks in the grouted road.

For the premixed concrete road they had used 6 bags of cement for 100 sq. ft. of 4 in. thick slab, while for the cement grouted road of the same thickness the average cement consumption worked out to 4.53 bags per 100 sq. ft., which showed a saving of about 25 per cent in cement. Also they had utilised only $1\frac{1}{2}$ in. to $\frac{3}{4}$ in. size coarse aggregate and avoided the use of smaller size coarse aggregate below $\frac{3}{4}$ in. and thus saved in the cost of such aggregate. Then again, because they mixed only cement and sand grout instead of cement and sand as well as coarse aggregate, there was some saving in labour. He expected that if the work had been done on a large scale they could have easily laid about $\frac{3}{4}$ to one furlong length of cement grouted road per day. He was, therefore, of the opinion that a cement grouted road would be about 20 per cent cheaper than ordinary premixed road of the same section. He suggested some more experimental lengths should be laid with this type of construction using appropriate equipment, so that if a proper technique is developed, advantage can be taken by all the Highway Engineers in the country of the economy of this type of construction for laying concrete roads.

Dr. M. L. Puri referred to the report of the Madras laboratory on the use of admixtures in concrete in which it was stated that the strength of concrete was improved with the use of Lissapol *N* due to the fact that it introduced certain reduction in the water-cement ratio of the concrete. He remarked that they should have made an attempt to find out if there was any entrainment of air in the concrete mix. Lissapol *N* and Dehydol-25 were products which were known to entrain air in the concrete and Shri Chaturvedi also had pointed out that many times they found that the strength of the concrete was reduced by the use of Lissapol *N*. This must be so, because if the quantity of Lissapol *N* was increased the percentage of air entrained went beyond 5 per cent, which was very detrimental for strength purposes. In fact, whenever these admixtures were to be used, a complete and judicious re-design of the concrete mix was absolutely essential to achieve the advantages due to entrainment of air. In U. S. A., where at least 95 per cent of concrete being used was air-entrained concrete, they cared not only for the strength of the concrete but they also selected that admixture which gave them the maximum durability. In India, after some time it is expected that the use of entrained air in the concrete would become quite prevalent and already, some of the laboratories were trying to produce air entraining agents from indigenous materials. But he cautioned that they should care not only for the strength but also select only those admixtures which added to the durability of concrete. There might not be much of the freezing and thawing problems in India, although these were met

with in certain parts of the country, but certainly they had to take into consideration the heating and cooling as well as wetting and drying cycles. All these tests should be performed before any admixture was actually selected.

Regarding Shri Chaturvedi's remarks about pozzolanas that in the work carried out in the C. R. R. I. there was a slight increase in water demand in the concrete mix due to the use of surkhi and his suggestion to use a combination of coarse as well as fine surkhis, Dr. Puri wished to point out that in case this practice was adopted, the coarser surkhi would act like a fine aggregate and would make the concrete over-sanded which was not desirable at all. For purposes of strength, they must use a surkhi for which optimum fineness of the order of about 4,000 sq. cm. per gram, tested according to Blaine's method, was fixed. But all this was in a tentative stage as yet and final recommendation would be given after some time. Dr. Puri remarked that so far surkhi had been regarded as just a powdered brick. The results of tests carried out in the C. R. R. I. had clearly shown that most of the surkhis prepared from bricks were no good as a pozzolanic material, and that it was absolutely essential before accepting a particular material as capable of producing a reactive surkhi to thoroughly investigate the material and fix up the optimum burning conditions as well as the optimum grinding conditions before its use. For this purpose, it was absolutely essential, if surkhi was to be used as a pozzolana in concrete for roads in India that these two points were taken into consideration. An All-India survey should also be carried out to locate the major deposits of the materials which were capable of producing reactive surkhi. Designing proper types of kilns where it might be possible to control the temperature to be able to produce a standardized material, was a very intricate problem.

Regarding another point raised by Shri Chaturvedi about economy of plastic membranes, Dr. Puri stated that this recommendation was only for use in arid regions of India where there was scarcity of water and it had to be brought from a long distance, and added that the cost of the plastic type of membrane was not more than 3 annas per sq. yard and the material could be used over and over again. So, he did not think there was any loss of economy by adopting this method in the arid regions of India.

Shri C. V. Nazareth did not agree with the remark that there was no saving in the cost of either cement or the aggregates in grouted concrete as compared with premixed concrete. So far as the grouted pavement failure of Simla-Kalka Road was concerned, that road was constructed in 1949 and he understood

that the black top was not removed prior to the laying of the grouted surface. Kalka becomes very hot in the summer season with the yielding of the black top, which was 1½ in. thick, the subgrade support was reduced very considerably, and he thought that gave rise to cracking.

As regards grouted concrete laid on Lucknow—Rae Bareilly Road, there was considerable delay in obtaining the grouting machine. As a result, the aggregate and a large quanity of cement were brought to the site about a year in advance of the commencement of the work.

Shri K.K. Nambiar remarked that apart from one experiment of grouted concrete road done in Madras State referred to by Shri Thadaney, there were 2 or 3 other instances where they had done 2 or 3 furlongs each of grouted concrete work which had resulted in good deal of economy. The saving in cement in one instance was about 20 per cent though the overall saving in cost would be about 8 to 10 per cent only. The finish of grouted concrete road did not look as fine as the usual slab type, so ordinarily the average man had a tendency to feel that the grouted concrete is not as good as the ordinary slab type of construction.

With regard to the poor performance of the grouted pavement laid on Simla-Kalka Road, he wanted to know whether the engineers had any difficulty in actually grouting the concrete road on an ascending gradient as his experience had been that it was difficult to do grouting work in such cases.

Regarding the comment of Dr. Puri that addition of Lissapol *N* would lead to considerable air entrainment and might weaken the concrete, Shri Nambiar stated that they had very successfully used Lissapol *N* in very moderate quantities in getting very high grade concrete. For example, on the Coleroon bridge on which they had used concrete of 7,000 lb strength and 2,500 lb working stress, Lissapol *N* was added in small quantities to improve workability without any deleterious effects on strength. It is true that it might add a little to the air entrainment. In fact, there was no concrete without any air and a small addition of Lissapol *N* might increase it to some extent, but it should be understood that Lissapol *N* was not essentially an air entrainment agent. It was just a wetting agent to improve workability and, if used in moderate quantities, it was certainly very helpful.

Referring to para 2.3.3, relating to testing of cement and concrete, Shri Nambiar mentioned that apart from the ultrasonic pulse method of test, there was at present a rough and ready

method of testing the concrete slabs and other structures by the use of a hammer, known as Smith's hammer. It was about 18 in. long and 3 in. in diameter, and the hammer was released by a spring. It hits against the surface and rebounds compressing the spring, and the measure of rebound of this hammer is the measure for the compressive strength of the concrete. The hammer can be used either vertically downwards to test road or ground floor, or horizontally to test a pillar or any other structure, and even upwards. Of course, with reference to the angle at which the hammer was used, different graphs had got to be used to give the compressive strength.

With regard to the specific question raised about deliberately introducing gaps in the gradation of concrete, Shri Nambiar felt it was certainly a good thing as it gave the option of getting sand either from a longer lead or introducing gradations in the coarse aggregate by a little extra labour. It would often be found that gap gradation might result in saving as also in securing better strength for the concrete.

Dr. I.S. Uppal stated that in regard to the use of admixtures, they had also tried some experiments using Lissapol *N*, soap nuts and various other surface active agents including pure soap itself, and found that it certainly reduced the strength of the mixes, though it was likely that if the mix was very rich, like 1 : 2 : 4 or 1 : 3 : 6, it might not show very significant reduction. They had tried the same thing in the mortars also and would recommend such admixtures only where waterpoofing qualities or other properties were required and not for the strength requirement only. Actually, it was found that when soap or such other material was added in the mortar, it improved the permeability of the weak mixes like 1 : 6 cement mortar more than that of 1 : 2 mix.

Shri G. De in reply to Shri Jagus's query about the composition of aggregate in concrete setts said they were of the same material, i.e., of trap stone.

Regarding admixtures of concrete, their results as regards Lissapol *N* were also similar in that they tended to reduce the thickness a little and improved the workability.

As regards indigenous agents, Shri De stated that they used ordinary soap nut, commonly known as ritha, and it gave very good results in regard to durability because they had done the freezing and thawing tests.

As regards joint sealing compound, some years ago, probably in 1950 or 1951, they had carried out certain tests with soft wood

ike Kalomoria Japonica, and found that these soft woods satisied the specifications as regards concrete joint fillers. Very ecently they had again tested the same in conjunction with the Forest Research Institute and obtained the same results. In act, if sufficient amount of this soft timber could be found, it ould be used very profitably and replace perhaps, the joint iller.

As regards prestressed concrete, there was likely to be a ittle bit of misunderstanding. Their object in handling pressressed concrete was mainly confined to prefabricated work, whether it was for roads or for buildings, and it was with that dea that the work had been taken up in the College of Military Engineering.

Shri K. F. Antia requested the research institutes—the C.R.R.I., the Lucknow and Chepauk research stations and various other laboratories, to consider the possibilities of nvestigation of rolled concrete with very lean mixes and the work could be done jointly with the co-operation of the Chief Engineers as considerable amount of field work was essential.

Regarding investigations to be carried out in connection with overlays on concrete pavements, Shri Antia felt that a joint nvestigation by the research institutes with the co-operation and help of the Chief Engineers was desirable. This subject was also mentioned in one of the Papers discussed at the current Session. In America, more than one instance were cited in which a concrete pavement had been strengthened by putting in extra overlay as thin as 2 in.

Shri Antia suggested that cutting of joints in concrete pavements by special machines should be encouraged even though it was difficult to get foreign exchange for such machines, and added that the research institutes might exercise their mind and produce some indigenous machine or some parts thereof which would be of help.

Shri R. L. Nanda stated that contradictory experiences and opinions were expressed about gap graded concrete from time to time in the U.S.A. and U.K. and also in the symposium on the Mixes Design and Quality Control held in London in 1954. There were persons like Kingston who were rather critical of gap graded concrete and believed it was useless. But some of the concrete engigeers like Steward and Mercor were of the opposite school of thought. Shri Nanda thought if it was expected to screen coarse aggregate to introduce gaps to suit certain poorly graded sands, it would be more uneconomical and inconvenient than designing the concrete for a particular strength even at the

cost of a little more cement if necessary. The rational way was to find out what aggregates were locally available for a particular job and then to design concrete mix accordingly instead of screening to create gaps or carting materials from pretty long distances.

Shri K. S. Sankaran in reply to Shri Nanda's point regarding gap graded concrete said it had been specifically stated that gap graded concrete was only advantageous where they had to use locally available poor sands. Secondly, gap graded concrete was economical when normally accepted sands of a greater lead had to be imported. Thirdly, gap graded concrete was only useful in the case of weigh-batching and stricter quality control.

Commenting upon the work done in the U.P. Research Laboratory with regard to the measurement of workability, Shri Sankaran remarked that they had compared the slump test with the compaction factor test. Engineers as well as research workers would agree that the slump test was only a measurement of the consistency of the concrete (the wetness of the mix) and it did not measure the workability of the concrete. Therefore, it was no point in comparing a slump test with any workability test. He added that there was the latest workability test known as V.B. Consistometor test which measures the workability in V.B. degrees. This test is able to give clear indication about the workabilities of dry mixes.

Shri B. S. Jootla stated that in addition to the grouted cement there was bonded concrete also which gave cheap roads. A pamphlet dealing with this subject was published some time ago by the Associated Cement Companies. He had done an experimental work with bonded concrete and it worked out very cheap and lasting on a road on which traffic was very high. He suggested that along with grouted cement and ordinary premixed cement, they should also try bonded concrete.

Shri S. R. Mehra replying to the qusetion raised by Shri Chaturvedi with regard to the cost of membrane curing or solid plastic membranes for single use stated that it costs Rs 3 per 100 sq. ft. for 100 gauge. The aggregates used in the water-cement study were the same and identically graded for all cements proposed to be tested.

FLEXIBLE PAVEMENTS

Shri Sujan Singh stated that in good old days when finances were not a major consideration, heavy soling, as thick as 8-9 in. was laid irrespective of design but now this thickness had come down to 3 in. soling and probably 3 to 4 in. metal, possibly due to need for economy.

Shri Sujan Singh added that the fear that design probably would bring expensive pavements must be shaken off. It might be that if a pavement was designed, in some cases there might be reduction in the thickness of the structure and saving might accrue, while in other cases it would necessitate a thicker or denser carpet requiring more finance, but that would pay for itself in the longer run. Further, with the present finances it might not be possible to follow the design methods for thousands of miles, but a start should be made in every State to do some milage with specifications based on design, so that advantage could be taken when funds were available to improve a much longer milage. This would also obviate the expediency of laying 1 in. chipping carpets all over the country whatever the traffic conditions might be.

Shri C. D. Harris referring to Shri Sujan Singh's comment about some overall specifications, stated that it would be beneficial only if the overall specifications would mean that the base courses and pavements were adequate. If instead of straight away concentrating on trying to put down improved pavements money is spent on designing and putting down bases of adequate thickness, coupled with correct composition of materials in the base courses, they would have long lasting roads and get more value for the money.

He stated that there is no use designing expensive bituminous pavements without adequate bases and sub-bases as the case may be.

Shri Harris did not agree with the suggestion of Karnal laboratory regarding tight limits for dense carpets, as he felt that it was difficult to generalise and to be, too, specific on a question like this. They were usually dependent on the type of aggregates available which had to be utilised to the maximum economic advantage. If they were going to lay down too tight a specification for dense carpets, then he thought, they were not going to get very far.

Regarding the work of stabilizing sands done by the C.R.R.I., Shri Harris remarked that it was the most unusual sand, as stated in the report, about 80 per cent passing 100 mesh; therefore, he was doubtful as to whether they were ever going to establish a satisfactory stabilization of sand for wearing surface. With the iron-tyred traffic in India this would be a difficult problem, but all the same was worth pursuing.

Shri K. K. Nambiar was in agreement regarding the need for proper design of pavement thickness which included base and sub-base and all that, and stated that unless bases were properly

designed, whatever carpets were put on top they were not likely to give good service. As regards the design of bituminous carpets, as remarked by Shri Sujan Singh, it was not a day too soon before they decided to do this. Hitherto, or less their designs were based on thumb-rule methods, because mostly they had been using very thin carpet or mostly resorting to surface dressing in the case of black topping of roads. But designing expensive bitumen carpets, had to be done on a very scientific basis. Various tests such as stability test, shear test, etc., had to be carried out to find out the correct percentage of bitumen as a little excess of bitumen was as deleterious as shortage of bitumen.

Regarding mechanization of all bituminous work, Shri Nambiar said that it was quite desirable but if it was made a positive condition that no bituminous work should be carried out unless it was mechanized, it would put a brake on the road programmes.

He felt that for sometime to come they might have to hold a balance between mechanization and manual labour and there were very good instances of surface dressing and thin carpets being done by manual labour by just using asphalt boilers and hand mixers. So it was worthwhile for the road engineers to so programme their works that continuous lengths of some miles could be taken where machines could be used so as to give very satisfactory and economic results; otherwise, mechanization would be very expensive.

Shri Nambiar suggested the use of rubber in bituminous pavements and cited the example of half a mile experimental length of a road in Madras where rubber powder was used with bitumen. It was expensive but a small percentage used with bitumen gave good results. He requested Shri Mehra to initiate some research in this direction if he had not already done so.

Shri P. D. Shivdasani referring to Shri Nambiar's comment that mechanization would require a very expensive type of equipment, mentioned that to mechanize the surface painting job only, would not require expensive equipment. On the other hand, if bulk supplies of asphalt were used, it would considerably lower down the cost and, at the same time, give a uniformly even surface which would mean a greater life.

Going through some of the works being carried out at the C.R.R.I., he found that great stress was being given to the stability factor only. Also, in some Papers he found that in the case of bitumen or asphalt being used they were advocating harder and harder grades while the practice in other countries

was to use a softer grade. No doubt hard grade of asphalt gave a higher stability figure, but the use of softer grade gave added durability to the pavement. To his mind, in their studies, the durability factor had not received as much importance as it should.

Referring to page 562 of the report on the work done by B & R Research Laboratory, Karnal, he agreed with Shri Harris that the gradings given therein were too strict as they were dependent on all types of factors besides availability of material, i.e., on the shape and quality of the stone and the type of binder used. Mention had also been made of aggregate passing No. 10 mesh screen, which did not signify anything; it should be passing No. 10 mesh screen and retained on specified mesh screen. By and large, it was not the correct way of recommending gradation; it should be based on some sort of void control and percentage of voids in the mineral aggregate to give some scientific basis to it. Also, for mix given in the report the design qualities were not shown. But it appeared that the amount of binder used was in excess.

Shri N. H. Taylor, referring to Shri Shivdasani's comment on the subject of the penetration of bitumen to be used in dense carpets, agreed that a hard bitumen would give a higher stability. In parts of this country where the rainfall was very high greater durability could be had by using a larger amount of bitumen than would be used in the U.S.A. An increase in the bitumen content might bring down the percentage of voids to 2 or 3 and if an adequate stability was to be retained in a mixture having a high percentage of bitumen, that bitumen must have a fairly low penetration such as 30/40.

With reference to surface dressing, although the use of bulk bitumen and pressure sprayers would enable large areas to be treated, there was a need of mechanised methods for producing the large quantity of aggregate required. In order to have a lasting surface dressing, a uniform size of chipping must be used. In countries more developed than India, contractors and public bodies could purchase single size chippings from an established quarry. This was not possible in any country where the road surfacing contractor had to produce his own chippings and for reasons of economy had to use the whole output of his crushers and granulators. That was one reason why it was easier to produce crusher run fine aggregate and use it in the from of a premixed carpet than to employ single size chippings in a first quality surface dressing. The difficulty of producing single size aggregate could be overcome if a two coat suface dressing was used, as a large chipping would then be used for the first treatment and a smaller size chipping for the second treatment.

The dust produced by the crushers could usefully be employed in the macadam base.

Whether a premixed carpet or a surface dressing was used, care must be taken in preparing the water-bound macadam base. A water-bound macadam with a plastic binding medium might behave perfectly until it was given an asphalt surface. Evaporation of moisture would then be restricted, the plastic binding medium would reach an equilibrium moisture content and the macadam would tend to become damp and unstable. It was much better to lay the metal, consolidate it, using a non-plastic binding material such as sand or stone dust, and immediately lay the chipping carpet on the surface dressing than to use moorum as a binding medium, to wait for three months and then attempt to brush or scrape the moorum or other binder off the surface.

Regarding mechanization, Shri Taylor said that chippings should be collected in large stock piles adjacent to the mixing plant if modern methods of mixing and laying were to be used or if the chippings were to be spread by lorries having gritting attachments working behind bitumen distributors. Shri Taylor was of the opinion that mechanization would be possible only if the P. W. D. specifications covering the collecting, stacking, spreading and consolidation of materials were changed to allow for the measurement of the completed work as one item.

Shri C. G. Swaminatham referring to Shri Shivdasani's comment that the foreign practice was to go in for softer grades of bitumen, invited his attention to B. S. 594 wherein for dense carpets grades of 30/40 and 40/50 have been suggested even for a country like England. In the same connection the Karnal laboratory had given certain gradings. Continuing, he said that for designing some sort of dense carpet the C.R.R.I. had obtained the material from a local quarry crushed into various sizes, viz., $\frac{3}{4}$ in. downwards, 3/8 in. downward and screenings and blended them in the same proportion as received from the quarry, and found that the final grading did not satisfy any of the existing limits. However, they were able to get quite a decent dense carpet from the point of view of stability and voids, etc. This actually stresses the need already emphasised by Shri Taylor last year, that every time a mix is to be designed it need not necessarily conform to any particular limits or any such thing, but should be tested in the laboratory from the point of view of voids, etc.

As regards construction and maintenance, with the help of bump integrator in the C.R.R.I. it was found that the surface laid with a mechanical paver was decidedly better.

Regarding low temperature tars, mentioned in para 3. 1. 3 (ii), he requested the representative of the Hyderabad laboratory who was present to say a few words about tars from their angle.

Regarding Shri Nambiar's point about use of rubber, Shri Swaminatan stated that they did undertake some work in the laboratory and found that it was quite good from the point of view of compressive strength, modulus of deformations, etc. Similar results had also been reported from laboratories abroad. But as regards service behaviour, there was probably no agreed opinion regarding the superiority of rubberized bituminous surface over non-rubberised one. Furthermore, he was not sure whether introduction of rubber in a bituminous surfacing in a country like India, where enough rubber was not available, would be economical.

Shri Narayana Rao explained the production of road tar from low temperature tar which was a bye-product obtained by low temperature carbonization of non-caking coke. Low temperature carbonization was quite different from high temperature carbonization used for the production of metallurgical coke and also gas for heating. Low temperature carbonization was used mainly to produce a smokeless domestic fuel from the non-caking type of coke which occurred abundantly in India. With a view to prevent wasteful use of the indigenous fuel such as firewood, charcoal, etc., the Govt. of India were setting up a large scale low temperature carbonization industry in the country in the next decade and they proposed to establish plants to produce about 10 million tons of smokeless domestic coke in a year; it was estimated that 300,000 tons of low temperature tars would be produced in these plants. Because the economics of the low temperature carbonization industry depended upon how best the bye-products are used. One of the methods suggested was the production of road tar from low temperature tars. In this connection, they were having close liaison with the C.R.R.I. also and experiments had shown that low temperature tars could coat the aggregates much better than the high temperature tars and prevented oxidization and weathering. The importance of the problem arose because the present production of road tar from high temperature tars was about 40,000 tons per year and the requirements by 1960-61 were estimated to be about 200,000 tons of road binder. To meet this deficit, they were importing about 150,000 to 200,000 tons of bitumen from abroad.

Shri R.N. Dogra stated that the only object in suggesting the specifications given in the report was that they were now at a stage when they needed better designs for dense carpets and

surface dressing might not be suitable for some of the roads. Unfortunately most of the work done up to now in the country was merely in the laboratory, the specifications had not been tried in the field to correlate the traffic with its life value in the field, and the stability value in the field with the values in the laboratory. It usually took 10 years or more to be able to get complete results and unless and until a start was made on these field experiments now, they would be waiting for a very long time. Therefore, he suggested that recommendation should be made to the P.W.Ds. to carry out field experiments with different specifications that were known for dense carpets as well as surface dressing and others, to obtain the comparative life values of different specifications.

Regarding the point mentioned in the report about tracking test being used for stripping of binder only, Shri Dogra stated that this test could also be used for stability test of carpets.

In India a period of three years was taken as life value for surface dressing, but in other countries where more uniform spreading of bitumen was done with sprayers under pressure, surface dressing life was as much as 9 years. Shri Dogra felt that if in India mechanized methods were used for surface dressing with proper kind of chippings, it would probably be possible to tide over a certain period of development of traffic on the roads.

Shri Dogra concluded by laying emphasis on the importance of correct traffic statistics for designing pavements as most of our present practices were based on assumptions or merely routine statistics which were not even reliable.

Shri K.K. Nambiar stated that the controversy about addition of rubber in bituminous pavements was due to the fact that the position was rather obscure at the moment regarding its efficacy. Shri Swaminathan himself doubted whether it was worthwhile to carry out these experiments. Since a lot of reports about experiments in other countries were available, he thought it was worthwhile to do some experiments in this country and work out its economics, as to whether it was suitable; if so, whether it was economical. He added that rubber added to the ductility of the bitumen to a great extent.

WATER-BOUND MACADAM AND GRAVEL ROADS

Shri C. D. Harris endorsed the recommendation made in the report that investigation as to the suitable types of soil filler or sand or stone-dust filler in the water-bound macadam should be undertaken. Also if an investigation into the water-bound macadam as a base course was to be undertaken, he would like to suggest that, if possible, this work should be extended to include crusher run stone with or without a binding material which, if used, could be a suitable soil binder, or a very low percentage of cement, or lime-stone dust. He wanted to see the question of water-bound macadam and crushed stone bases generally extended further to find out the possibility of incorporating such types of bases for the whole of the base construction, omitting the normal type of boulder soling and seeing whether they could economise in the thickness by utilizing such type of base courses.

Shri C. L. N. Iyengar stated that he had been confronted with a couple of problems in laying of concrete roads with water-bound macadam as a base as invariably, the proposed widths of concrete over water-bound macadam were in excess of the available metal widths. In requiring a foundation of a uniform bearing capacity, several times the possibility of re-opening the macadam and spreading it over the required layers, as an alternative for setting a uniform bearing subgrade, had been suggested. Apparently, there appeared to be a lot of hesitation in disturbing the macadam crust for purposes of doing this and, as such, very narrow widths on sides have been attempted to be consolidated alternatively, revision of alignment had also been attempted by the same method. Unfortunately, this had not been found satisfactory. He did not know whether some investigation would be required to find out as to whether really the desired results could be achieved by redistributing the macadam crust without any additional material and obtain the required uniformity of the subgrade.

Commenting upon considerable variations in the degree of compaction obtained with water-bound macadam by the various processes, viz., by the wet method, dry method and rolling, etc. Shri Iyengar stated that in recent work that he had done it was shown that the bearing capacity of the water-bound macadam had a direct relationship with the void ratio in the macadam. He stated that more experimentation on this subject is needed.

Shri A. K. Deb stated that the Army had many occasions to construct emergency roads and they had mostly resorted to construct water-bound macadam roads. Due to various types of vehicles and the varying wheel loads, the necessity for design of the road arose on many occasions. To his knowledge, at present there was no method existing by means of which they could arrive at a suitable thickness of the water-bound macadam corresponding to various wheel loads. They had been using the C. B. R. method only and this method has got only limited application. Actually, it could not be applied for want of any waterproof topping. He wondered if anybody could give them

any clue as to how water-bound macadam roads could be designed or in what way endeavours could be made to find out reasonable thickness corresponding to various wheel loads.

Shri S. R. Mehra interposed that, *ipso facto*, it is to be taken for granted that the values of the thickness determined by the C. B. R. method apply when the subgrade has been saturated. Consequently there should be no objection to using the C. B. R. method for design of unsurfaced water-bound macadam.

So far as construction of water-bound macadam roads was concerned **Dr. I. S. Uppal** felt that their stability could be improved by the use of lime which had already been recommended by the C. R. R. I. Some experiments had been carried out in the Punjab and it was found that addition of 1 per cent of lime to ordinary graded sand increase its C. B. R. value up to about 40 per cent under saturated conditions. If the first one foot of the subgrade could be raked up and 1 or 2 per cent of lime mixed in it, that road was not likely to fail under saturated conditions because it would have very good C. B. R. value. There were roads in the Punjab in waterlogged areas which failed under heavy traffic load. He felt that if those roads were given this treatment, it should be helpful.

Shri D. C. Chaturvedi referred to the report of the Madras Research Station that certain water-bound macadam roads there had failed and wanted to know whether these roads were surface painted, or just water-bound macadam without surface painting, because the nature of the failure was not given in the report.

He further enquired about the details of tests being carried out by the C. R. R. I. on low grade aggregates so that they could also do similar tests on kankar and standardize it on the same lines, as kankar was a soft aggregate available throughout U.P.

Regarding the third point for discussion about gravel, he wanted to know if it concerned gravel roads meaning gravel and finer material, or was it the use of gravel for the road construction. (Shri Mehra clarified it was about the use of gravel for road construction). He also wanted to know what part grading played in these tests.

Shri S. R. Mehra replying to the comments said that the normal conception of gravel roads that seemed to prevail was to get hold of any gravel which was available and to spread it on the road expecting that in the course of time it would stabilize itself. That was one method of constructing a road when the traffic developed with the road. But there were cases, for example, in areas where river-borne hard gravel was

available, where it would be economical to construct normal roads with the given traffic intensities with properly graded gravel. This was almost a standard method of construction in Sweden and Norway and in various other countries where hard gravel was available in large quantities. There seemed to be no reason why this method should not be introduced in India also in areas where it could be applicable. It could result in considerable saving as it was a cheap method of construction where hard gravel was available, provided a little care was taken to grade the gravel properly and to give it suitable amount of binder and surface treatment in the normal way.

Shri K. L. Sethi referred to water-bound macadam roads being used as a base for the concrete road or for black-top, and said that while selecting the binding material, it should be borne in mind that the material does not have any detrimental effects on the concrete or the black-top, i. e., bitumen. At the time of concreting or black-topping they should test the binding material to see whether it had sulphates or not. He suggested that the binding material should have a plasticity index about 9 and sand content of the order of 40 per cent.

SOIL ROADS INCLUDING STABILIZATION

Shri S. R. Mehra read out the points for discussion under the sub-head soil roads including stabilization.

Dealing with first point, he said that many of our roads were now being found to be inadequate in thickness for the loads that they were expected to carry either now or in the near future. One way of remedying this deficiency would be to make up the existing thickness with additional stone metal. The other method would be to dig up the existing crust, make up as much of the thickness with cheaper material like soil or soft aggregates and then put back the stone with some additional stone to ensure proper interlock. No doubt one did not like to dig up an old road, but there might be cases where it would be considerably cheaper to dig up the existing road and re-make it properly with proper use of the material locally available.

Point (2) regarding remedial measures for roads in waterlogged areas was left out for Panel discussion* on the subject.

Referring to the third point, Shri Mehra stated that since the indications were that the bond between the surface treatment and surface of the stabilized soil was a major factor when failures took place, this was a subject on which further research

* Published at pages 861 to 876 of the Journal of the Indian Roads Congress, Vol. XXIII-4, October 1959.

might be usefully carried out. He invited members to give suggestions as to what direction these researches might follow.

Regarding the next point on construction of embankments on marshy ground, Shri Mehra stated that this related to some work being done in the C. R. R. I. in connection with the Eastern Express Highway of the Bombay P. W. D. which passed over very very bad marshy soil.

Shri H. S. Bhatia referred to a note received from Brig. S. K. Bose in connection with the Paper on Stabilization of Black Cotton Soils submitted by Dr. Uppal and himself, and stated, that as suggested in the Paper, for stabilization of black cotton soils 4 to 5 per cent of lime was needed to give a compressive strength good enough for using the material as a base course. He agreed with Brig. Bose that the field experiments could not get that compressive strength, and, therefore, addition of lime was not going to add to the strength part of it. The chemical nature of the black cotton soil did play a very important role, and there were two methods of finding out whether this soil was going to have some sort of structural strength. One method was to have the chemical analysis of the soil to find out the silica sesquioxide ratio because that would give an idea whether the soil was going to have some strength or not. The other method was to just mould the blocks to find out the compressive strength after 7 days curing. If the soil had low silica sesquioxide ratio, they could only expect the flocculation action of lime acting on the black cotton soil, and in that case resort might be made to some sort of compound stabilization by adding certain percentage of cement, etc., along with lime. That aspect of the problem was being investigated in the C. R. R. I.

In connection with the second point raised by Brig. Bose regarding the use of burnt black cotton soil clods, Shri Bhatia stated that they were able to find out that the burnt black cotton soil clods gave strength which compared well with the ordinary type of aggregate suitable for use in road construction. Brig. Bose was of the opinion that cement should be added to that aggregate, but he personally felt that the addition of cement in this case might not be necessary because the impact value under wet conditions could be favourably compared with any type of good aggregate. Therefore, for mechanical stabilization they might not use cement and only have proper grading to get proper results.

Shri Bhatia, in conclusion, stressed the necessity of having some arrangement for standardization of testing method for

soil stabilization work, to have proper sizes of blocks, etc., so that the available data could be co-ordinated by different organizations.

Dr. I. S. Uppal referred to the work done during the World War II by the Military Engineering Research Station, Lahore, on some investigations on the use of Turkey Red Oil alone and in conjunction with lime as anti-stripping agent for bitumen coating of the wet stones in connection with the construction of roads during the monsoon season. The specifications evolved were reported to have been adopted on bulk-scale on the Burma Front during that war. Recently, he added, Turkey Red Oil was used on field scale while laying the bituminous carpet during rainy season on a small stretch of experimental road near Karnal.

Further, as a result of some recent experiments conducted in connection with preparation of waterproof mud plaster, it was observed that the incorporation of small quantity of Turkey Red Oil in the bitumen increased its penetrating properties into the soil. Its use could, therefore, be recommended for improving the bond between the first coat of bituminous surfacing and the stabilized soil crust of the road. The addition of this oil to the extent of about 1 per cent by weight of the bitumen was expected to improve the bond of bitumen with comparatively wetter surface also, as the Turkey Red Oil has the property of being miscible with water as well as with bitumen. The second coat could then be of the ordinary bitumen as usual without the addition of any surface active agent. Field scale experiments were being tried in the Punjab. He hoped other State laboratories would carry out similar experiments.

Shri P.L. De referring to the stabilization of black cotton soils with lime, say, about, 5 per cent, as recommended, was of the view that the quality of lime should also be mentioned because as yet there was no standard quality of lime in India.

In West Bengal stabilization of black cotton soil with lime had also been tried and it was found that with 5 per cent lime, the increase in C.B.R. value was high; in fact, from 3 per cent it rose to 60 per cent. Such high values, he thought, might not be necessary, and therefore, they had tried with lower percentage of lime. With 2½ per cent of lime they had considerable increase in the C.B.R. values, which might be due to the very good quality of lime.

Regarding the use of 4 per cent wood tar and 5 per cent of lime soil mixture, mentioned in para 3.3.2, Shri De felt that its

economy should be worked out because wood tar might be costly. He enquired whether the combination of cement and lime had been tried anywhere.

Shri C.L.N. Iyengar stated that in para 3.3.2 about stabilization of black cotton soils, most of the emphasis appeared to have been laid on the strength aspect of stabilization with lime or lime plus wood tar, etc., but the problem dreaded so far was with regard to the swelling and shrinkage characteristics of the black cotton soil. He wished some data had been given on these points along with improvements in the mechanical strength of these admixtures.

Further, he wanted to know whether the mechanical properties of the black cotton soil, viz., liquid limit, plastic limit, plasticity index, etc., could also be obtained with lime and other admixtures, and to what extent a very small percentage of cement could alter the working properties of this soil.

Regarding the question of primer for use in connection with stabilized soil surfaces, Shri Iyengar stated that they had not done any extensive work on these lines, but in one case requiring bonding of a thin bitumen carpet to the soil cement base, a diluted primer was used and a penetration of ¼ in. to ½ in. was obtained. The report about this road for the last 2 to 3 years was very satisfactory. That was in Mehsana District of Bombay.

Shri G. De referring to the comment made by one of the speakers regarding stabilization of black cotton soils, stated that the point which Brig. Bose wanted to bring out was that if the black cotton soil was heated to 500 deg. and mixed with certain proportion of normal or ordinary black cotton soil and then with cement, the C.B.R. values would be rather more than what was obtained with the normal soil plus the heated soil. The object was that if they had normal soil plus the heated black cotton soil, the durability after compacting them in a 2-in. cylinder was very very low and could not possibly be used for road construction purposes.

Shri D. C. Chaturvedi referred to cement stabilization experiments on a provincial road as well as on an O.D.R. in U.P. Their experience had been that the 2-coat surface dressing did not adhere very well to soil cement. Actually, the stretch which was laid on a provincial road about 10 miles from Lucknow had failed miserably. On an O.D.R., extensive patch repairing with this method was being done. He felt that as suggested by Shri Mehra either grafting or something else might have to be adopted but so far soil-cement had not stood well even with 2-coat surface dressing.

Referring to the previous two speakers' comments on soil-cement roads, **Shri H.H. Campbell** stated that in his experience, adhesion to a cement stabilised road base could be ensured or improved if a bitumen prime coat with a kerosine flux were used, a most important point being to slightly dampen the cement stabilised base first before applying the primer. This would obviate the rolling up or balling up the effect mentioned. His advice was based on his experience of surface dressing 70 miles of similar type of road in Nyasaland, Southern Africa.

Shri Campbell was inclined to believe that if the cement stabilised base mentioned had been dampened and swept free of dust before applying the prime coat, the results would have been successful. He added that although physical conditions in Nyasaland were similar, the road carried mainly heavy lorries but no iron tyred traffic.

Shri Campbell suggested the adoption of a kerosine cut-back type of bitumen, which is standard worldwide practice, because he thought that a diesel oil fluxed primer would be too slow curing if followed in the normal way by a surface dressing after a period of 24 hours.

In regard to the use of diesel solvent for primer, **Shri S. R. Mehra** stated that diesel oil appeared to keep on evaporating through the surface treatment and thus keep the binder soft for a very long time, sometimes for 3 to 4 months. That is why it was now recommended that diesel solved primer should not be used when it was intended to put a bituminous surface treatment over it.

Diesel, as a solvent, helps penetration; it penetrates into a hard surface like cement soil much better than either fuel oil or even kerosine solved primer, but it has that disadvantage when you are putting surface treatment on top of it.

With regard to the type of traffic on the cement soil surface, Shri Mehra stated that whereas pneumatic tyred traffic would travel comfortably on it if it was painted properly, there was some doubt as to whether the iron-tyred traffic would not cut it up by abrasion and further research appeared to be needed in that direction.

TRAFFIC AND TRAFFIC SAFETY

Shri C. L. N. Iyengar stated that the idea of a short count method for sampling of traffic was a very good one as conside-

rable amount of money would be saved in case of a country-wide traffic survey. As such, the sampling size to be adopted both under urban and rural conditions should be evolved by having some sort of preliminary experiments. In this report as well as in the Road Research Bulletin No. 5 the period over which this sample had been tested was one of a 39-day count and each day count covered a period of 16 hours. Usually, the period adopted was of the order of 40 hours to 160 hours of traffic count as against nearly 640 hours of traffic count done in this study.

To give a good indication of the A.D.T., Shri Iyengar felt that if they had got, what is called, a pattern, then a short count could be established by a borrowed pattern, from a neighbouring facility, from where short counts of as much as 5 minutes separated by a lapse of time could be taken rather than continuous recording of traffic over a period of hours, as two 5-minutes counts in a day could reveal traffic patterns which could then be inter-related to borrowed pattern by actually 3 to 5 per cent if the volume of traffic was very heavy; whereas the same thing could be used on a rural road where the traffic might not be heavy by 20 to 30 per cent. Therefore, a lot of work will have to be done before establishing this standard.

Regarding the use of plastic markers, Shri Iyengar said that on Bombay city streets where the traffic was purely of motor-vehicle type, these markers cracked up very soon and had to be relaid within the course of a week. As an alternative, they were trying stainless steel markers which could be prepared from the scrap metal utensils industry and embedded in the concrete pavements. The problem was of salvaging the studs at the time of relaying the surfacing normally required once in 2 to 3 years. Any other type of markers would be lost, whereas the stainless markers had the additional advantage of that they could be salvaged.

Shri Iyengar added that they had also tried a series of concrete blocks with white cement topping which could prove successful if embedded into a concrete pavement where the surface was not easily disturbed. But they might create problem if embedded in a bituminous pavement as either the surface or the block would ride higher, thus causing damage to the surface.

The C. A. I. also proposed the use of screen stud concrete blocks where the surface of the block adjacent to the pavement was also of concrete.

Shri Iyengar felt that the suggestion regarding staggering of office hours recommended for relieving the problem of congestion on certain roads, was a good idea, but it has got its limitations as it depends upon the nature of traffic that is developing in a place. In a city like Delhi, where the traffic is orderly and of Government servants, this might be easy to enforce. But where there is a large number of commercial organisations whose activities are tied up with banks, etc., there might be a lot of opposition for staggering office hours. Therefore, this matter needed examination in greater detail before any recommendations were put in bold print in the Paper.

Shri T. R. Sehgal referred to the point raised by Shri C.L.N. Iyengar, regarding sample techniques, and explained that the size which was adopted in their study, i.e., 10 per cent, was taken up as they did not have the idea of the standard error because no survey had been taken in the country so far over the year round. They had taken a sample size of 10 per cent, which was 39 days in order to have the maximum information available. He hoped that on the basis of this, it might be possible for the future surveys to fix the sample size.

Regarding borrowed traffic pattern from a neighbouring facility, Shri Sehgal pointed out that the traffic counters used in western countries for enumeration of traffic were not workable here because they had got different types of traffic, fast traffic, slow traffic, and cyclists. As such, they needed a separate flow for their use for highway planning purposes.

They had carried out 39 days surveys and tried to have a standard mathematical formula so as to know as to which type of distribution would fit exactly to the traffic flow as found in their mixed traffic conditions. In the western countries a distribution called Poisson's distribution fitted well to the type of flow found in those countries. They had also tried to fit the Possion's distribution so that from this distribution they could estimate the flow by having flow of 5 minutes, for the period to which the traffic was distributed as per Poisson's law. But they had found that it was fitting very well for a few days. But in most of the days it did not fit well and so it was dropped.

Having got the flow for one year they had got the flow for each day and they were now finding out the traffic patterns, as Shri Iyengar also pointed out on the basis of the traffic carried by an hour expressed as a percentage of the daily traffic. He hoped that a Paper would be submitted to the Congress next year on the subject when this study would be finalized.

Shri U. J. Bhatt, in his closing remarks congratulated Shri Mehra for condensing the results so ably in such a short space and also sorting out points for discussion. He also thanked all the members who had participated and contributed to the discussion which had been a very interesting and useful one.

The Chairman, in the end made a strong recommendation that the time devoted for discussion of the research work, covering the whole of the country, deserved no less than one full day. He hoped the Indian Roads Congress authorities would give the matter their full consideration.

Panel discussion on

"Roads in Waterlogged Areas"*

Sunday, 11th January, 1959.

Shri K. K. Nambiar (Chairman) called upon **Shri S. R. Mehra,** Director, Central Road Research Institute, to introduce the subject for discussion.

Shri S. R. Mehra stated that the problem of waterlogging had been divided into three parts, viz., where there was pure waterlogging without any complications regarding occasional flooding or presence of detrimental salts in the subgrade; where there was waterlogging as well as flooding; and where there was warerlogging with detrimental salts.

After going into the reasons for the various effects of waterlogging on the roads and in the background of the experience gained from a careful inspection of more than a dozen roads, some suggestions had been made with regard to the action that might be taken in the case of roads already under use and those still to be constructed in such areas. In the case of existing roads, it had been suggested that where economically possible, side drains should be provided and connected up with natural or artificial drainage so as to depress the water table as much as practicable. For areas subject to flooding, the provision of necessary height of embankments had been suggested. In the case of salt infested areas, a capillary cut-off in some suitable form had been recommended. It had also been recommended that in all new construction in such areas, suitable thickness of pavement should be designed on the assumption of full saturation of the subgrade, and provided accordingly.

The note had been written with the intention that the personal experience of various highway engineers might be beneficial to those who were faced with the problem of road construction and maintenance in waterlogged areas, and also with a view to see whether in the background of these discussions, some tentative recommendations could be made by the Indian Roads Congress.

Shri G. C. Khanna stated that the condition of some of the roads in the Punjab especially in the districts of Amritsar, Ferozepore, and Hoshiarpur had deteriorated seriously in the

*Published at pages 279 to 290 of Volume XXIII-part 2 of the Journal of the Indian Roads Congress, December 1958.

last few years. Unevenness of road surface and in some cases settlement of the ground had taken place. All that damage had further been accentuated by the use of heavy diesel trucks and the Leyland buses which carried as much as 10-ton loads. So, these roads were presenting a very difficult problem to the maintenance engineer. If they started re-doing the roads, that would cost something like Rs 70,000 per mile. If they just did 3 in. of water-bound macadam, as had been suggested, the cost would be about Rs 20,000 to 25,000 a mile. Even if it was assumed that a road had to be reconditioned after a period of 40 years, he had worked out that in the Punjab they would require a sum of approximately Rs 50 to 60 lakhs per annum. If they had to do the road all over again with the other method, i.e., excavating the wearing coat and putting in a new soil layer, etc. he thought the cost might rise to Rs one crore. They had to set the roads right and it was a very grave and acute problem. They had referred to the Government of India for setting right the National Highways and suggested that a sum of Rs 15 lakhs a year (referring to conditions in the Punjab) should be set apart for re-doing those roads; they had approached their own Finance Department that, if possible, the additional funds for maintenance should be given. But, as usual, they had not been able to make any headway. What he was suggesting was that in the third Five-Year Plan they should keep a distinctly separate sum of setting right those roads. That was the position so far as the financial side of the problem was concerned.

Regarding the technical aspect of this matter, he roughly estimated that they were required immediately to take steps to set right about 400 miles of roads. The main problem was how to accomplish that task, which necessitated laboratory analysis which invariably took a large time due to shortage of trained personal equipment etc.

In this note mention was made about depressing the water table. He had discussed this matter with the Chief Engineers of the Irrigation Department who were doing the drainage work and they felt that it would be possible to allow the water standing on the roads to pass through the drains, but whether it would help depress the water table, was a very doubtful matter and also probably not a practicable proposition. It might be possible to depress the water table by about 2 in. or so per annum.

So, it would be necessary to try to get more money for improvement of roads and also to improve the technique for doing so. Further, the engineers should become more and more scientific minded and establish close liaison with the laboratory staff.

Shri P.N. Srivastava pointed out that they had similar difficulty in Mathura area when they had serious floods recently. Although it was predicted that the desert was approaching Mathura, somehow the water table was going up. There was endless trouble in the recent floods and N.H. No. 2 was totally blocked. He had a drain dug at the perimeter on both sides of the road to lower the water table and this measure did help much. But in the next rains while measuring the water in one of the wells, he had found that the level of water was higher than the surface of the road. He was thus doubtful if any solution could be found except by reconstructing the entire road with a high embankment and introducing some impervious layer to break the capillary action of the water table. Another method they had tried at damaged places on the N.H. route near Etawah in stretches of waterlogged areas was that instead of adopting the elaborate method of raising the whole road, the painted surface was scraped off and the W.B.M. allowed to remain exposed. That was found convenient for some time and gradually with the capillary action the water evaporated and the surface was painted again in the dry season. That might not be a complete cure, but it did make the road tolerable.

There had been a lot of agitation in the western U.P. regarding re-modelling of all the bridges. They were taking up that question seriously and their Government desired that all bridges must have adequate waterway and their banks should not hold up the drainage water in any way.

The Irrigation Department was looking into this question as the waterlogging was mostly due to the canals system. He requested Shri Mehra to suggest some economical way to lower the water table.

Shri R.N. Dogra stated that rise in water table was attributable to two or three factors, viz., increased irrigation and the construction of canals, roads and railways which obstructed the natural drainage of surface water as water from natural precipitation found its way into the sub-soil and was raising up the water table. The point was that in such areas due to the rise of water table the capillary section reduced the bearing capacity of the soil underneath the road crust. The only thing to be done in such cases was obviously to lower the water table. In that connection, one had to consider the case of existing roads and of new roads to be constructed.

As far as new roads were concerned, the problem was comparatively easier because assuming that the soil would be saturated they could find out the bearing capacity and design the road crust to take the likely loads; they could prevent the water

from rising above into the embankment by providing an insulation layer. But the problem was more difficult in the case of existing roads where the embankment was much too low and not insulated and where they could not prevent the capillary rise of moisture taking place. In such cases, the only remedy lay either in depressing the water table or in re-doing the road. Depressing of water table was possible by means of drains along the roadside. He did not agree with Shri G.C. Khanna that this was not likely to depress the water table, because in Holland they kept their water table down by about 5 or 6 ft as a result of a network of drains all over the country and by constant pumping. If they could lead out the water from those drains into a natural drainage channel or if they could pump out the water and carry it away, it was possible to depress the water table quite effectively. In the Punjab at the present moment there were not enough funds for a complete net-work of those drains which could effectively take away the water from the sub-soil for ultimate disposal. He felt that eventually when the net-work of those drains developed there was no reason why the water table should not be lowered. He personally felt that this should be possible at least in 50 per cent of the cases.

The alternative, as far as he could see, was either to accept the wavy road or to raise or insulate the embankment and design the road crust for the bearing capacity of the saturated soil. There was no half way measure so far as he could see.

Referring to new roads, he felt that it was very essential to design the road crust scientifically in exactly the same way as a beam or any other engineering structure instead of following thumb rules. If they could insulate the embankment at the highest flood level and then design the road crust on top of that by taking the capacity of the soil to carry the loads, there should be no difficulty he felt, in providing a road to take the required load. But for this there was need of correct statistics about loads; mere assumptions would not do. Traffic statistics should be collected to give a forecast of the future trends, axle loads, **etc.**

It was absolutely essential to keep the water out of the embankment in the case of new roads and as far as he knew investigations on this had been carried out at the Central Road Research Institute and Buildings & Roads Research Laboratory, Karnal. Two or three methods had been suggested. One was bitumen membrane, advocated by the Central Road Research Institute. That method had been tried on Batala-Srigobindpur Road. The membrane was certainly very effective in keeping the water out, but while carrying out the experiment they had felt that it had a possibility of getting damaged

and water seeping through it. Therefore, some experiments had been carried out at the Karnal laboratory by using soil with a certain percentage of bitumen in it, and instead of a membrane of bitumen they had used a bituminised soil crust of about 1½ to 2 in. thickness. The results of those experiments had been published in a research Paper in one of the Journals of the Indian Roads Congress. Results of the investigations of other laboratories available also showed that the bituminised soil seemed to prevent the water from getting into the road crust more effectively than the single membrane. Another method of insulating the embankment was the use of coarse sand which provided capillary cut-off. It had been said that probably a very thick sand insulation was required but that, of course, depended upon the materials available. It was also a question of economics which could be gone into in each particular case when they were designing the insulation layer. There were other methods also using other types of capillary cut-off such as surface active agents, etc., on which further research was required which was being carried out.

Shri A. K. Deb pointed out that the Army had to face the problem of waterlogged areas during the last war in the regions of Burma, Assam, and East Pakistan. The Engineer-in-Chief had set up a research organization, called the Airfield Experimentation Section, at Kanchrapara in West Bengal, and certain experimental stretches were laid there with the principle called in the army, hut's matrix method. The experimental strips were inundated completely after about a month of their construction and there was 2 to 3 ft of water standing on those experimental strips for at least three months. The behaviour of the road was, however, fairly successful, atleast from the army engineers' point of view. He did not consider that was a permanent solution to the road construction problem in waterlogged areas, but its usefulness could be kept in view. Further, he suggested that some kind of membrane should be tried and the membrane should be water-proof as well as air-proof. He did not say that this method should always be used because it was only an expedient measure and in the army they expected a road to behave well, say, for six months or so. The success of that method mainly depended on the membrane which being water-proof kept away the capillary rise of water from the bottom. He did not know whether any experiments on a field scale had been carried out, but he thought it was worthwhile to do so.

Shri S. N. Gupta giving his observations of West Bengal stated that he felt that waterlogging took place not only by increase in the subsoil level of the water table but also

by tidal action. The lower part of Bengal was subject to tidal action and sometimes the fluctuation was as much as 12 ft from the lowest water level to the highest water level in the river or canal. The failure of existing roads had occurred, as mentioned in para 3 on page 281 of this note, evidently by reduction in the bearing capacity of the saturated soil which had resulted in the settlement of the road crust. Where this deformation was not very pronounced or not repeated closely, they sometimes took remedial measure* which was given on page 282 of the note. But in the worst affected areas where soling had been so damaged that it was not advisable to increase the thickness of the crust they had to take out the whole crust and relay it over again.

Regarding lowering the water table by drainage, he agreed with Shri Khanna that if not impossible it was very difficult; moreover, as the note also stated self-sufficient drainage system for road projects was almost absurd for economic reasons, but where it could be combined with the existing canal system or a drainage scheme undertaken for reclaiming particular areas, the problem would be automatically solved. In West Bengal the Irrigation Department had come to the rescue in one or two areas.

Regarding new roads in the waterlogged areas, their design was based on the principle of testing the bearing power of the soil in saturated condition and designing the thickness accordingly. Naturally, the road did not suffer any further due to waterlogging. As a matter of fact, they had constructed a road in the Burdwan district that was flooded during one year when it remained under about 2 ft of water for more than a month. Surprisingly, the road suffered no deformation at all. The crust consisted of mechanically stabilized soil base course about 8 to 10 in. thick and water-bound macadam and black topping over it. The reason for this, they thought, was that the loss in the bearing power was not to such an extent as to deform the surface under traffic on that road.

Regarding Shri Deb's comment, he thought that it was worthwhile to make some experiments with that type of membrane to keep the water off. Probably Shri Deb did not know that similar work was done on N.H. 2, i.e., Grand Trunk Road, mile 52 to 53, during the war years under the joint supervision of the army authorities and the P.B.S. people who had supplied the sheets. The entire road bed was filled

*To increase the thickness of the road crust so much that the prevailing traffic loads, after dispersion through the thickness of the crust, become so low that the subgrade soil in its saturated condition can safely support them.

up with surrounding water and the road failed miserably. The reason was that in Bengal the effect was from all sides not only from below but even from top, and it was almost impossible to keep the water off the road for ever. Because of the variation of water table, there was swelling and shrinkage variation seasonably and also day to day due to tidal action. They had to design a road taking into account the saturated condition of the soil.

Regarding salt infested waterlogged areas, they had such an area bordering on the Bay of Bengal. They had completed test experiments in that area. The roads there were also badly affected and they had not been able to analyse completely the reason for that, but they were still working on the problem.

Shri B. S. Jootla endorsed the view already expressed by various speakers that waterlogging was generally due to excessive irrigation going on for the last 40 or 50 years. All the remedies as mentioned in the note, were not costly but many of them were not practicable, because depressing of water by drainage was after all a palliative and not a permanent solution. Besides increasing the crust or depressing the water table, there was another method which could be adopted. He suggested strengthening of the sub-base of the waterlogged portion of the embankment by injecting cement. That was done in one of the anicuts where the apron was being damaged. There they had put in perforated pipes and with pressure grouting machines they had used grouted cement. That apron was still standing quite alright. Similarly, if the base was pressure grouted up to the water surface the bearing capacity of the soil would easily increase and there would be absolutely no trouble. That would also be a permanent solution.

Shri P. L. De stated that one of the measures for depressing the water table was by drainage. Other speakers had mentioned about the cost of constructing such drains. But the cost of maintenance of such drains was also very considerable, because once the drains were choked they could not function properly and thereby served more as a water reservoir to supply more water to the subgrade.

The increase of pavement thickness by the C. B. R. method was no doubt the best method if it worked out to be economical. Another suggestion was to increase the height of the embankment thereby raising the subgrade just below the hard crust. That might also be tried if found economical.

Regarding the use of membranes, he was told by the I. C. I. people that there was a patent membrane, Alkathene, which had

been used on experimental basis on some roads in U. P. He requested engineers from U. P. to give the details.

Another suggestion of using a sand layer for cutting the capillary rise of water had been made. He thought that would be very costly because he had worked out from the data given in the book by Dr. A. N. Puri " Soils—Their Chemistry and Physics " that the thickness required for coarse sand would be 15 cm. or 6 in. For medium sand it would work out to 45 cm. or 18 in., and for fine sand it would be something like 100 cm. or 40 in. That meant very great thickness of sand was required. He thought in waterlogged areas local sand was generally not expected to be available and, if it was available at all, it would be more economical to use stabilised soil-sand because, even when greatly saturated it would have at least as high as 15 to 16 C. B. R. value. In that case, hard crust of about 9 in. might be sufficient.

Regarding the method of calculating the required thickness of sand layer, given in Appendix 1, it was not necessary to have such an elaborate apparatus. In fact, that apparatus was designed by Dr. Puri for the accurate determination of mean diameter of silt. For sand, it was much easier and accurate to find out the mean diameter by sieve analysis only. Moreover, capillary rise in a particular sand could be easily determined directly by filling a glass tube having a filter or bottom plug at one end and placing that on top of water and directly measuring the height of water.

Finally, he stated that the C. B. R. method as given in Appendix 2 was the best method for the design of road crust in watterlogged areas.

Dr. I. S. Uppal thought the most economical solution lay in improving the subgrade rather than looking for an expensive method. Lime had been largely used in America and a lot of work had been done by the Central Road Research Institute and the Karnal laboratory had also found that addition of 1 per cent of lime in any type of soil improved its C. B. R. In the case of clayey soils where the C. B. R. under saturated conditions was almost zero, it improved to about 20 to 25 by addition of 2 per cent lime. The finer material, which was over 60 per cent (finer than .01 mm) was all eliminated and coagulated by addition of lime. In the sandy soils, the C. B. R. increases from about 8 to 50 or 60 by the addition of only 1 per cent lime. In trying to find the optimum sand content which would require the minimum quantity of lime they had found that in graded soil, containing about 35 per cent sand, addition of only 1 per cent lime improved the C. B. R. from about 8 to 40 under saturated

conditions. If instead of looking for other methods the existing road was dug up one foot to 15 in. deep and 1 or 2 per cent (quantity could be determined by laboratory) of lime mixed properly with the soil dug, and then recompacted, and the stone metal or moorum whatever was required put over that, he thought that was likely to stand because the total thickness of the crust under the worst saturated conditions would be about 20 in., including the brick soling and the stone metal. There were various roads which were already sufficiently high and where the embankment was 5 to 6 ft high and still they were waterlogged and being damaged. In that case it was not possible to raise the height of the road. But if they could split up the road into portions and just try experiments it should be possible to get some good results. They were trying to do that in the Punjab.

They had calculated that addition of 1 per cent lime to soil for about 24 ft width with 12 in. thickness below the hard crust would cost roughly Rs 4000 to Rs 5000 per mile. That was the cost of lime which would be involved for that particular thickness.

Regarding Shri De's point that sand absorbed water, he fully agreed with him that even coarse sand could absorb water upto about 15 in. height. They had tried some experiments in the laboratory using soap to reduce the capillarity and found that if they used about 0.2 or 0.3 per cent of soap for coarse sand, the water would not go beyond half an inch even for 3 to 4 months when left in contact with the sand. Medium sand might require only 0.3 per cent soap and there was no possibility of water rising up. He thought in that case the layer of sand could be considerably reduced from 15 to 16 in. to about 2 to 3 in. just to be on the safe side.

Shri K. K. Nambiar stated that Dr. I. S. Uppal and Shri R. N. Dogra had referred to some experiments done in the Karnal laboratory on the capillary cut-off the results of which were given in the other Paper by Dr. I. S. Uppal. There they had compared 40 lb of primer per 100 sq. ft. of area with 2 in. thick loose layer impregnated with cut-back and the conclusions were that the quantity of bitumen cut-back at 4 per cent of weighted soil for 100 sq. ft. of the 2 in. thick loose layer compacted to about 1.5 in. would be approximately 45 lb as against 40 lb of primer for 100 sq. ft. area. The difference of 5 lb was not much as compared with the advantage gained over the primer treatment.

But actually calculating the quantity of bitumen at 4 per cent, according to him, worked out to about 60 lb and not

45 lb for a compacted thickness of 1.5. He did not know how that had been arrived at.

(Dr. H. L. Uppal explained that alluvial soil in dry state weighs between 75-80 lb per cu.ft. in loose condition; this gave a corresponding figures of 50-53.3 respectively. He agreed with Shri Nambiar that a figure of 45 was incorrect. Apart from the quantity it should be interesting to know the actual behaviour of such treatment in the field as compared to spraying method).

Shri C. D. Harris stated that it was not clear what the Irrigation Department were doing about the problem of waterlogging. If, as said in the note, the Irrigation Department were going to reclaim waterlogged areas, then perhaps their efforts could be co-ordinated so that reclamation was concentrated along areas of National Highways and other roads of importance. At the time of reclamation improvement of the roads could also be undertaken.

As regards reconditioning, Shri Khanna had said that the cost would be Rs 70,000 per mile. This might well be true but he felt it was possible that the cost could be reduced by upgrading the existing road crust material. If an increase in thickness of 4 to 5 in. was necessary, it might be worth investigating whether 2 to 2½ in. of high type bituminous carpet could be substituted where stone was scarce or expensive.

Mention had been made in the note of longitudinal side drains and he would like to suggest that consideration be also given to a system of lateral herringbone drains feeding into these longitudinal drains. Those lateral drains or trenches would be of 6 to 9 in. square section filled with rubble and coarse sand and be placed in the subgrade immediately below the base course. They would serve to drain off any capillary water in the top of the subgrade and assist in draining off any water which might percolate through the surface.

Shri N. H. Taylor stated that he did not know how the areas of canals compared with areas of roads. But if membranes were going to be used, he wanted to know whether it would not be possible to apply certain membrane in the canals themselves to prevent water leakage. A lot of water must be lost from the canals and those losses possibly could be avoided.

There was another point regarding the method of improving the road rapidly. He had carried out some time ago some research on the rise of water by capillary action in the soils and had prepared some samples with and without a primer on top.

When he had taken those samples out in the afternoon sun to get good pictures, he had found that the water under the bituminous surface rose very much more rapidly than under untreated surface, and finally he was not at all sure whether the bitumen surfacing had desirable effects. He wondered whether instead of putting more bituminous surfaces on the roads, those roads should not be entirely stripped of non-absorbent surface so that the water which came up could be carried away as rapidly as possible by the sun. One speaker had already said that he had tried that method but, unfortunately, when the dry weather came he had again put the impervious surface. In such a case he would try something else and try to lay macadam of some sort which was durable and which would give a more favourable surface and, of course, from which water could evaporate.

Shri H.H. Campbell stated that Shri Dogra had cited the case of Holland. He quite agreed that conditions in India were quite different in many ways, but nevertheless Holland had a great deal of experience of waterlogged conditions from which they might profit. Shri Dogra had also mentioned the possibility of pumping out water if they were not able to drain the waterlogged areas by the natural gravitational means. Most of the waterlogged areas, he thought were limited to certain sections of the country. One idea that he had in mind was to use a new element—the element of wind. How about wind mill type of pumping?

Secondly, everywhere he had been, the engineers were very much afraid of mechanising their road surfacing method because of cost and they were afraid of doing the manual labour out of work and creating unemployment. It could be shown that mechanized surfacing methods could reduce the surfacing cost by approximately one-third. If they did that, surely they could very usefully use the money in employing the labour for improving drainage conditions. Co-operation in that respect between the Roads Department and the Irrigation Department was necessary.

Shri C.L.N. Iyengar mentioned that in a large part of the country, the problem of waterlogging was confined to the rainfall period and not to general rise of sub-soil water level.

An observation had been made that the deformations of the pavement were maximum during the period when the sub-soil water was at its highest level. That might be true of soils which were not properly stabilised and compacted. In the case of soils with highly expansive characteristics, the recession of the subgrade with drying out of the moisture might cause more serious deformations than when the sub-soil water level was high.

In the reference to the C.B.R. method of pavement design, a suggestion had been made for allowing a saturated subgrade condition which should not, however, mean that the drainage requirements of the embankments, etc., could be ignored. They were still to be taken into account and provided for satisfactorily.

The common assumption in the C.B.R. design curves provided for 2 in. minium bituminous carpet, not merely for structural stability but also from the necessity of precluding the entry of surface moisture to the top layers of the base course. However, where thinner bituminous carpets were adopted with these design curves, an additional thickness of water-bound macadam construction should be provided to substitute for the higher strength of the thicker bituminous carpet.

Referring to an experiment carried out on preventing the subgrade recession by the use of soil cement, Shri Iyengar pointed out that the material was handled by the maintenance crew without enforcing other controls taking the percentage of cement at 10 per cent, as against 6 to 8 per cent required by tests. That was adopted as a matter of expediency for correcting the subgrade under the concrete pavement. At this site, recession of the subgrade was so fast that successive layers of bitumen over the top of concrete pavement during the course of one year called for an addition of as much as 5 in. thickness to make up the levels with the rest of the pavement. In one site along this experiment after the removal of the pavement, there was no time left for concreting after subgrade correction; there the same soil cement mix to a depth of about 6 in. compacted under the same uncontrolled conditions, giving densities of only 95 to 100 lb cu. ft was used, whereas the maximum density was 117 lb cu. ft., and was covered up with about $1\frac{1}{2}$ in. premixed carpet. That particular stretch had several times been under 4 ft of water in the worst floods (which occurred quite often in Bombay) for two successive years and it carried a daily traffic of about 15,000 to 20,000 tons. Conditions were still quite satisfactory and with this performance it looked as if a soil cement layer might give satisfactory results as far as behaviour under saturated condition of the soil was concerned.

Pointing out to a case on Bombay-Agra Road where, on a curve, nearly 300 to 400 ft length of embankment for half its width was washed out during rains, he stated that actually, of the two lanes of concrete one lane was hardly resting for half its width on the embankment. The pavement had been completely salvaged by underpining of the pavement even after the washout. That showed the advantage of some of the semi-rigid and rigid types of pavements.

Shri P. J. Jagus clarifying the point raised by Shri De about the use of solid membranes for development of air-pressure underneath the pavement if the capillary rise was there from beneath, stated that the suggestion was made on the presumption that the solid membrane would be completely air-tight. In the case of membranes like alkathene or polytheline sheets whose puncture value was very low, it was likely that even during laying operation or during the compaction of the structural layers of the pavement on top, the membrane might get punctured. Even a smallest pull would release the air-pressure that might have developed underneath. Against that, his personal feeling was that since a number of capillary cut-offs had been discussed in the Paper, such as a layer of sand, stabilised bitumen and sprayed bitumen it might be desirable to use the same alkathene sheets as a positive cut-out below the pavement.

Shri S. N. Gupta had mentioned about the use of P.B.S. sheets and cited the example of the pavement having completely failed. But probably he was referring to those roads which were subjected to flooding, and there was no wonder that any positive type of membrane became a very dangerous proposition where the water had ingress from the top of the pavement and was actually held up and destroyed the stability of the entire structure as a whole.

Dr. I. S. Uppal had made a suggestion with regard to the use of soap. He did not know whether the treatment of that type would be at all permanent because unless and until soap combined in a complex manner with the soil ingredients, it would have a tendency to wash out because of the wetting and drying of the soil underneath.

Dr. I. S. Uppal referring to the use of soap, stated that they had actually given a number of washings to the sand after treating with soap, and washing-drying — 12 times, and the capillary had not been affected at all. It had a permanent effect. They had been actually keeping those capillary tubes in water for about a year without the water rising up.

Three or four Papers on this subject had already been published in the Indian Concrete Journal.

Shri S. R. Mehra stated that in the background of the discussion which had taken place, it appeared that in the first place there was no reason why in areas where it was possible without undue uneconomic expenditure to connect up roadside drains with existing natural or artificial drainage system, that should not be done. It had been stated by Shri Khanna that he

had talks with the Irrigation people in regard to the effectiveness of these drains, but so far as irrigation was concerned, those drains were put at distances of something like a couple of miles the grid was one or two mile wide if not wider. They worked out on a very long range programme hoping that in course of time the level would go down low enough to allow agriculture to be practised. But so far as roads were concerned, the drains would be only about 100 ft apart and, therefore, they were likely, except in very badly drainable areas and heavy clays and things like that, to bring down subsoil water level considerably to improve the bearing value of the soil to enable the road to take up the prevalent traffic without very detrimental deformations. That was after all what they were trying to do. They were trying to tide over the reconstruction of the roads in as much length as possible by as many years as they could without bringing them to a state where it would be impossible for the traffic to go over them.

As regards the removal of the surfacing concerned, he thought it would be a very useful idea. It was certainly worth trying in the case of roads which were perhaps difficult of drainage and it might tide over some years, if effective. It stood to reason that if evaporation of the subgrade soil or moisture from the subgrade soil was helped by removing the waterproof seal from the top, the bearing capacity would increase.

As regards the capillary cut-off, the necessity arose only in areas where there was salt and where new construction was to be carried out. It did not arise in the case of existing roads because it was not possible to go under the road to put a seal. As regards the type of seal to be adopted, it all depends on the economics of the case. Shri Mehra agreed that if it was possible to have a 1½ in. of bituminous seal, soil impregnated with bitumen, it was better than impregnating the soil with a cut-back which would go only about 3/8th of an in., but it was a matter of economics and could be gone into on the merits of the case. Alkathene had possibilities. On the other hand, as pointed out by Shri Jagus, its puncture value was fairly low and even during construction there might be danger of puncturing. But those were matters which would have to be dealt with in due course from research angle.

As regards using sand as a capillary cut-off, in the method given by Dr. Puri, the point that arose was that that method determined the thickness of a sand layer which would completely cut-off capillarity. On the other hand, there was a possibility that at some depth from the saturation level there might be a case of partial saturation where the sand could not communicate

further moisture into the soil, and it might be possible to do with a lesser thickness than given by that method of capillary cut-off. The matter was being gone into and he was sure the results should be available before long.

In regard to lime stabilization or cement stabilization for use in new roads, it was again a matter of economics. A method had been suggested for use starting with the cheapest possible materials from the bottom and going up to more expensive material on the top. But the fact remained that necessary thickness would have to be provided. What was to be provided depended on the economics of the case, assuming that in waterlogged areas water resisting material would have to be used.

A speaker had raised the question of cutting out losses from canals. That was a burning problem with the Irrigation Department all over the country and as far as he knew there was a definite decision of policy now that the main canals as well as the main distributaries would all be lined to prevent the loss of water taking place and resulting in other damages. But so far as the existing canals were concerned, he was afraid there was nothing very much that could be done in the matter, because that meant lining a very much bigger section than would be required in the case of a lined channel.

In so far as the reasons for waterlogging were concerned, the irrigation people had been working at it for years and years to his personal knowledge. He happened to go to their Annual Research Session and he knew that only recently there was a symposium held by the C.B.I. & P. and almost for three hours they were trying to argue the whys and wherefores and how it could be stopped. It was such a big subject with so many implications that they had not been able to find the answer so far, nor it was likely that they would find the answer to cutting out waterlogging. But so far as road engineers were concerned, it had comparatively limited scope and what they had to do was to see how the exsisting affected roads could be made to serve the purpose as long as possible. And, as far as the designing of new roads in waterlogged areas was concerned, there seemed to be no difference of opinion that they should be properly designed in thickness.

Shri K. K. Nambiar (Chairman) thanked all the speakers in making the discussion interesting and useful.

He particularly referred to Shri Campbell's suggestion to install windmill types of pumps if ordinary pumps were more expensive. It seemed to him a suggestion which could certainly be followed up if they could somehow depress the water level

without very much maintenance expenditure in installing those types of pumps. It was worthwhile looking into that.

Some of the suggestions were quite new and had to be carefully experimented upon before they could finalise the specifications. He was sure the experiments could be carried out in the various parts of the country by the various Chief Engineers of States so that with the help of the Central Road Research Institute they would be able to finalise specifications and evolve sound practice for dealing with treatment of roads in waterlogged areas, not only for roads which had already been constructed but also for roads which were to be built in the future.

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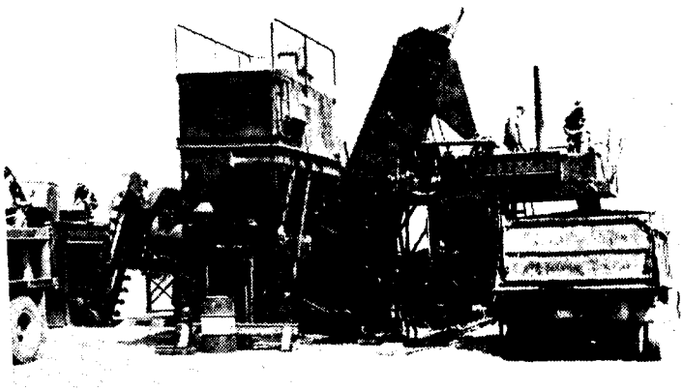

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