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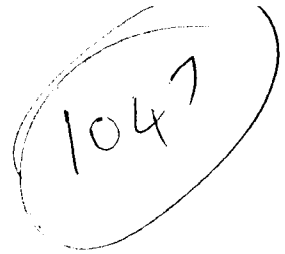


LIST OF MEMBERS OF THE COUNCIL FOR 1956-57

1. F. P. Antia
2. D. P. R. Cassad
3. C. J. Fielder
4. E. A. Nadirshah
5. L. R. Patel
6. N. Durrani
7. B. Chaudhury
8. W. X. Mascarenhas
9. K. K. Nambiar
10. C. M. Bennett
11. M. S. Bisht
12. D. N. Gupta
13. M. A. Kayyum Khan
14. P. V. Divatia
15. H. Anantachar
16. A. C. Malhotra
17. Kishori Lal
18. U. J. Bhatt
19. K. K. Kartha
20. B. Prasad
21. Brig. D. B. Chopra
22. N. G. Dewan
23. H. P. Mathrani
24. G. D. Joglekar
25. R. R. Thimmaji Rao
26. J. K. Bannerjee
27. R. N. Dogra
28. E. V. S. Iyer
29. S. R. Naidu

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

INDIAN ROADS CONGRESS, TWENTY-FIRST SESSION, SHILLONG, MAY 1957.

Shri P. L. VARMA, President, 1956—57.

Shri P. L. Varma was born in Hoshiarpur District of Punjab in 1901, took his Bachelor's degree with Honours from the Government College, Lahore, and secured his engineering degree from the Thomason Engineering College, Roorkee, passing with credit. He was appointed in the Punjab Service of Engineering in 1924, where he was promoted as Executive Engineer in 1937 and was responsible for execution of a number of buildings such as Council Chamber, Lahore, etc. In 1942, he was appointed as Under Secretary to the Government of Punjab and in 1945 was made Superintending Engineer (Planning) for the Post-War Planning Scheme, which post he occupied till 1947 when he was sent to the United States of America as a leader of the Road Delegation, and on his return was posted to the Punjab. In January 1948, he was promoted as Chief Engineer and Secretary to the Punjab Government Development Organisation. On the abolition of that post in 1950, he was appointed as Chief Engineer, Chandigarh Capital Project. In 1953, he took over as Chief Engineer and Secretary to Government, Punjab, P.W.D., Buildings and Roads Branch, in addition to Chief Engineer, Capital Project. He was appointed as a member of the Union Public Service Commission in 1956 and is holding this post at present. His major contribution to the State as Chief Engineer is creation of the city of Chandigarh which has come into being all due to his imagination and forethought. He is a member of the Institution of Engineers (India) and has thrice been elected as President of the Punjab Centre.

INDIAN ROADS CONGRESS

NOTICES AND ANNOUNCEMENTS

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

The next General Session of the Indian Roads Congress will be held at New Delhi from the 4th to the 8th January, 1958.

2. On the occasion of the next Indian Roads Congress Session a Seminar on **Low Cost Roads** will also be organized by the ECAFE. The Seminar on low cost roads will immediately follow the Indian Roads Congress Session and will be held from the 10th to the 18th Jan., 1958. It is suggested that good Papers on Highway Engineering including low cost roads incorporating the experience gained by various engineers in India should be contributed to the Indian Roads Congress so that the foreign delegates attending the Seminar could also participate in the discussion on these Papers.

3. **Procedure**: Members who intend to contribute Papers on any subject connected with Highway Engineering are requested to intimate the fact to the Secretary, Indian Roads Congress, and to send a short synopsis of their proposed Papers 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 time to study Papers well in

advance of the date of the Session, it is hoped that Members will make an effort to send their contributions **as early as possible.**

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

5. The youngor engineers are particularly requested to contribute Papers which, if required, will be suitably edited by the Indian Roads Congress Office 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 9 to 14 of Volume XXI, Part 1 of the Journal of the Indian Roads Congress —February 1957.

II. NEW ADMISSIONS

LIST OF MEMBERS OF THE INDIAN ROADS CONGRESS ENROLLED FROM 1-1-1957 TO 31-7-1957.

Serial No.	*Roll No.*	*Name*	*Address*
1	2182	R. Subramanian	Junior Engineer (Highways), No. 3, Kanniah Naidu Street, **Madras-17.**
2	2183	S. Arumuga Swami	Senior Scientific Officer, Central Road Research Institute, P. O. CRRI, **New Delhi.**
3	2184	K. V. Ranga Rao	Junior Engineer, Highways, Special, Gundur, **Distt. Nellore,** (Andhra Pradesh).
4	2185	P. K. Premanand	Head Draftsman, Cochin Port, **Cochin-1.**
5	2186	S. N.P. Sinha	Assistant Engineer, P. W. D., B. & R., Provincial Division, **Moradabad** (U. P.)
6	2187	Amar Jit Singh	Sub Divisional Officer I, Construction Division, P. W. D., **Patiala** (Punjab).
7	2188	N. Sivaguru	Assistant Engineer (Consultant), C/o. The Deputy Engineer, Thana Sub Division, **Thana.**
8	2189	H. N. Maheshwari	Assistant Engineer, Central P. W. D., 81, Barron Road, **New Delhi.**
9	2190	A. Annamalai	Assistant Engineer, Highways, Dindigul, **Distt. Mathurai** (Madras State).
10	2191	Mahesh Chandra Sharma	Assistant Engineer, P. W. D., B. & R., City Sub Division, **Jaipur** (Rajasthan).
11	2192	V. M. Chitale	Executive Engineer, P. W. D., B. & R., **Shivpuri** (M. P).
12	2193	D. Talukdar	Sub Divisional Officer, P. W. D., Ghilamara, **North Lakhimpur** (Assam).
13	2194	Khwaja Imamuddin	Lecturer, Engineering College, Muslim University, **Aligarh** (U. P.)
14	2195	A. B. Lall Bedi	Assistant Engineer, Roads, Narwana Sub Division, **Narwana** (Punjab).

Serial No.	Roll No.	Name	Address
15	2196	Jitendra Kumar Bhargava	Assistant Engineer, Bridge Division, **Garhmukteshwar** (U. P).
16	2197	Satinder Singh Mehta	Sub Divisional Officer, P. W. D., B/R., Bridge Construction Sub Division, **Dehra Gopipur**, Kangra District. (Punjab).
17	2198	H. B. Gajria	Assistant Engineer (Consultant), Ministry of Transport & Communications, Deptt. of Transport, Roads Wing, Jamnagar House, Shahjahan Road, **New Delhi-2.**
18	2199	Brijendra Kumar	Junior Engineer, C/o. Shyam Behari Lal Saksena, Advocate, President, Municipal Council, 'C' Scheme, Malviya Marg, **Jaipur** (Rajasthan).
19	2200	H. N. Darukhana-wala	Deputy Engineer, Bombay P. W. D., C/o. Mrs P. F. Lali, Gool Mahal, B-Block, Ground Floor, Sleator Road, **Bombay-7.**
20	2201	U. C. Ghose	Engineer & Managing Director, C/o. Messrs Bridge & Building Construction Co., Private Ltd., **Gauhati** (Assam).
21	2202	T. K. Natarajan	Senior Scientific Officer, Central Road Research Institute, P. O. CRRI, **New Delhi.**
22	2203	V. I. Carpenter	Deputy Engineer, P. W. D., Navchoki, Hathana Street, **Broach** (Gujarat).
23	2204	P. K. Mukherjee	Bitumen Engineer, M/s Burmah Shell Oil Co., **Cuttack-8** (Orissa).
24	2205	C. D. Harris	Bitumen Manager, M/s Burmah Shell Oil Co., Burmah Shell House, Ballard Estate, **Bombay-1.**
25	2206	Rajendra Prasad Jain	84, Pram Puri, **Meerut City** (U. P).
26	2207	Lajpat Rai Chaudhri	Assistant Design Engineer, A2/102 Rajouri Gardens, **New Delhi-15.**
27	2208	A. R. Dawar	Assistant Engineer, Roads, Delhi-Municipal Committee, House No. 2275, Gali No. 68, Naiewala, Karol Bagh, **Delhi.**
28	2209	Bhim Singh	Assistant Engineer, (R. & B.), Rajasthan P. W. D., **Jaipur.**

Serial No.	Roll No.	Name	Address
29	2210	J. W. Keswani	Chief Resident Engineer, Banihal Tunnel Project, **Srinagar.**
30	2211	S. K. Saxena	Assistant Engineer, P. W. D., B/R, City Sub Division, **Kotah** (Rajasthan).
31	2212	Akhouri Bankey Behari Lall	Executive Engineer, Central Division, P. W. D., **Patna.**
32	2213	B. P. Jain	Assistant Engineer, P. W. D., B/R, City Sub Division No. III, **Jaipur.**
33	2214	S. R. Joshi	C/o S. B. Joshi & Co., Private Ltd., Dhansiri Bridge Works, Post Orang, Distt. **Darrang** (Assam).
34	2215	M. B. Gharpuray	C/o S. B. Joshi & Co., Private Ltd., Dhansiri Bridge Works, Post Orang, Distt. **Darrang** (Assam).
35	2216	N. S. L. Rao	Executive Engineer, C. P. W. D., **Gauhati Airport P. O.**
36	2217	N. V. Kanetkar	C/o S. B. Joshi & Co. Ltd., Barak Bridge Works, P. O. Silchar, Distt. **Cochar** (Assam).
37	2218	S. P. Bhargava	Assistant Engineer, P. W. D., B. & R., 5/345, 3rd Road, Sadarpura, **Jodhpur.** (Rajasthan).
38	2219	S. S. Baxi	Assistant Engineer, National Highways, North Sub Division, Baxi House, Ganesh Ghati, **Udaipur** (Rajasthan).
39	2220	D. R. Das	Executive Engineer, (R/B) North Lakhimpur Division, **P. O. Lakhimpur** (Assam).
40	2221	M. Sharma	P. A. to Superintending Engineer, N. E. F. Agency Circle, C. P. W. D., **Shillong.**
41	2222	R. M. Bhakta	Resident Engineer, C/o. M/s S. B. Joshi & Co. Ltd., Examiner Press Building, 35, Dalal Street, Fort, **Bombay-1.**
42	2223	Miss S. S. Joshi	Design Engineer, Joshiwadi, Manmala Tank Road, **Bombay-16.**
43	2224	Nilakanth Misra	Assistant Engineer, P. W. D., P. O. **Keonjhargarh**, Distt. Keonjhar (Orissa).

Serial No.	Roll No.	Name	Address
44	2225	K. P. Tyagi	Assistant Engineer, P.W.D., (B. & R.), Residency Road, **P. O. Udaipur** (Rajasthan)
45	2226	Kishan Singh	Lecturer in Civil Engineering, No. 3, Poly Professor's Quarters, Professor's Colony, Banganga, **Bhopal** (Madhya Pradesh).
46	2227	S. C. Chaudhuri	Sub Divisional Officer, P. W. D., **P. O. Mawphlang**, Distt. K. & J. Hills, (Assam).
47	2228	B. G. Khubchandani	Assistant Executive Engineer, Planning Division, N. E. F. Agency, **Shillong**.
48	2229	P. C. Bhattacharjee	Executive Engineer, **Nowgong**, (Assam).
49	2230	T. P. Madhavan	Bitumen Engineer, M/s Burmah Shell Oil Co., **New Delhi**.
50	2231	Yadav Chandra Sahariah	Executive Engineer, (R. & B.), **P. O. Jorhat** (Assam).
51	2232	S. C. Sen	S. E's S. D. O., P. W. D., (T. C.) Office of the Executive Engineer, Tezpur Division, **P. O. Tezpur** (Assam).
52	2233	Bipin Chandra	Sub Divisional Officer, P. W. D., Ranikhet, **Distt. Almora** (U. P).
53	2234	Birendra Prasad	Sub Divisional Officer, P. W. D., **Buxar** (Bihar).
54	2235	R. P. Mital	District Engineer, P. W.D., **Muzaffarnagar**. (U. P).
55	2236	A. S. Tiagi	Assistant Engineer, N. E. F. A., P.O. Lokra Distt., **Darang** (Assam).
56	2237	Amar Chandra Kundu	Executive Engineer, Sibsagar Division, **P. O. Sibsagar** (Assam).
57	2238	K. George Mathew	Assistant Engineer, P. W. D., **Peermade** (Kerala State).
58	2239	Tarun Kumar Ray Chaudhury	Sub Divisional Officer (Roads), Krishnagar Construction Sub Division, **Krishnagar**, (W. Bengal).
59	2240	H. E. Roy	Sub Divisional Officer, P. W. D., D. D. B. C., Sub Division, P. O. *Nazira*, **Distt. Sibsagar** (Assam).

Serial No.	Roll No.	Name	Address
60	2241	Naranjan Singh Bawa	Senior Scientific Assistant, Central Road Research Institute, **New Delhi**.
61	2242	V. Braganza	Executive Engineer, Uttar Pradesh, P. W. D., **Agra** (U.P).
62	2243	Mohd. Muzzaffar Husain	Assistant Engineer, Office of the Chief Engineer, P. W. D. (B & R), **Gwalior** (M.P.).
63	2244	S. C. Dikshit	Executive Engineer, Provincial Division, P. W. D., **Fatehgarh** (U.P).
64	2245	R. K. Saxena	Assistant Engineer, Prakash Bhavan, Chateri Bazar, **Lashkar** (M.P).
65	2246	S. K. Sen	Assistant Engineer, W. & B. Deptt., 31/A Raja Basanta Roy Road, **P. O. Calcutta-29**.
66	2247	S. K. Chanda	Assistant Engineer, W. & B. Deptt., 65/A, Dr. Suresh Sarkar Road, **Calcutta** (W. Bengal).
67	2248	Amitava Bannerjee	Assistant Engineer, Roads & Design Division, No. I, 5, Lake Terrace, **Calcutta-29**.
68	2249	M. K. Mukherjee	Assistant Engineer, W. & B. Deptt., 54, Madhusudan Biswas Lane, **Howrah** (W. Bengal).
69	2250	Padma Lochan De	Assistant Director, Roads & Buildings Research Institute, Govt. of West Bengal, 70, Chetta Road, **Calcutta-27**.
70	2251	K. C. Barua	Sub Divisional Officer, P. W. D., Shillong P. O., K. & J. Hills Division, (Assam).
71	2252	S. S. Das	Junior Engineer, Assam, P. W. D., C/o Shri S. K. Das, Professor—Para Malki, **Shillong** (Assam).
72	2253	V. K. Raju	Junior Engineer, C/o. The Executive Engineer, K. & J. Hills Division, **Shillong**.
73	2254	V. K. Mathur	Junior Engineer, K. & J. Hills Division, **Shillong**.
74	2255	S. P. Banerjee	Junior Engineer, P. W. D., 58, Maharaja Tagore Road, **Calcutta-31**.

Serial No.	Roll No.	Name	Address
75	2256	H. Ahmed	Superintending Engineer (R & B), P.W.D., **Jorhat** (Assam).
76	2257	J. C. Chakrabarty	Executive Engineer, Assam C.P.W.D. Division, Haitumukhra, **Shillong.**
77	2258	P. K. Baruah	Sub Divisional Officer, P. W. D., Bharali Bridge Sub Division, Tezpur, **Distt. Darrang** (Assam).
78	2259	S. K. Saha Banik	Temporary Junior Engineer, C/o S.K. Das, Professor, Para Malki, **Shillong.**
79	2260	C. N. Bose	Assistant Engineer (Roads), 194, Harish Mukherji Road, **Calcutta-26.**
80	2261	H. A. Singh	Assistant Engineer, Highways Division, P. W. D., Manipur, **Imphal.**
81	2262	B. Mukherjee	Assistant Engineer, Planning & Design (H) Division, P. W. D., Manipur, **Imphal.**
82	2263	P. K. Datta	Assistant Engineer, (W. & B.), Malda Construction Sub Division, **P. O. Malda** (West Bengal).
83	2264	V. D. Seshgiri Raju	Municipal Engineer, Officer on duty as P. A. to Sanitary Engineer, **Madras.**
84	2265	V. V. Navare	Dy. Secretary to Government, P.W.D., Bombay, Sachivalaya, **Bombay-1.**
85	2266	S. C. Sen	Resident Engineer, Bridge & Building Construction Co. Ltd., **Shillong.**
86	2267	Hiteswar Gohain	ExecutiveEngineer, **Gauhati** (Assam).
87	2268	C. R. Keshava Murty	Assistant Engineer, P. W. D., 24-Old Extension, **Kolar** (Mysore State).
88	2269	B. S. Sivarudrappa	Assistant Engineer, **Saklospur**, Hasson Distt. (Mysore State).
89	2270	S. K. Dutta Choudhury	Sub Divisional Officer, Jail Building Sub Division, P.O. Gauhati, **District Kamrup** (Assam).
90	2271	P. K. Medhi	Assistant Engineer, P. W. D. (R. & B.), Gauhati Division, **P. O. Gauhati** (Assam).
91	2272	G. B. Oza	Partner, Oza Brothers & Co., (Engineers & Contractors), Bahadure Buraj, **Broach** (Bombay State).

Serial No.	Roll No.	Name	Address
92	2273	H. K. Bose	Assistant Engineer, Govt. of West Bengal, P. O. Sonarpur, **Distt. 24-Parganas.**
93	2274	M. M. Saikia	Sub Divisional Officer, P. W. D., Silchar, Barak Bridge Sub Division, **Silchar** (Assam).
94	2275	N. D. Gupta	Principal, Assam Civil Engineering College, **Gauhati.**
95	2276	S. P. Grover	Sub Divisional Officer, P.W.D., B. & R., **Karnal** (Punjab).
96	2277	B. C. Patnaik	Assistant Engineer, P. W. D., at Patapool, Sutahat, P. O. Cuttack-1, **Cuttack** (Orissa).
97	2278	U. N. Barua	Sub Divisional Officer, P. W. D., A. C. E. I. Sub Division, **P. O. Gauhati** (Assam).
98	2279	Tara Chand Tandon	Assistant Engineer, Tissa Sub Division, Himachal Pradesh, P. W. D., **Chamba.**
99	2280	R. Bhattacharjee	Executive Engineer, P. W. D., **P. O., Tejpur,** (Assam).
100	2281	M. Zaman	Sub Divisional Officer, P. W. D., Jhalukbani, **Gauhati** (Assam).
101	2282	H. Kakati	Executive Engineer, **Gauhati** (Assam).
102	2283	K. M. Joshi	Superintending Engineer, **Belgaum,** (Mysore State).
103	2284	K. V. Rao	Executive Engineer, **Chitaldrug** (Mysore State).
104	2285	S. K. Chakrabarti	Assistant Engineer, Survey Division No. II, Dev. (Roads) Deptt., Anderson House, Alipore, **Calcutta.**
105	2286	O. P. Wasan	Research Assistant & I/C P. W. D. Research Laboratory, Thatipur, P.O. Morar, **Gwalior.**
106	2287	K. K. Das	Assistant Engineer, P. W. D., Chief Engineer's Office, Building Design Branch, **Shillong** (Assam).
107	2288	A. K. Roy Choudhury	Executive Engineer (Designs), Chief Engineer's Office, R & B, P. W. D., Assam, **Shillong.**

Serial No.	Roll No.	Name	Address
108	2289	S. K. Pal	Executive Engineer, Barpetu, District **Kamrup** (Assam).
109	2290	A. Bhattacharyya	Executive Engineer, P. W. D., B/R, Goalpara Division, **Goalpara** (Assam).
110	2291	S. Nasiruddin Ahmad	Sub Divisional Officer, P. W. D., **Muzaffarpur** (Bihar).
111	2292	Dan Lal Mathur	Junior Engineer, Nayabas Dandiyon-Ka-Chowk, **Jodhpur** (Rajasthan).
112	2293	S. Seetharaman	Assistant Engineer, Consultant, Ministry of Transport & Communications, Deptt. of Transport, Roads Wing, Jamnagar House, Shahjahan Road, **New Delhi-2.**
113	2294	T. Satyanarayan	Assistant Engineer (H), **Kovvur**, West Godavari District (Andhra Pradesh).
114	2295	L. B. Baxi	Assistant Engineer, National Highways, **Kherwara** (Rajasthan).
115	2296	N. Ramachandra Rao	Assistant Engineer (H), **Gudur**, Nellore District (Andhra Pradesh).
116	2297	Dr. Jai Krishna	Reader in Civil Engineering, University of Roorkee, **Roorkee** (U. P).
17	2298	D. Subba Rao	Dean and Professor of Civil Engineering in the Faculty of Tech. & Engineering, M. S. University of Baroda, **Baroda.**
18	2299	S. G. Karnik	Executive Engineer, P. W. D., **Guna** (M. P).
19	2300	Shariff Amanuddin	Junior Engineer, (H), **Kandakur**, Nellore District (Andhra Pradesh).
20	2301	Bhagwati Lal Mathur	Assistant Engineer, P. W. D., B/R, Hanumangarh Division, **Sriganganagar** (Rajasthan).
21	2302	S. T. Ramanathan	Junior Engineer (H), No. 5, Conronsmith Road, Gopalapuram, Cathedral Post, **Madras-6.**
2	2303	Hari Shankar Rastogi	Assistant Engineer, Bridge Design Division, U. P., P. W. D., **Lucknow.**
3	2304	S. L. Joshi	Assistant Engineer, City Sub Division, P. W. D., B/R, **Jodhpur** (Rajasthan).

Serial No.	Roll No.	Name	Address
124	2305	R. P. Jyotishi	Sub Divisional Officer, P. W. D., Sub Division No. II, **Hazaribagh** (Bihar).
125	2306	S. N. Mazumdar	Sub Divisional Officer, P. W. D., Shillong 'B' Sub Division, **Shillong** (Assam).

ASSOCIATE MEMBERS

1	64	M/s Builder Brothers Private Limited.	Engineers & Contractors, Strand Road, **Gauhati** (Assam).
2	65	M/s Agrind Fabricating Limited.	6-Ganesh Chandra Avenue, **Calcutta-13.**
3	66	M/s Gannon Dunkerley & Co. Limited.	4, Lyons Range, **Calcutta.**
4	67	The United Provinces Commercial Corporation.	6-Ganesh Chandra Avenue, **Calcutta-13.**

III. DEATHS

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

Serial No.	*Roll No.*	*Name*	*Address*
1	1370	L. N. S. Bibhuty	Assistant Engineer, Mica Mines Welfare Works, P. O. Jhumri Tilaiya, **Dt. Hazaribagh.**
2	1718	G. S. Gnana Prakasam	Superintending Engineer(H), 60, Gopathy Narayanaswamy Chetty-Road, T-Nagar, **Madras-17.**
3	2043	G. P. Sengupta	Executive Engineer, W & B., **Midnapur** (West Bengal).
4	29	J. S. Narasimham	Research Officer, Engineering Research Lab., Red Hills, Nampally, **Hyderabad.**
5	1603	S. M. Madbhavi	Executive Engineer, Ghataprabha Left Bank, Canal Division No. 2, Jamkhandi, **Distt. Bijapur.**

IV. 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	340	B. Sinha
2	400	K. M. Vasay
3	403	Mohd. Farhatullah
4	587	S. C. Gupta
5	912	S. Panchanathan
6	988	T. Bala Krishna Menon
7	1011	N. K. Patel
8	1137	A. C. Das
9	1342	L. U. C. Sinha
10	1354	G. N. Srivastava
11	1378	D. N. Varma
12	1403	B. R. Khosla
13	1484	K. S. Deshpande
14	1537	T. Prem Sagar
15	1548	Mohd. Abdul Khadir
16	1642	Mukteshwar Prasad
17	1645	M. Natarajan
18	1658	A. Sivarama Pillai
19	1660	B. D. Ahuja

V. INDIAN NATIONAL GROUP OF THE INTERNATIONAL ASSOCIATION FOR BRIDGE AND STRUCTURAL ENGINEERING

There is an "International Association for Bridge and Structural Engineering", (with headquarters at Zurich, Switzerland). The object of the Association is to promote international co-operation among scientists, engineers and manufacturers, and to facilitate interchange of knowledge, particularly in regard to bridge and structural engineering. The Association has been doing very useful work by arranging discussions and publishing Papers, promoting research, etc.

It was considered desirable to form a National Group of the Association in India so that practicing engineers in this country could derive maximum advantage of the facilities available through the activities of this Association. The formation of a National Group at the present time would be particularly useful in view of the vast field for the execution of numerous and extensive bridge and structural engineering projects which are planned in the national five-year plans in the Central and State Government sectors and also in the private enterprise section.

The idea of organizing such a National Group was well received by the engineering profession in India. The matter was also discussed by the Council of the Indian Roads Congress and by the Chief Engineers who favoured the idea of the Indian National Group of the IABSE.

Accordingly, a Committee consisting of representatives of the Government of India, Ministry of Transport & Communications, Railway Board, Engineer-in-Chief, Army Headquarters, C. W. & P. C., C. P. W. D., Business interests was constituted to draft the constitution of the Indian National Group of the IABSE. The constitution prepared by the Committee was considered by the general body of persons interested in the Indian National Group at their meeting held on the 15th May 1957. A copy of the constitution adopted at that meeting is at pages 473-478.

Membership is open to qualified individuals, Government Departments and organizations connected with or interested in Bridge and Structural Engineering. The details of the qualifications prescribed for membership and Associate membership will be found in Article 4 of the constitution. Those who are interested in the membership of the Indian National Group of the IABSE may kindly fill up the application form and send it to the Secretary, Indian Roads Congress who is also the Secretary of the Indian National Group of the International Association for Bridge and Structural Engineering.

INDIAN NATIONAL GROUP OF THE INTERNATIONAL ASSOCIATION FOR BRIDGE AND STRUCTURAL ENGINEERING

CONSTITUTION

I. NAME & OBJECTS

Article 1. Name

The name of the Society is the Indian National Group of the International Association for Bridge and Structural Engineering. The short title shall be IABSE(ING).

Article 2. Objects

The aim of the Society is to promote co-operation among scientists, engineers and manufacturers, and to foster the exchange of knowledge, ideas and results of research work in the sphere of bridge and structural engineering in general, whether it be in steel, reinforced concrete or any other material.

For this purpose, the Society may adopt necessary means e. g., publish or arrange to publish Papers or Periodicals. It may also accept subscriptions, subsidies, etc., grant pay, prizes and honoraria for the work done in furtherance of the objects of the Society; hold periodical meetings to discuss technical questions and to promote such other activities as may be incidental or conducive to the attainment of the objects of the Society.

II. MEMBERSHIP

Article 3. Membership

There shall be two classes of members :

(a) Members, and

(b) Associate members.

Article 4. Qualifications for Membership

(*a*) *Members.*

The minimum qualification for a Member shall be any one of the following:

(i) Corporate Membership of the Institution of Engineers (India);

(ii) The possession of a degree or diploma recognised by the Institution of Engineers (India) for exemption from the examination for Associate Membership;

(iii) Ordinary Membership of the Indian Roads Congress;

(iv) A Science Graduate carrying out research on any aspect which has or would have a bearing on Bridge and Structural Engineering.

(*b*) *Associate Members.*

Government Departments, Local authorities, Scientific Institutions, Port Authorities, Firms and Technical Associations connected with or interested in Bridge & Structural Engineering will be eligible for Associate Membership.

Article 5.

Every Member and Associate Member of the National Group will remain a member of the International Association for Bridge and Structural Engineering as long as the member is on the rolls of the National Group.

Article 6.

Application for membership in the form annexed, and supported by one member of the National Group, will be addressed to the Secretary of the Group. The Executive Committee has the power to accept or reject any application.

III. ENTRANCE FEE AND SUBSCRIPTIONS

Article 7. Entrance Fee

An entrance fee shall be payable by Members and Associate Members on election in the following scale:

Members	...	Rs 15
Associate Members	...	Rs 300

Article 8.

Subscription for a Member and an Associate Member shall be Rs 15 and Rs 100 respectively per calendar year, payable before the 31st of January of the year to which it relates. Names of members who have not paid subscription till the 31st of December of the year to which they relate shall be removed from the rolls of the Group.

For re-admission, a fee of Rs 15 and Rs 300 shall be charged from Members and Associate Members respectively. Life membership may be obtained by one initial payment of 20 times the annual subscription.

Membership of the Society can only be terminated at the end of a calendar year, at least 8 months notice being given to the secretariat beforehand.

IV. MANAGEMENT

Article 9. Managing Committee

The Management of the Society shall be in the hands of a Managing Committee consisting of the following Members and Associate Members of the Group:

a. A representative each of the Union Ministries of Transport & Communications, Defence, Iron & Steel, Railways and Natural Resources and Scientific Research.

b. A representative each of the Central P. W. D., Engineer-in-Chief, Army Headquarters, Central Water & Power Commission, Indian Standards Institution, Institution of Engineers (India), Indian Roads Congress, and the National Buildings Organization.

c. A representative each of the State Public Works Departments.

d. A representative of non-Government Associate members.

e. Three representatives of Members.

f. Three representatives of Bridge & Structural Engineering Firms.

g. Three representatives of Technical Associations sponsored by the connected industries.

h. Three representatives of Scientists connected with any aspect of research on Bridges & Structures.

i. One representative of Associates of Principals of Technical Institutes.

Article 10.

The meetings of the Society shall be held as and when considered necessary by the Executive Committee but at least one meeting shall be held every year.

Article 11.

The Managing Committee shall meet annually to elect a Chairman and Treasurer from amongst the Members and Associate Members of the National Group, and 4 members of the Executive Committee from the members of the Managing Committee. They shall also receive the report of the Executive Committee at this Annual meeting.

Article 12.

The Secretary of the Indian Roads Congress shall act as the Secretary of the Society for the time being.

Article 13. Executive Committee

The day to day management of the Society shall be carried out by an Executive Committee consisting of the Chairman, the Treasurer, the Secretary and four members. The Executive Committee shall meet at least twice a year and the quorum shall be three.

Article 14.

The term of office of the Managing Committee, the Office-Bearers and Members of the Executive Committee shall generally be a year. But they will continue to hold office till the next election.

Article 15.

During the interval between two annual meetings, the Executive Committee shall have all the powers of the Society except to amend rules. All the decisions of the Executive Committee shall be placed before the Managing Committee.

Article 16.

Amendments to the rules shall be carried out only by a 75 per cent majority of the Members present either at a meeting of the Managing Committee or by postal ballot. At least a month's notice shall be given for such a meeting. In case of a postal ballot, one month's time from the date of posting shall be given for the receipt of replies.

Article 17.

The quorum at the meetings of the National Group will be 15 and for the Managing Committee 25 per cent of the strength of the Committee.

V. GENERAL

Article 18.

The Managing Committee, as defined in Article 9, shall determine the seat of the Society which, for the present, shall be at the same place as the office of the Indian Roads Congress.

Article 19.

In the last month of each calendar year, the National Group will send to the International Association for Bridge & Structural Engineering at Zurich an up to date list of Members and Associate Members with their addresses and professional affiliations. Any amendment to the constitution of the National Group shall also be sent to the Secretary of the International Association at Zurich.

Article 20.

Members or Associate Members of the Society may submit to the Secretary of the National Group each year before the end of June, statements of their activities, if any, in the field of bridge and structural engineering along with brief abstracts of their publications, if any, during the previous calendar year. The scope of this statement is left to the discretion of each member.

Article 21.

The Managing Committee shall prepare a summary of all the statements received, with a view to give a comprehensive picture of the activities in bridge and structural engineering in India during the previous calendar year.

Article 22.

Before the 1st of October each year, the Chairman of the National Group shall send to the Secretary of the Executive Committee of the International Society, 100 copies of the Annual Report of the National Group ; one copy of the Report shall be forwarded at the same time to each Member and two copies to each Associate Member.

Article 23.

A complete set of the International Report, whenever received from the International Society, shall be published by the National Group. If it is in a language other than English it shall be translated into English. One copy of the Report will be sent to each Member and two copies to each Associate Member.

Arrangements for the translation of Papers published by the Association at Zurich written in languages other than English will be made by the National Group.

INDIAN NATIONAL GROUP OF THE INTERNATIONAL ASSOCIATION FOR BRIDGE AND STRUCTURAL ENGINEERING

Application for membership

The *undersigned* *
The undersigned public authority *
association *
firm *
organization *
desires to *join the National Group* of the International Association for Bridge and Structural Engineering as Member/Associate Member and declares his * its * agreement with the statutes of Association.
** *We shall be represented by* _____

Place.....Date.....

Name and Designation.....

Profession .....

Address.....

Signature.

* Cross out the words not applicable.
** Applicable to Associate Members only.

Particulars.

Date of birth.....

Academic qualifications.....

Brief details of professional career with dates .....

Research experience and Papers, if any .....

Membership of other Scientific or Technical Institutions .....

Interests—steel work or reinforced concrete, etc. .....

Special requirements. .....

From my personal knowledge of the applicant and in consideration of his qualifications as stated above, I recommend him as being in every respect a fit and proper person to be admitted to the National Group. } Applicable in case of Members only.

Signature of Supporting member.
(Roll No.)

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

Vol. XXI-Part 4 SHILLONG May 1957

PRESIDENTIAL ADDRESS

The Twenty-First Session of the Indian Roads Congress was held at Shillong from the 11th to the 18th May, 1957, and was formally opened by Shri Bisnuram Medhi, Chief Minister of Assam at 11-00 a. m. on the 12th May, 1957, in the premises of the Assembly Building. The proceedings opened with an Address by Shri P. L. Varma, the President, the full text of which is given below:

It is an honour and a pleasure to me as President of the Indian Roads Congress to extend to you, Sir, our felicitations and gratitude for the honour that you have done us by consenting to open this 21st Indian Roads Congress in your Capital and to welcome you amidst us. To those distinguished guests who have so kindly spared time to join this function, I am also very grateful. Your presence, Sir, I consider a true expression of kindly thoughts towards, what I may term, "the road movement" in the country, a movement which represents one of the basic needs of the people. Our thanks are also due to your Government who have made arrangements for our stay in a munificient manner and have made us comfortable in these lovely surroundings.

Indian Roads Congress

The Indian Roads Congress, Sir, is a technical Society. It is an All-India forum for examining and assessing the needs of road communications, pooling knowledge of construction of roads and bridges, of traffic engineering and of other allied matters, and preparing a road building programme on sound lines. Sir, this is the first institution, if I may say so without appropriating egotistic praise, which, as far back as 14 years ago, was largely instrumental in producing an integrated road plan for the whole of India—known as "The Nagpur Plan." It visualised an integrated development of roads for the whole country at a time when very few among us were ever

conscious of countrywide development, and the word "plan" was practically unknown in India in its present concept. This lead augured well and today we have a certain length of road communications which has served our growing economy, if not satisfactorily, at least to some extent. The dynamic planning activity to build up our economy on a countrywide

The President delivering his Address

scale has been, to a very large extent, possible by the forethought of our forbears. They could successfully project their mind into the future and we record our gratitude to them. I am happy to state that at the end of the first Plan period, the total milage of roads stood at 3,16,668 (1,21,617 metalled and 1,95,051 unmetalled). The target envisaged in the Nagpur Plan was 3,31,000 miles. This is no mean achievement.

Time to Modify Nagpur Plan

I have talked of the Nagpur Plan. It was the first peep into the future of India. It has served as a beaconlight to shape

our road policies. Vast changes are taking place in the country as a result of the rapid development of our economy on all fronts. It is time that we should pause and take stock of the present and future needs. It is time that we should examine policies leading to adequacy of our road system. Various regions of the country are developing on a pattern different from those which the original Plan had visualised. Consequent on the undertaking of river valley projects, the location of new industries, availability of cheap power and large scale irrigation, the problem of road and rail transport has to be tackled from an entirely new concept of regional planning. It means also that new socio-economic factors have to be reckoned with. Demand for communications in the various regions will naturally take a different pattern. The re-orientation of the needs of transport has, to some extent, been examined by the Railways, but when we consider that three-quarters of inland transport in all advanced countries is done by road, we should, without losing any time, take stock of the future regional distribution of population, their needs, and the part that roads will play in fulfilling them. It will be a serious lapse on our part if we allow to develop now a road pattern which will eventually have to be scrapped at least in parts. Industrial zones will want different types of roads and where agricultural economy is predominant, the demand will be of a different type. The Indian Roads Congress needs giving immediate attention to this problem.

Rural Road Plans

This leads me to so-called rural areas. I would term them 'areas of agricultural economy'. There is a movement of rural uplift in the country. It is a dynamic movement. A broad based socialistic pattern of society has been visualised and is being created. It means looking after and nursing the growth of 87 per cent of India's rural population. It means creating rural universities, and rural colleges and execution of various extension schemes. The aim is not only laudable but is obligatory. Even the highly prosperous and industrially advanced nations are seriously taking stock of the weighted development of their society in the city and are making every effort to carry modern civilisation back into the country so as to enrich those who could not so far avail themselves of the advantages of the nation's development.

Mr. Trevor Jones, at one time Chief Engineer of the Punjab, stated, while sending his greetings to me, that I should bring out in my Address the fact that 'civilisation is roads'. If modern civilisation has to be carried right to the last man, the words coming from one who lived 30 years in this country and is now

living in a highly industrialized land, are worth heeding. The Extension Services carrying the best medical facilities to the last man, providing him with educational facilities and broadening his mind and making him feel part of the nation, can only (I emphasise the word, *only*) be done by providing suitable communications to his very door. This communication system must be provided first of all if the aim is to have an all round balanced development. We cannot wait and say it will grow gradually after prosperity has dawned. The cost of the effort that is needed to carry modern amenities to every part of the country without communications will be enormous. Can we afford it? Or, can we afford to wait? The reply is obvious.

Rural Development

I have dealt with the problem of rural communications in the foreground of this Address for various reasons. It is an essential development, but the development is slow and as such it is my duty to point out an objective approach to this problem. What factors should we keep in mind while thinking of our rural communications? Land is scarce. Holdings generally are small. The importance of the bullock in our rural economy may keep the bullock cart on the road for an unlimited long period. Owing to the paucity of finances, maintaining of the roads to a usable standard presents a difficult problem. Obtaining land for road construction is a serious problem. Its acquisition for community purposes without compensating in kind is an extremely difficult process and entails hardships on individuals. These have to be and must be reckoned with. In the Punjab, a very successful attempt of consolidating the holdings and taking the land needed for community purposes including that for roads out of the pool of village land and distributing the remaining on pro-rata basis amongst the landholders, has proved a very valuable approach to the problem. It may be the only approach. It does not involve individual hardship. Small losses or small gains to a community, when shared by all, lose their sharpness. The difficult problem of land acquisition for road communications can thus be solved. A Central model legislation with concurrent powers with the States needs to be enacted.

I will be failing in my duty if I do not acknowledge the enthusiasm that has been evinced by rural people in the rural uplift movement. It is popularly called Shramdan movement. This movement can solve the financial problem of the rural road system to a very large extent. It needs to be rationalized, vitalized, and given an impetus. But I will be equally failing in my duty if, from some of the examples that I have seen, I do not sound a word of caution. Uncoordinated, ill-planned and technically unsound schemes, if executed, may subsquently need serious modification. It may kill the laudable incentive of free gift of one's effort in the form in which it is being given. A few words from this platform may be audible all over India and a large measure of human labour may be diverted into the execution of a more balanced rural communication system which should not need large-scale modifications later on. It is time that those who are in charge of such works should pause for a moment and consider the necessity of obtaining sound technical advice on such matters. Similar uneconomic developments are taking place in other spheres requiring technical advice and skill at the right level, but here I need only refer to rural communications.

Urban Problems

So much for our rural communications; but there are urban problems equally large and equally important. In contrast to the large expansive rural system covering practically the whole of the country, the urban needs are concentrated and are capable of being surveyed and arranged with precision and in detail. A city, however, is no longer a small unit of olden days. Now-a-days, it embraces a region for keeping it alive and vital. We hear of Great London Plan—Greater Delhi and Greater Bombay Plans. Our road policy towards the urban need has been based on chronic poverty idea of local body finances since old times. The pattern of taxation was so evolved that this chronic poverty became a bye-word—and urban population, the elite and the educated, could never think big. Cities became slums. Their communications went down to low levels. Even the Government considers a national Highway passing through a city a local problem. The incoming day-to-day food from the farms, from the fisheries, from the milkmen in the villages, is carried by man-propelled or slow-moving transport on roads designed for fast traffic which was left and is still left uncared for to sort itself out. The street problems of the city are multifarious, more so in India where we have mixed traffic on the roads. Street capacities need to be enlarged but the work has remained unattended for want of funds with the local bodies. Government must need take up the matter of local body finance seriously.

Still there is another, and a much bigger, problem requiring careful thought and decision. The psychology of using self-propelled units by every individual is growing. We should not forget that it takes only 4 sq. ft. of area to seat a person in a cinema or a stadium, but it takes 250 sq. ft. of area to park his conveyance. If in time to come, as it will happen, every one drives his own car to such a place, the problem is not of catering for seating in a recreational place, or in a working organization, or

in a departmental store, but reduces itself to making provision for parking the cars. Should we allow such an individualistic psychology to grow, or should we resist it and create from the very beginning (the disease has just germinated) the habit of using public conveyance by restricting the use of individual cars outside the limits of certain congested areas of the city. We may learn a lesson from the countries who have allowed this psychology to grow and are unable to solve the problem now. Should we not create a society democratic enough which will use for going to work and back, a public conveyance? It will be an act most befitting the socialistic pattern of society. It will stop the blight coming to the central portions of the city. It will save a large amount of human effort in constructing, demolishing, and reconstructing some portions of the city which have given "character" to it. Let us make an experimental beginning anywhere but let us make it immediately. It will be an unpopular experiment but a win lead.

The city communication problem is worth serious study. We should consider our urban plans in relation to the region round a city and within the city think of mass transport. And the last, but the most important aspect, we should think of altering the taxation pattern to obtain finances for the city.

To obtain lasting countrywide results, a thorough study of the three problems mentioned above, viz., regional, rural and urban road communications, is imperative. It needs immediate attention before we get accustomed to forms fixed and rigid when it may be too late to mend. In the perspective depicted above, the Nagpur Plan does need revision. Let us revise it boldly, not basing our solutions of the problems, if I may repeat the word, on the subconscious feeling of chronic poverty. Our so-called poverty, with proper guidance, can be used to enrich our life just as a badly smelling manure in the hands of a good gardener converts itself into the fragrance of the flower.

Execution of the Plan

Assuming our plan stands reconsidered, revised, brought up-to-date and is approved, the prospect of executing it seems to be worth studying with much more intensive thinking than we do now. To implement any plan, there are three basic requirements: (1) adequate finance, (2) efficient and conscientious personnel, and (3) an efficient procedural method where effort to execute is reduced to the minimum, mistakes are eliminated, responsibilities squarely shouldered at various levels in a rising order of hierarchy, and when mistakes are committed they are detected easily. I will deal with these problems in detail.

Finance

The second Five-Year Plan provides for Rs 269.5 crore for road construction, comprising Rs 55 crore for National Highways, Rs 27.5 crore as Central aid to States, Rs 25 crore as Central Roan Fund—representing a part of road-usage taxation, and Rs 162 crore as States' expenditure. Per square mile of area, the road milage in our country is 0.26 as compared to 1.11 in the United States of America, 1.99 in the United Kingdom, and 2.4 in France. Even in this low figure of 0.26, 60 per cent of the roads are unmetalled. This amount of Rs 269.5 crore will add a road milage of 0.05 per square mile only. Is it adequate? Is not this progress extremely slow? If 75 per cent of the inland transport is done by road, are we justified in restricting the road plan to the figures quoted by me? I hear even this target is likely to be reduced. Some of the immediate needs of even National Highways such as the cost of widening them at least to two-lane width and building of bridges on main streams, cannot be met from this amount. Should we not change our policy for financing roads particularly if, from the funds available, there is no chance of appropriating a larger figure?

It may be well to indicate the magnitude of road development required in our country. The target in Nagpur Plan was to have a road system so that no village was more than 5 miles away from a metalled road in a developed area and 20 miles in an undeveloped area. The milage of metalled roads assessed for this purpose was 1,23,000 miles. This target is expected to be reached during the second Plan period. If we now desire to bring all the villages within a distance of 3 miles of a metalled road in developed areas, 9 miles in semi-developed or forest areas, and 20 miles in undeveloped areas, the total length of metalled roads should be 3,20,000 miles. The cost of such road system with corresponding development of unmetalled roads would be something like Rs 4,000 crore. The total provision for road development in the second Plan is Rs 269.5 crore. At this rate, we shall need 75 years to attain the proposed target. Even then we shall have a road system at the rate of 0.5 mile per square mile of area against the figure of 1.99 of Great Britain and 2.4 of France. The need for greater allocation of funds for road development cannot, therefore, be over emphasised.

If finance are scarce and there is no help, we might think of other avenues. Road construction bonds redeemable after a fixed number of years and guaranteed by the State can be projected. Road user taxation can be directly or indirectly earmarked exclusively for road development only. These methods were stressed at some length by my predecessor last year. The inadequate

provision of funds for road development reflects in heavier transport costs. The saving will be of the order of 25 per cent.

The other advantages resulting from good communications which act as High Transmission lines of transport of civilisation into the country cannot be evaluated in terms of rupees and pice, but that they are very considerable cannot be denied.

Funds should be guaranteed on a long term basis. Recently, the United States of America have, in 1956, approved a 13-year programme to be followed after 1970 by a 10-year programme with guaranteed funds. The road financing policy followed so far on a halting day-to-day budgeting has proved inadequate for a continuous road programme. Adequate funds on long range basis have to be guaranteed if good road communications are to be obtained.

Apart from the funds for construction, the highway departments should be permitted to utilise one to two per cent of the funds in any plan for preparing the future projects. Collection of data for the plans of the future is very important. Fact finding surveys are indispensable for correct planning. The advantage is that in the subsequent development of the road needs in the 3rd, 4th and 5th Five-Year Plans, a correct and a realistic picture could be projected. Such a fact finding organization will require training and it will take time to evolve. The Centre and the States both need such an organization. I have stressed this point particularly because any organization which does not appear to produce immediate results is looked upon as unnecessary. The statistical sections of this type will not only collect facts and figures for future planning but will assist the administration in checking performance.

Personnel

Regarding the second point, the personnel required for execution is a real bottleneck. Trained engineers are not available to the extent that the country's needs demand. I suggest that at least on the road construction the need can be satisfied by taking off a percentage of the engineering students from various institutions and after a short detailed instruction course putting them in the field. The practical side of the engineering can be picked up by them with a certain amount of basic training without difficulty. After 2 to 3 years, each of these young men can be reverted to the college for completing his studies. I feel that for certain types of mind this sort of course will greatly help in making them sound engineers.

Procedure and Administration

The third is the most important problem. With assured finance and even a competent staff in the field, the procedure which is adopted for carrying on works is so faulty that achievements are slow and poor compared with the efforts put in. We are conscious that the Government is alive to this problem since it appointed Mr. Appleby to go into the organizational aspect of this problem. It will not be out of place to quote verbatim from this authority. The faults are so obvious that even a study of a few months by an outsider has brought them out. He says :

"The relationship between persons in the secretariat and persons in the "technical services" is too rigidly remote. It is true that one of the great virtues of the Indian system is the emphasis placed on "generalist" qualifications for officials in top positions. But there is no single source of generalist personnel, no single formula for developing them. Some persons with technical background become competent generalists. Others are capable of transformation into generalists by a diversification of their experience, and some persons put through the experience conventional for preparation of generalists never develop any real capacity for high-level performance. Even some persons in business or in the universities can qualify rather quickly for high level generalist posts. Conversely, top level governmental generalists often can be admirable heads of technical or industrial organizations. The persons capable of serving well at high levels are rare birds ; they must be sought wherever they may be found, and developed by various means.

"The very word 'administration' here is too narrowly conceived as relating to financial administration and personnel administration coupled somewhat vaguely with other functions of the secretariat. Administration is basically the conduct of programmes important to citizens and to the nation; fiscal administration and personnel administration are merely aspects of the general management of a variety of programmes. Administration here seriously needs a much more marked orientation to the conduct of programme, because 'administration' here is by and large negative. The system of personnel arrangement and personnel management contributes importantly to this bad condition."

It has, however, not been possible to implement these suggestions. Administration is run on old lines. Technical services are as remote from Government and, if I may say, more remote than even in olden days. The result is what we see.

There is another and a more vital factor—the procedure laid down for regulating the execution of road works. Suitable

alteration in the procedure to meet the conditions created by the demand for highly accelerated progress is necessary. Modification of the outmoded administrative outlook is called for. Frustration following in the wake of poor results despite herculian efforts has to be avoided. New incentive studies are to be made. Such factors leading to indirect losses are many times more than the various committees can be expected to fathom. It is time that national effort (which is not sufficient to cope with the work) should be utilized fully and not at a fraction of the efficiency as at present. The mill-stone of tradition in procedure is hanging round our necks and only allows us to walk at a time when we should be running fast. Balanced delegation of powers, fixing responsibility at all levels, and taking serious note of lapses is the immediate need of the country. Recently, the Prime Minister, speaking at the Institute of Public Administration, stated that only those nations grow who can adjust themselves to changing conditions. His vision sees the faults. Let us eradicate these.

The bottlenecks take the form of sanctions for personnel which lag very much behind. There are abnormal delays in obtaining such sanctions. Further delays occur in obtaining persons from the market. The rules for purchasing of tools for construction have to be streamlined.

Three-Year Programme

Another aspect of this problem of procedure, which is important, is detailed planning. It is distinct from the broad planning and fact finding unit mentioned earlier. I have voiced it before at another place, but it applies very forcibly to road development. In any working year, there should be with the department concerned a programme under execution and a completely technically and financially approved programme for the next year, and planning of the third year programme should be in hand to be sanctioned in the following year. The process is to be repeated every year. This procedure will ensure sound and considered schemes both technically and financially. The distinct advantage of this procedure would be a better control on the technical and financial side. No last minute projects will be rushed through. The thoughtlessness that is found in certain schemes will be eliminated. Well considered, balanced and thoroughly examined schemes will emerge. Hurry which at the present moment retards speed will be eliminated. There will be less work for Audit, less work for Public Accounts Committees and less waste of public funds. At present, the builder is frustrated because he is not able to build well; the user is frustrated because he thinks that he has not got full value for his money; and the Government is not satisfied because of their not being

able to prove to the public that they made the best use of the nation's money. There is no other way, as far as I can see, which can be devised to eliminate the present chaotic procedural conditions which are frustrating all concerned, particularly the younger generation whose initiative is being sapped at the very start.

I cannot over emphasise the immediate need of Government eliminating the devitalising factor of carrying on works under present conditions. I hope they will take notice of this factor.

Landscaping

Now, I pass on to another aspect which is technical, but has an aesthetic bearing. It is not the duty of a Road Engineer only to build roads; his technical contribution should not be confined to providing smooth and safe roads. He must create road environments which contribute substantially to pleasant road journeys. Somehow or other, in the last 150 years this aspect has not received any consideration. As our ideas are based on immediate and, if I may say, cash economy effects, we let borrow pits be made next to our embankments. They permit not only water to stagnate but at the same time, reduce the stability of the road. The surrounds become unhealthy and a source of malaria. Instead of beautifying the surrounds of the approach of a bridge across a large canal or river and landscaping it and making it a beauty spot which being easily accessible by road may serve as a recreation place, we convert the surrounds into marshes with undergrowth of reeds, brambles and bushes, and make them into places to be shunned rather than sought after. Landscaping of highways is not planting of roadside trees. It is the creation of environment along the road which are peaceful, aesthetically satisfying and make journey along the road pleasant less fatiguing, and interesting. Every highway engineer's office should have properly trained landscape architect attached to it. Sooner or later, the society will revolt against the poor surrounds of a road, but the cost of restoration of the damages done will be out of proportion to that spent on executing the work now. Landscaping is a slow process. It takes years to bring nature into a form that will prove satisfying. This neglect of the surrounds of roads to my mind, is unsocial, and sooner a beginning is made to arrest it the better it will be. I am certain that such a proposal will be decried as luxury and something unproductive, as something that can be dispensed with, as something which is not development, and as something which will finally be termed unnecessary, or at best, capable of being postponed. It is for us in the Roads Congress to examine this aspect of road development and provide for it in all the estimates that

have to be sanctioned. As I project my mind in the future, I see these roads growing not only as arteries of traffic but providing journey of lasting memories. Let us lose no time in making a beginning of building aesthetic into our roads.

Research

Touching on another technical aspect of the road projects, I have to emphasise the need for a large scale utilization of our research results.

The Indian Road Congress has, through its various committees, been very keenly fostering research work on highway problems in the country. It has played an unusually important part in getting the Central Road Research Institute set up as a national laboratory under the Council of Scientific and Industrial Research. A good deal of work is being done in this Institute and other Institutes in the States with the objective of making the execution of road works in the 5-year Plans and the future plans efficient and economical. But there are still several States which do not possess road laboratories. It is essential that such laboratories are set up in all the States as soon as possible. The Indian Roads Congress will assist in collaborating with the State laboratories and the Central Road Research Institute on problems of common interest and investigations on any particular local problems.

Application of the results of research is normally a slow process. It gets sometimes a spurt under conditions of wartime stress or in industrial ventures in which cases strong motives operate. We will be constructing the bulk of our road programme in the next 10 to 15 years. How important it is that the results of research obtained in this country and also in other countries should be made applicable to this heavy programme of construction. May be that in time to come with large resources of atomic energy where high temperatures can be obtained it may be possible to simply bake the earth crust to certain width and grades to form roads.

Funds for research work are generally not sufficient. Laboratory conclusions cannot be applied in the field on a large scale and without experiments under working conditions. It being experimental stage, a certain amount of risk is involved and, under the present conditions, even experimental failures come up for an unusual type of public criticism. The initiative in applying the research to field construction is deteriorating. We have to arrest this tendency at all costs. Probably, out of construction funds we should create Road Research Fund. It will put road research work beyond the pale of day-to-day problem of budgeting; the irksome and frustrating task of making a convincing case for each research project and its application under field conditions. A high-powered committee of the Indian Roads Congress would help the various Governments in organizing this fund and by providing such expert committees out of their membership which, as we all know, embraces the entire road engineering talent of the country.

Under the auspices of the Road Research Division, there will be a special session this year to examine and coordinate road research in India. I hope that as at Nagpur, the country's road plan came to be associated with that city, the research programme in future will be associated with Shillong and will become the basis of our research projects.

I have gone in brief into the question of the necessity of revising our Nagpur Plan, and revising our ideas of rural and urban development plans. I have also discussed the question of finance and the elimination of bottlenecks of serious nature that prove to be impediments to the execution of the plans. I have touched upon the question of personnel and how it can be made available. I have suggested a continuous 3-year programme to be on the table of each engineer. I have emphasised the need for research and the manner in which funds can be provided for research work.

Reading through the Addresses of the past Presidents, I find that suggestions are made every year but they do not find any implementation and that, in certain cases, they are not even considered. I hope that some machinery can be devised in which the suggestions made by the various independent institutions in India are objectively considered by Government, without which our institutions will lose their dynamic thinking.

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

INAUGURAL ADDRESS *

by

SHRI SAIYID FAZL ALI,

Governor, Assam

Ladies and Gentlemen,

I was keenly looking forward to the pleasure and privilege of being present at the opening of this Session of the Roads Congress and of being able to extend my personal welcome to the distinguished delegates assembled here from all parts of the country. Since however, to my deep regret, this has not proved possible, I must content myself with the expression of my earnest solicitude for the success of your deliberations on a subject which is so vital for the progress of our country.

Shillong by virtue of its scenic beauty and salubrious climate can well claim to be the queen of the hill stations of India. Delegates to this Congress could not have failed to notice the picturesque, though tortuous, ascent to this bracing plateau which rises to an altitude of about 5,000 feet above the sea level. With your expert vision, I am sure that you must have been able to discern with greater technical comprehension than an average layman the nature of the obstacles and limitations which must be overcome in order to open up road communications in these parts. The magnitude of the achievement in connecting Shillong with other parts of the State is, however, evident even to the eye of the layman and is equally clear that this is an achievement which is fully matched by the importance of the link that has been forged. Road Transport is of far greater importance for Shillong than it is for any other State capital in India, for unlike other State capitals Shillong has not the advantage of any alternative means of transport like river, rail or air and has to rely exclusively upon the road transport for everything.

The importance of roads has been recognised throughout history and there is nothing surprising in the fact that those who built the great Empires of the past were also the greatest pioneers in road-building. Roads were vital for the consolidation, maintenance and expansion of these Empires. The Romans were perhaps the greatest road builders of the past and their success in maintaining their vast Empire for as long as they did was largely due to their net-work of excellently maintained roads. In those

* Owing to the un-avoidable absence of the Governor of Assam, his Address was read by the Chief Engineer, P.W.D., B. & R., Assam.

Shri B. Choudhury, Chief Engineer, P.W.D., Assam reading out the Address of the Governor of Assam

days it was literally true that all roads led to Rome, for the only permanent and usable roads at that time were those which were due to the pioneering efforts of the Romans. In our country, all the great Kings and Emperors of the past were fully alive to the importance of connecting various parts of their domains with their capitals through an efficient system of roads. The Grand Trunk Road which is yet maintained as one of the most important artery of communications in Northern India was built centuries ago. Despite the growth of alternative means of transport, such as rail, river and air transport, in the intervening period, the Grand Trunk Road remains a vital link in our country's network of transport and communications. This is so because the road transport has advantages which are of its own. These advantages are intrinsic and unique and they are of such a nature that they are indispensable to a country like ours, with limited financial resources and vast distances to negotiate. They are particularly indispensable in this period of our development when we are most anxious to open up new avenues of economic growth and prosperity. One might even venture to say that at least in the foreseeable future there is no chance of road transport yielding its importance or being displaced by other media of

transport, no matter how high a stage of development these newer media might achieve. Road transport might not be as cheap as the river transport, but it is certainly much quicker and has a great extensive range than the river transport. It might be neither as cheap in the long run, nor as swift as the rail transport, but it can be opened up more quickly and at a fraction of the initial cost of the latter. It can also reach out to points where rail transport can never hope to find access. It might be neither as swift nor as far-reaching as the air transport, but it provides an incomparably cheaper means for the continuous movement of commodities in bulk.

In our pre-independence days, the road system under the British grew up largely, if not mainly, in response to the needs of a strategy or administration. Since independence however the direction and extent of our road planning has been much influenced by the need for promoting our economic development. It has been increasingly felt that if the country has to progress and if the standard of living of our people is to be raised, road development too must be planned in such a manner as to enable us to use fully our national resources in a balanced and co-ordinated manner, bringing the desired results in the shortest possible time. At about the time of Indepedence Assam had only 2,610 miles of motorable roads including 899.8 miles of national highways. Of these, 2,040 miles were in the plains districts and 570 miles in the hills.

According to the Grid and Star formula, evolved in the Chief Engineers' Conference held in Nagpur in 1943, Assam's requirements of motorable roads including national highways was fixed at 13,200 miles. On attaining of Independence, shortage of road length in Assam was keenly felt and a programme was drawn up in the post-war plan for augmenting our road milage. But unfortunately this programme had to be dropped even before it got half way through for want of financial assistance from the Centre. Subsequently, the development of road communications in the State virtually came to a standstill until the First Five Year Plan took shape. On the completion of the Second Plan, a further length of 1,872 miles of new roads will be added to the existing length bringing the total to 8,668 miles. The Second Plan emphasises improvement and stabilisation of the existing roads in order that these might be able to stand up to heavier traffic rather than the building of new roads. Further 16 bridges of total 5,400 feet in length have also been taken up under the Second Five Year Plan.

But considering the total road needs of Assam, even the programme of expansion as outlined in the Second Plan can hardly be said to be adequate. Unfortunately this is a State where roads

are subject to have wrought by the elemental forces of floods and earthquakes. The Assam rail link is apt to be disrupted by floods and for several months in the year it happens that the traffic must be either reduced or suspended. Within the State, we have also many turbulent rivers which cause widespread flooding and breaching of roads at many points every year. Inaccessible but important places in the hills too need to be linked up by a net-work of all-weather roads. As such the need for better and more stable roads in Assam can be hardly over-emphasised. We must have roads which must prove capable of withstanding the fury of the elements but which at the same time should not be beyond our means.

I would like to take this opportunity of expressing the importance of road development not only in Assam but also in the entire submontane Northern region of India, stretching from Assam to Kashmir. A net-work of roads facilitating easy transport in this region is considered to be of great national importance from the point of strategy and security. In this connection I cannot do better but to quote from the address delivered by Shri Chandulal Trivedi, Governor of Punjab, at the 16th Session of the Indian Roads Congress held at Simla in April 1952 :—" To Napoleon," he said, " is attributed the saying that an army marches on its stomach. It would be perhaps equally true to say that in war a nation marches to victory and in peace to progress mainly on its communications of which roads are very important elements."

Founded by Sir Kenneth Mitchel in 1934, the Indian Roads Congress has grown in strength and importance and to-day it provides a forum where road engineers from all over India and elsewhere can regularly get together to exchange views, share experiences, formulate opinions and generally tender expert advice to Government on how to plan our road development to serve our mighty national projects as well as our security.

Confronted with problems of such magnitude I need hardly stress that economy in construction and design assumes foremost importance. It is particularly in this regard that the opinion and advice of experts can be of greatest value. I am tempted to quote again from the speech of Shri Chandulal Trivedi on the question of economy without being understood that I necessarily endorse the view expressed therein. " Might I ", he observed, " voice the feeling that I have come across that an engineer is sometimes, if not often, a man who can do for Re 1-8-0 what an ordinary man with commonsense can do for himself for Re 1." The distinguished persons who are here would better be able to assess whether and to what extent such a feeling might yet

prevail and I am sure that as responsible experts they will do their best to remove any impression of this nature. Of course, it is true that costs are high and with the increasing tempo of our national economy they might even tend to rise, but by the exercise of a little initiative in the judicious use of the local available materials without detriment to quality and if possible enlisting some measure of voluntary offer from the people in the locality, it should not be impossible to effect some economy in what is undoubtedly a costly venture.

I do not propose to take more of your time and I will now conclude with my best wishes for the success of your deliberations.

ADDRESS OF

SHRI BISNURAM MEDHI,

Chief Minister, Assam

Mr. President, delegates to the Indian Roads Congress and ladies and gentlemen,

I am happy to welcome you all today to Assam amidst the charming scenery and inspiring surroundings of this beautiful hill station of ours. I, on behalf of myself, my colleagues in the Government and the people of Assam, thank you for holding the present session of your Congress in this State. I do hope your stay here will be pleasant and comfortable and you will carry happy memories of your stay here in this beautiful hill station and our problem State.

Assam, situated on the North-East corner of our country has problems peculiar to her own. Heavy rainfall, frequent floods and earthquake often cause devastations which our Engineers have to face both during construction as well as maintenance. I hope the deliberations of your Congress will help to a great extent in solving our problems and in the reconstruction of the country.

Economic prosperity of a country depends to a great extent on improvement and construction of a network of roads. In order to achieve an all round improvement, it is essential first to have a good system of road communications. Apart from national economy and other social benefits, we have to consider the question of defence as well.

For the purpose a well developed and properly planned system of roads is an essential pre-requisite. It has a special significance to Assam, as we do not possess adequate railway facilities, and also due to our peculiar and strategic situation having a very long length of international boundary. Road Engineers have, therefore, a great responsibility in this respect.

In any programme of road development, the cost of construction is a very important consideration. Our funds for development being limited, it is for the Road Engineers to evolve methods for construction of low cost roads. Some research is obviously needed in this direction. I hope Road Engineers from all over the country who have assembled here to-day, will certainly give a serious thought over this matter of construction of low cost roads. In some of the hill areas, where we have started construction of roads, we find difficulty in getting hard stone for construction of all-weather roads and carriage of such

The Chief Minister delivering his Speech

materials becomes expensive. It is up to you to see how roads could be economically constructed in these hill areas also.

With regard to the State of Assam as also for the whole of the country, the milage of roads per square mile of land area and per head of population is much lower than those in other advanced countries. Most of our important villages are not connected by road and some even are away from any motorable road by 10 miles or over. Under the Second Five Year Plan, we have in Assam a programme for construction and improvement of about 2,000 miles of roads, which will bring up the total of road mileage within the State to 8,900 approximately as against the target of 13,200 miles recommended under the Nagpur Plan. Similar is also perhaps the position in other States of the Republic. Planned efforts to increase our road communications are, therefore, essential.

There is a general complaint from the Public about the inefficiency of the Administration and also delay in execution of projects in various Departments of the Government. Now, that you have all gathered here for technical deliberations, you might also discuss and suggest ways and means for general improvement in these regards and how to speed up the work and economy can be effected. I know, the Indian Roads Congress, during its brief span of existence for about 24 years has rendered yeoman service in the matter of research and laying down of standard specification for roads is our country. With the advent of the 5-Year Plans, highway engineering has become more and more important and construction work has accelerated a great deal.

The responsibility and duty of the Engineers have increased very considerably, but the dearth of technically qualified men has been a great handicap, and this greatly impeded the progress of work.

In Assam, particularly Engineering Institutes came into being after independence and even then much remains to be achieved in the standard of teaching. We have to depend a lot on Engineers recruited from outside the State as the requisite number of such persons is not available whithin Assam. In the matter of smooth and speedy execution of the various projects under 5-Year Plans, dearth of technically qualified persons has proved to be a formidable hurdle to overcome in our State. Nonetheless, we have been trying to push forward our various developmental work and I am proud to say that the success so far achieved is very encouraging.

I am particularly happy to note that as a result of this session of the Indian Roads Congress and your esteemed visit to our State, engineers of Assam will get many experiences and by your valued suggestions, they would be able to carry ahead their various constructional work with success.

I do not like to speak here at length. I accord you all a hearty welcome to Assam and fervently hope that your deliberations under the charming and refreshing atmosphere of Shillong would be fruitful.

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.

The Rajyapal in his Address has laid emphasis on the need for better road communications for the hilly regions subjected as they are to the fury of the elements which are beyond our means to control. The Congress has from time to time been focussing attention on this problem. Only yesterday, the Bridges Committee of the Congress discussed the question of revising the Bridge Code keeping in view the elemental forces of floods and earthquakes.

The Congress also appreciate what the Rajyapal has stated about the necessity for economy in design and construction. May I say, Sir, that the engineer does not claim to buy the materials at half the market rates or to pay his workers half the normal wages. At the same time he should not make substandard works under pressure of subconscious suggestion based on chronic poverty of India. What he should do, and generally does, is to so design and construct his structures that the minimum of labour and materials are used but at the same time structures become the wealth of the nation to serve their purpose and to endure.*

You, Sir, have complained about the inefficiency of the department and the delays. We are conscious of them. I have dealt with all that goes to reduce our efficiency and cause delays. We are, Sir, asked to mend a pencil with a blunt knife. When we ask for a good knife we are denied one. How to produce the desired efficiency under these circumstances? We want reorientation of outlook completely towards the engineer. His capacity is there. Let us change his 'Tools.'

May I now request you to announce the names of Authors of the following Paper which has been commended.

Paper No. 180— "Stabilised Soil Construction in the Formation of Tuticorin-Tiruchendur Road."

E. C. Chandrasekharan &
T. S. Chandrasekhar.

[*Subsequent correspondence exchanged on the subject is also published in the following pages—*Ed.*]

Copy of D. O. letter No. IRC 5(2)/57 dated 17-5-1957 from Shri M. S. Bisht, President, Indian Roads Congress, Camp Shillong to Shri T. S. Krishnamurti, Private Secretary to the Governor of Assam, Govt. House, Shillong.

The engineers assembled for the 21st Session of the Indian Roads Congress are very grateful to His Excellency for the encouraging Address delivered at the inauguration of the Session. However, they feel concerned over the quotation from the speech of Shri Chandulal Trivedi that "an engineer is some time, if not often, a man who can do for Rupee one and annas eight what an ordinary man with commonsense can do for Rupee one." Perhaps it was His Excellency's intention that the engineers are playing for safety and designing structures which are over-safe and that, in the present circumstances, a more economic approach would yield equally good results. In this connection, it is admitted that structures are built with a view to endurance and that accounts for somewhat higher costs. If this be His Excellency's intention, then we may be permitted to state so in an explanatory note when we publish the speech in the journals of the Indian Roads Congress.

This letter may kindly be placed before His Excellency.

Copy of D. O. letter No. PSG/1/57 dated 24-5-57 from Shri T. S. Krishnamurti, Private Secretary to the Governor of Assam, Raj Bhavan, Shillong to Shri M. S. Bisht, President, Indian Roads Congress, Jamnagar House, Shahjahan Road, New Delhi-2.

With reference to your letter No. IRC-5(2)/57 dated 17th May 1957, I am desired by His Excellency the Governor to state that the remark in question which was quoted from the previous speech of Shri Chandulal Trivedi was not meant to cast any kind of reflection on the work of the Engineers but as the sentences which followed the quotation would show, it was meant to draw the attention of the delegates to a remark which had to be taken note of and to ask them to assess whether the impression to which Shri Chandulal Trivedi had referred still prevailed and if so, in what way it could be met or removed. What you have suggested in your letter is certainly one of the explanations for the high cost and if, as you say, a more economic approach could be made to yield equally good results, the impression should be capable of being easily removed. His Excellency appreciates your letter and hopes that the Roads Congress would continue to flourish under your guidance.

SPEECH

by

SHRI BISNURAM MEDHI,

Chief Minister of Assam at the opening of the Exhibition

Friends, I thank you for the honour you have bestowed on me by requesting me to open the Exhibition held in connection with the Twenty-first session of the Indian Road Congress. Roads are the life-line of progress and necessity and urgency of more and more roads in this strategic part of India cannot be over-emphasized. I am sure, your fruitful deliberations and lessons obtained from this exhibition will go a great way in achieving the goal you have in view.

An exhibition of this kind is something new in this part of India. The Indian Roads Congress has been held for the first time in this State. I take this opportunity of welcoming you all to Assam.

The Chief Minister delivering his Speech

A good communication system is a condition precedent for a country's development. In our country, digging of wells,

planting of trees, building of roads and rest houses had always been regarded as a great virtue since ancient times. Even then India does not have the required length of roads till today. The road milage per one lakh persons in India is 89, and that per square mile is. 22. A progressive transport system is wholly dependent on a chain of good roads. In India there are 88 vehicles for about a lakh of people. This figure is very low in comparison with other countries. In the United Kingdom, for every one lakh of people there are about 7,000 vehicles. A more efficient network of roads would encourage more use of automobiles and it would, in turn, foster better trade and commerce in the country.

Assam is very undeveloped in the matter of communications. I need hardly emphasize that Assam is one of the most backward States in India in so far as transport and communications are concerned. Nearly two-thirds of Assam are hilly region, where communications are still in the undeveloped condition. Transport in the hill areas needs a great deal of improvement. Distances in some parts of these hills are measured not in terms of miles or metres, but in terms of walking days.

Assam is a border State surrounded almost on all sides by foreign territories. It is linked up with the rest of the country by a narrow strip of land through the Sub-Himalayan region. Railway communication connecting Assam with the rest of the country is also not adequate. The communication and transport problems have been accentuated greatly after the partition of the country. The people living in the border areas of Assam and East Pakistan have been facing great difficulties for want of roads. Their economy, which is entirely dependent on their cash crops, has been thrown out of gear due to loss of market in Pakistan and want of roads to the nearest markets in Assam. With the attainment of independence, we have given topmost priority to building of roads particularly in hill areas. Road construction in hills is a tough job, but I am glad to find that despite tremendous odds, we are making a great headway in this respect. In this context, therefore, development of road communication in Assam has assumed very great importance. At the dawn of independence, Assam had only 2,610 miles of motorable roads, including about 900 miles of national highways. Of these, 2,040 miles were in the plains districts, while the rest in the hill districts.

The Nagpur Plan of 1943, evolved at a conference of State Chief Engineers, recommended the increase of Indian Union's road milage to 3,85,000, of which 2,90,000 miles would be motorable. This means that the net increase envisaged in the Nagpur Plan works out at 50 per cent.

According to the Nagpur Plan, Assam's requirement of motorable roads, including National Highways was fixed at 13,200 miles. Under the Post-War Reconstruction programme, a vigorous road making scheme was taken up, but that had to be abandoned half-way, as Central assistance was suspended.

Under the First Five-Year Plan, therefore, a bold road development programme was taken up in Assam.

One thousand, three hundred and seventy-three miles of roads and 4,300 running feet of major bridges were included under the general plan. The estimated cost was Rs 432 lakhs, and the target of expenditure fixed was Rs 265 lakhs within the Plan period. The target of expenditure achieved at the end of the Plan period was, however, 262 lakhs. The balance was carried over to the Second Plan as spill over.

For the Autonomous, Hill Districts, 625 miles of roads were envisaged to be constructed with Central assistance under Article 275. The estimated cost was Rs 342 lakhs, and the target of expenditure fixed at Rs 256 lakhs within the Plan period. The target achieved was, however, Rs 184 lakhs and the balance carried over to the Second Plan as spill over. The target could not be achieved in full, due to various bottlenecks, the main being the shortage of labour and non-availability of bridging materials from outside the State.

In the Plain Tribal areas, 82 miles of roads were included under this programme at an estimated cost of Rs 26.8 lakhs. Rupees 16.8 lakhs were spent during the Plan period and the balance carried over to the next Plan.

Besides those projects envisaged under the First Five-Year Plan, there were also a number of other schemes for road construction from funds available from the Government of India under various grants-in-aid.

With roads, comes the question of bridges. We have in Assam 321 major bridges totalling about 58,500 running feet. Many of the streams and rivers are yet unbridged and there are 105 boat ferries, which present a serious bottleneck to the free movement of road traffic. Priority had, therefore, been attached to the construction of bridges during the First Five-Year Plan period. Total length of bridging taken up under different programmes approximated 11,615 running feet at an estimated cost of about Rs 26.6 lakhs. Of these, the Barak Bridge at Silchar, has a special feature worth mentioning. The total length of the bridge will be 720 feet with a free board of 30.09 feet for allowing steam vessels to pass during high floods. The central span will be a 400 feet suspended span, self anchored.

In the Second Five-Year Plan, a gigantic road development scheme has been envisaged, at a total cost of Rs 1,185.84 lakhs. This amount will be spent on implementation of general state level schemes and schems undertaken with funds available from grants obtainable from the Government of India under Article 275 of the Constitution.

On completion of the Second Plan, a length of 1,872 miles will be added to the existing road milage in Assam, bringing the total to 8,499 miles. In the Second Plan, much stress has been laid to improve the existing road where traffic is developing considerably, rather than adding to the length.

An additional programme of Rs 38.0 lakhs is being selected for new road schemes, under Article 275 in the Hill Areas. This will bring the total road length to about 8,668 miles by the end of Second Five-Year Plan.

Sixteen bridges totalling about 5,400 ft in length had been taken up under the Second Five-Year Plan.

Friends, I have already taken a long time. My aim in speaking before you all about Assam's road needs and the programmes of development is to draw your attention to the problems of Assam and to give you an idea as to how the State Government desire to solve them. I am happy that for the first time Assam has been able to play host to such a distinguished gathering as the Indian Road Congress delegates. I also hope that your deliberations would help our Engineers to carry ahead our various road construction projects and flood protection measures.

With these words, I declare the exhibition open.

JAI HIND.

MESSAGES

to

the Twenty-first Session of

The Indian Roads Congress

held at Shillong from the 11th to the 18th May, 1957.

Shri Jawaharlal Nehru,

Prime Minister of India.

I send my good wishes to the Annual Session of the Indian Roads Congress. I am glad this is being held at Shillong, because the improvement of communications is perhaps more important in the hill regions of India than in any other part of the country.

Shri C. P. N. Singh,

Governor of the Punjab.

I am very happy to learn that the Indian Roads Congress is holding its next Annual Session at Shillong shortly. Roads form one of the most important features of our development plans. In a way, they symbolise the march of India. The old interior is being rapidly linked up and everywhere the people are coming out of their age-old shells.

It is but proper that an activity of this kind should be backed up by scientific study and thorough research work. The Indian Roads Congress can serve that purpose. The venue of the present session is especially significant for the implementation of the roads programme. I wish the delegates all success.

Shri Raj Bahadur,

Minister for shipping, Government of India.

It is a great pleasure for me to send my greetings and good wishes to the distinguished delegates and engineers gathering at Shillong from all corners of the country for the 21st Session of the Indian Roads Congress.

To carry our country forward on the onward march of progress, we have to exted our road-communications to its remotest corners and link up its farthest village and hamlet with what is termed as "modern civilisation."

The success achieved by the nation for the implementation of the First Five-Year Plan and the launching of a much more ambitious Second Plan have released an un-precedented wave of enthusiasm and energy in our people for all developmental activities and programmes. This enthusiasm has found expression in the execution and completion of numerous works of construction, major and minor, by voluntary labour organised under the Shramdan movement. May I, therefore, suggest that the Congress while considering the problem of development of rural communications, especially the construction of feeder and approach roads to our villages, may consider the possibility of harnessing this enthusiasm in our people and capitalise it for accelerating and augmenting the pace and extent of our road-construction programmes and schemes.

The expansion of our industries and our programme of rural reconstruction must be harmonized and synchronized to avoid possible hazards of lop-sided development of our economy.

The extent of development of road-communications provides a safe barometer for measuring the growth and progress of a nation. Keeping in view the present level of development of our road system, we cannot but be conscious of the supreme need to grow in size—and grow at a much greater speed—to measure up-to the stature and standard of other advanced countries.

The advice of the Congress, which represents the cross-section or even the cream of our engineers and experts in this field, will undoubtedly be of immense value, both to the Central and State Governments in our country. I wish the Congress the best of success in its deliberations and results.

Shri K. Santhanam,

Chairman, Finance Commission, Government of India.

During the past one year, I have travelled along the roads of almost every State in India. While in many places I was pleased to find the roads maintained in a good condition, I regret to say that in other places the road-maintenance leaves much to be desired. I am rather concerned that there should be a large programme of road building without adequate provision for maintaining even the existing roads in good condition. I hope the Session will consider ways and means of ensuring a minimum standard of maintenance throughout the country.

Sir Kenneth Mitchell, Past President, I. R. C.

Once again I thank you for your invitation to the 21st Session of the Indian Roads Congress. I fear that I have delayed replying to it until the last day of the Session and can only hope that it was as successful as usual.

The main reason for my delay in replying is that I wanted to look out and send you some old photographs on road conditions in Assam which I collected at the time of the Jayakar Committee. One in particular I remember was labelled " Assam Trunk Road, 1924." It showed a small car down to its axles in mud being towed by an elephant. Also they are locked away in some box and could not find them.

I always hope that someday somehow I shall be able to attend. Thank you for asking me.

Shri G. M. McKelvie, Past President, I. R. C.

Again I have to say I am very sorry I shall not be able to attend but I take this opportunity to send my greetings to my many old friends and to wish you all a very successful meeting.

The Papers to be read at this session seem particularly valuable and I sincerely wish I were with you all again to listen to words of wisdom from pundits and to partake of the good fellowship which is a particular feature of these occasions.

Long may the I. R. C. continue to do its good work.

Messages for the success of the Session have also been received from :

(i) American Society of Civil Engineers ;
(ii) The Institution of Engineers, Australia ;
(iii) American Road Builders Association ;
(iv) Japan Society of Civil Engineers ;
(v) The Road Research Laboratory, Harmondsworth, U. K.;
(vi) The Highway Research Board, U. S. A.;
(vii) The Institution of Civil Engineers, London ;
(viii) The Bureau of Public Roads, U. S. A.

THE INDIAN ROADS CONGRESS
21st SESSION—SHILLONG—MAY 1957

At the invitation of the Govt. of Assam, the Indian Roads Congress held its 21st Session at Shillong.

Due to the unavoidable absence of Shri Saiyid Fazl Ali the Governor of Assam, his Address was read by the Chief Engineer, Public Works Department, Assam. Shri Bisnuram Medhi, Chief Minister of Assam also addressed the Session. Shri P. L. Varma, Member, Union Public Service Commission delivered the Presidential Address. Shri Y. Guyon, Consulting Engineer, Paris and an eminent authority on prestressed concrete attended the Session. Besides reading a Paper on Indian Bridges he gave the benefit of his advice to the Committees of the Congress. Shri J. C. Macgregor and Shri Van Dyke attended the Session as representatives of the Institution of Civil Engineers, London and Bureau of Public Roads, U.S.A. respectively.

Messages of goodwill from Shri Jawaharlal Nehru, Prime Minister of India, Shri C. P. N. Singh, Governor of the Punjab, Shri Raj Bahadur, Minister for Shipping, Govt. of India and several others, were received.

Ten Papers were discussed. For the first time a general report of Road Research in India was discussed. A Panel discussion on Use of Soil in Cheap All-weather Road Construction was arranged.

The Paper " Stabilized Soil Construction in the Formation of Tuticorin-Tiruchendur Road, by E. C. Chandrasekharan and T. S. Chandrasekhar " read at the 20th Session of the Congress held at Nagpur was commended.

There was the usual round of technical activities. The Specifications and Standards Committee, the Bridges Committee, the Research Organization Division, the Education Subcommittee, the Soil Research Subcommittee, the Manufacture of Road-Making Machinery & Mechanization Subcommittee, the Road Transport Development Committee, and the Road Transport Operation Cost Committee met and discussed various technical problems during the Session. The Council held its 48th and 49th meetings. At the 49th meeting held on the 16th May, Shri M. S. Bisht, Chief Engineer, Buildings and Roads, Uttar Pradesh was elected President. Shri Kishorilal Mathur, Chief Engineer, Rajasthan, Shri B. Chaudhury, Chief Engineer, Assam and Shri C. J. Fielder of Shalimar Tar Products were elected Vice-Presidents.

Chief Minister, Assam opens the Exhibition

A Council Meeting

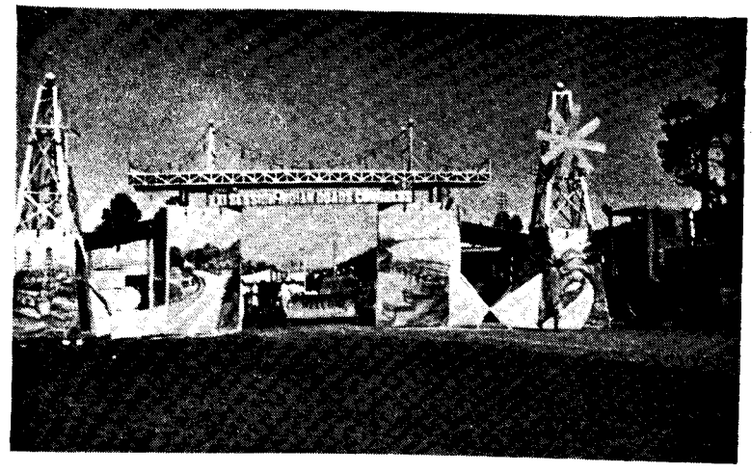
Paper Discussion

Shri Y Guyon
delivering a Lecture to the Congress

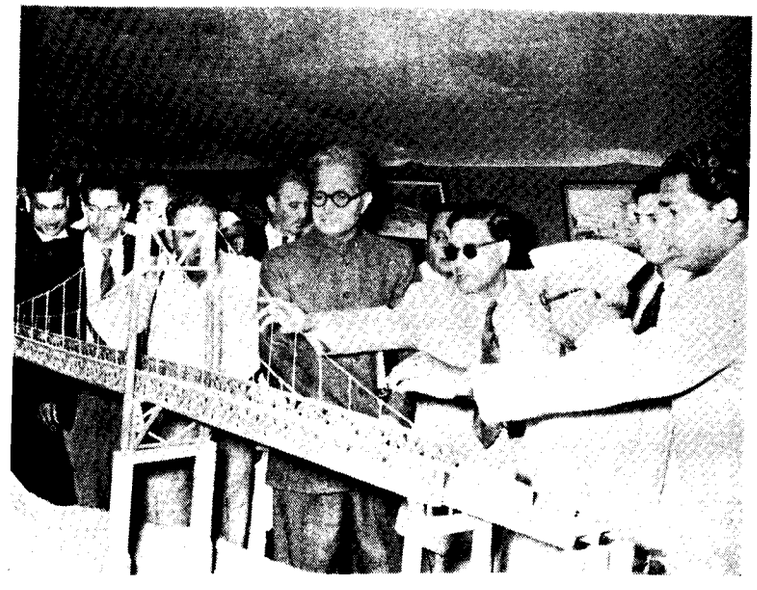
At Home of the Governor

A Committee at work

Chief Engineers' Meeting



Gate of I.R.C. Exhibition



A Stall at the Exhibition

The Chief Engineers of the various States held a meeting during the Session to discuss various technical problems.

On the 12th May, Shri Bisnuram Medhi, Chief Minister, Assam opened the technical exhibition arranged by the Indian Roads Congress. Declaring the exhibition open, the Chief Minister said that roads occupied an important position in the national reconstruction work that was now going on in the country and gave an account of the work done in the field of road development in Assam.

List of Government Departments and Engineering Firms who participated in the Technical Exhibition at Shillong

States

1. Andhra Highways Department
2. Assam Flood Control & Irrigation Department
3. Assam Forest Development Department
4. Assam Government Emporium & Central Stores Department.
5. Assam Publicity Department
6. Assam P. W. D.
7. Bihar P. W. D., B. & R.
8. Bombay P. W. D.
9. Madras Highways Department
10. Punjab P. W. D., B. & R., Research Laboratary, Karnal
11. U. P., P. W. D., B. & R.
12. West Bengal, Road Development

Engineering Firms

1. M/s Assam Oil Co. Ltd. & M/s Burmah-Shell Oil Co., (India Trading) Ltd.
2. M/s Gannon Dunkerley & Co.
3. M/s Greaves Cotton & Co. Ltd.
4. M/s Heatly & Gresham Ltd.
5. M/s James Warren & Co. Ltd.
6. M/s Jessop & Co., Ltd.
7. M/s Shalimar Tar Products (1935) Ltd.
8. M/s Standard Batteries Ltd.
9. M/s Tractors (India) Ltd.
10. M/s Voltas Ltd.
11. M/s William Jacks & Co. Ltd.

Others

1. Central Road Research Institute
2. Concrete Association of India

Minutes of the 48th Council Meeting of the

INDIAN ROADS CONGRESS

held at Shillong on the 11th May, 1957.

Present :

P. L. Varma — President

F. P. Antia	C. J. Fielder
J. K. Bannerjee	W. A Griffiths
C. M. Bennett	H. R. Gupta
M. S. Bisht	E. A. Nadirshah
S. K. Bose, Brig.	K. K. Nambiar
D. P. R. Cassad	B. Prasad
B. Chaudhury	R. C. Roy
R. N. Dogra	H. P. Sinha
N. Durrani	H. G. Verma

J. Subrahmanyam — Secretary

The following co-opted Members attended :

A. Z. Ahmed	D. P. Nayar
K. F. Antia	S. R. Mehra
D. G. Bhagat	T. Mitra
S. B. Joshi	S. N. Majumdar

The following invited Members attended :

C. S. Anantapadmanabhan	Sujan Singh
V. V. Gopalakrishan Ayyar	J. M. Trehan
R. S. Bhalla	B. V. Vagh
P. D. Shivdasani	B. N. Das, Col.
K. D. Lahkar	A. K. Sen

1. Confirmation of the Minutes of the 47th Council Meeting.

The Minutes of the 47th Council meeting held at Nagpur on the 12th January 1956 published at pages 503 to 506 of Volume XX-part 4 of the Journal of the Indian Roads Congress were confirmed.

2. Approval of the Minutes of the Executive Committee Meetings.

The Minutes of the meetings of the Executive Committee held at New Delhi on the 21st April and 22nd November 1956 and the 9th and 10th April 1957 were approved.

3. Audit Report for the year 1955–1956.

The report of the auditors for the year 1955–56 was recorded.

4. Draft Report of the Council to the General Body of Members for the period 1st January to the 31st December 1956.

The draft report was approved.

5. Budget.

The budget estimate for 1956–1957 was approved.

6. Changes in the Memorandum* of Association, Rules, Regulations and Bye-laws of the Indian Roads Congress.

The Council considered the recommendations of the Executive Committee on the changes in the Rules and approved them.

It was also decided that the Director, Central Road Research Institute should be an ex-officio member of the Council. The changes in the Rules and Bye-laws agreed to by the Council are given in Appendix–I.

7. Seminar on Low Cost Roads and the venue of the next General Session.

The Council discussed the suggestion of the Chief of the Transport Division, ECAFE received through the Government of India, Ministry of Transport, Roads Wing to hold a seminar on Low Cost Roads at the time of the next Annual Session of the Indian Roads Congress. The Council accepted the suggestion and the venue will be fixed shortly.

8. The Council decided that memoranda on the following points raised in the Presidential Address of Shri K. K. Nambiar should be prepared by the new President and placed before the Council for their consideration :-

   (i) Establishment of non-lapsing funds for financing all road development and maintenance programmes.

   (ii) Creation of an All-India Service of Engineers.

9. It was decided that the Consulting Engineer to the Government of India (Road Development) should be requested to prepare a note on the action so far taken to prevent ribbon development on roads. A Committee consisting of M/s H. P. Sinha, K. K. Nambiar, N. Durrani, D. P. Nayar and P. L. Varma to study

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* Revised Memorandum of Association, Rules, Regulations and Bye-laws are published as Appendices 2 & 3.

the subjects and to make recommendations was appointed.

10. The Council noted that the State Governments have been addressed by the Government of India, Ministry of Transport, Roads Wings to take necessary action to ensure that road diversions made at the time of repairing roads are maintained properly.

11. The Council decided that information regarding safe load carrying capacity of bridges and culverts should be collected to enable determining the optimum loading to be permitted on roads.

12. It was also decided that a suitable Technical Secretary should be appointed as early as possible and that the State and Central Governments should be approached to increase the subsidies to meet the additional expenditure.

Appendix 1

Rules and Bye-laws revised by the Council at their 48th meeting held on 11-5-1957

Rule 2. **Objects.** The objects of the Society shall be :

* * * *

f. to suggest legislation for the development, improvement and protection of roads.

* * * *

Item (iii) of the first footnote of Rule 5-b.

*The expression "qualified engineers" shall for the purposes of this Rule be deemed to include :

* * * *

(iii) Any person who shall, in the opinion of the Council, by reason of academic qualification or long practice in engineering, road research or otherwise be sufficiently qualified in engineering to bring him within the said expression.

* * * *

Revised Rule 9 of the Memorandum of Association, Rules & Regulations of the Indian Roads Congress.

GOVERNING BODY

9. The Society shall be controlled by and the management of its affairs shall be entrusted to a Council constituted as follows :

a. A representative of each participating* administration, to be nominated by the Government of the administration concerned from among the ordinary members of the Society.

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* Participating administrations are those States of the Indian Union and Union Territories who participate in the activities of the Indian Roads Congress by guaranteeing to send a specified number of senior delegates to the General Sessions (or if no delegates are sent, to pay the delegation fees for those delegates) and, in addition, subscribe to the funds of the Society.

b. A representative to be nominated by the Engineer-in-Chief, Army Headquarters, India, from among the ordinary or associate members of the Society.

c. A representative of the Central Public Works Department of the Government of India to be nominated by the Chief Engineer of that Department from among the ordinary members of the Society.

d. The Consulting Engineer to the Government of India (Road Development) for the time being.

e. The Director, Central Road Research Institute, India.

f. Past Presidents of the Society, for a period of three years after they vacate their presidentship.

g. (i) Six ordinary or associate members of the Society or representatives of associate members elected under Rule 5—c (ii) (not being public servants) to be elected annually at the time of the Annual General Meeting by a board consisting of all such members present at the meeting.

(ii) One ordinary or associate member or a representative of associate members elected under Rule 5—c (ii) excepting those given representation under Rule 9—b, 9—e and 9—g (i) to be elected annually at the time of the Annual General Meeting by a board consisting of all associate members or representatives of associate members elected under Rule 5—c (ii), but being public servants, present at the meeting.

Provided that in the event of any dispute as to the composition of the board the dispute shall be referred to the President of the Society for decision and his decision shall be final; and provided further that in the event of the votes of the said board being equal in respect of two or more candidates, a fresh election shall be held in respect of such candidates, and if upon such fresh election there are still equal votes in respect of any candidates, the decision shall be taken by drawing lots.

h. One ordinary or associate member of the Society to be elected annually at the time of Annual General Meeting by a board of district board engineers and district board assistant engineers who are members of the Society, but are not under the administrative control of the Chief Engineer of the territory in which they are serving, and are present at the meeting.

i. One ordinary or associate member of the Society to be elected annually at the time of the Annual General Meeting by a board of municipal, improvement trust and cantonment engineers who are members of the Society and are present at the meeting.

j. Four ordinary or associate members of the Society or representatives of associate members elected under Rule 5—c (ii) who shall all have been members of the Society for at least five years to be elected by the Annual General Meeting; Provided that members elected from any one territory shall not exceed two.

13. The Council shall have power :

a. to fill any vacancies on the Council that may occur between two General Meetings of members elected under Rule 9-g, h, i & j, and

b. to add to its number by co-opting not more than ten members of the Society; such co-opted members shall also have voting powers except for the purposes of Rules 24 and 26.

Revised Bye-Laws

Bye-law 1-i.

Bank means the State Bank of India or any other Scheduled Bank approved by the Executive Committee of the Indian Roads Congress.

Bye-law 10-a.

The estimate will be prepared as under:

Estimates of annual receipts and expenditure on various accounts (Head of classification to be fixed according to the source of income and main heads of expenditure).

Bye-law 24.

The Treasurer who shall be the Consulting Engineer to the Government of India (Road Development) for the time being, shall have charge of all funds of the Society. In addition, he shall exercise powers similar to those of the head of a Department of the Central Government.

APPENDIX—II

I. MEMORANDUM OF ASSOCIATION

OF THE

INDIAN ROADS CONGRESS

1. **Name**—The name of the Society shall be " The Indian Roads Congress ".

2. **Objects**—The objects of the Society shall be:

a. to promote and encourage the science and practice of the building and maintenance of roads;

b. to provide a channel for the expression of the collective opinion of its members on matters affecting roads;

c. to promote the use of standard specifications and to propose specifications;

d. to advise regarding education, experiment, and research connected with roads;

e. to hold periodical meetings to discuss technical questions regarding roads;

f. to suggest legislation for the development, improvement and protection of roads;

g. to suggest improved methods of administration, planning, design, construction, operation, use, and maintenance of roads;

h. to establish, furnish, and maintain libraries and museums for furthering the science of road making;

i. to publish, or arrange for the publication of proceedings, journals, periodicals, and other literature, for the promotion of the objects of the Society;

j. to accept subscriptions, subsidies, donations, endowments and gifts in furtherance of the objects of the Society;

k. to invest and deal with the funds of the Society or entrusted to the Society, to acquire and hold any movable or immovable property, and to borrow or raise money for the furtherance of the objects of the Society and to sell, lease, exchange, or otherwise deal with the same;

l. to grant pay, prizes, honoraria, or scholarships (including travelling scholarships) for meritorious work in furtherance of the objects of the Society;

m. to do all such other lawful things as may be incidental or conducive to the attainment of the above objects.

3. **Income and Property**—The income and property of the Society, whensoever and howsoever derived, shall be applied solely towards the promotion of the objects of the Society as herein set forth and no portion thereof shall be paid, or transferred or distributed, directly or indirectly, by way of dividend, bonus, interest, or otherwise howsoever, by way of profit to the members of the Society; Provided that this shall not prevent the payment in good faith of remuneration to any officer or servant of the Society or other persons in return for services rendered.

4. **Governing Body**—The Governing body of the Society shall be the Council as constituted by the Rules and Regulations of the Society.

II. RULES AND REGULATIONS

MEMBERSHIP

5. The Society shall consist of:

a. **Patron and Vice-Patrons**:

Such persons as accept the invitation of the Council to be a **Patron or Vice-Patrons** of the Society from time to time: Provided that there shall never be more than one patron and six vice-patrons at any one time.

b. **Ordinary Members**:

Such qualified engineers* who are or have been connected with roads,† and such other persons being scientists of eminence in, or being engaged in a responsible capacity in the sciences

* The expression "qualified engineers" shall for the purposes of this Rule be deemed to include:

(i) Corporate Members of the Institution of Engineers (India).

(ii) Persons holding such qualifications as are acceptable by the Institution of Engineers (India) for election to Corporate Membership.

(iii) Any person who shall, in the opinion of the Council, by reason of academic qualification or long practice in engineering, road research or otherwise be sufficiently qualified in engineering to bring him within the said expression.

† The expression "connected with roads" shall, for the purpose of this Rule, be deemed to include, being or having been:

(i) connected with the construction and maintenance of roads, or

(ii) engaged (whether in public employ or in business or otherwise) in connection with roads or materials used in connection with roads or the use of roads or in writing about the same or otherwise connected with roads to an extent, in the opinion of the Council, sufficient to bring a person within the said expression.

allied to road construction and maintenance, as may be elected ordinary members of the Society by the Council.

c. **Associate Members**:

(i) Such persons, who, while not eligible to be ordinary members, are or have been in the opinion of the Council, engaged in the administration of roads or road transport or so engaged in business connected with the construction and maintenance of roads or with the manufacture or sale of material used in connection with the making or repairing of roads or of road transport vehicles, or the operation thereof, as may be elected associate members of the Society by the Council; and

(ii) Such Institutions, Government Departments, Public Bodies, or Firms who have been, in the opinion of the Council engaged in the administration of roads or road transport or so engaged in business or work connected with the construction and maintenance of roads or with the manufacture or sale of material used in connection with the making or repairing of road transport vehicles, or the operation thereof, as may be elected associate members of the Society by the Council. Each such body shall be represented at any time by only one nominee approved by the Council.

d. **Honorary Members**:

Such persons who on account of their being in the opinion of the Council sufficiently distinguished or interested in road may be elected honorary members of the Society by the Council. Honorary members shall at no time exceed 25 in number.

6. **Entrance Fee**: An entrance fee shall be payable by members on election on the following scale:

		Rs
Patron, Vice-Patrons and Honorary Members	...	Nil
Ordinary Members	...	25
Associate Members	...	120

Provided that no entrance fee shall be payable by any ordinary member who shows to the satisfaction of the Council that his basic pay on the date of his election is not more than Rs 300

7. **Subscription**:

a. A yearly subscription shall be payable by members on the following scale:

		Rs
Patron, Vice-Patrons and Honorary Members	...	Nil
Ordinary Members	...	25
Associate Members	...	120

Provided that a rebate of Rs 5 in case of ordinary members and Rs 20 in the case of associate members may be claimed if the subscriptions are paid within three months of the due date.

b. Ordinary members whose subscriptions are not in arrears may compound their future annual subscriptions by a single payment depending upon their age at the time in accordance with the age table below. Age shall be reckoned as that on the birthday nearest first October of the year of commuting annual subscriptions.

Associate members of at least 5 years standing elected under Rule 5-c (i) on attaining the age of 55 years may, on their retirement from their profession, be permittted by the Council to compound for life by a single payment, according to the table for ordinary members.

Age Table for Compounding for Life Membership

Age	Compounding Fee	Age	Compounding Fee	Age	Compounding Fee
25	397	36	307	47	180
26	391	37	296	48	167
27	383	38	287	49	153
28	376	39	276	50	139
29	368	40	264	51	124
30	360	41	253	52	109
31	352	42	243	53	93
32	343	43	231	54	77
33	335	44	219	55	60
34	325	45	207	56 and over	40
35	316	46	193		

c. A year shall for the purposes of this Rule, be from the first day of October until the last day of September following. Subscription shall be due on election and on the first day of October of every year following that date while a person continues to be a member of the Society.

8. **Cessation of Membership**:

a. Any member who has not paid his subscription due within two years of the due date shall automatically cease to be a member.

b. The Council shall have power to cancel the membership of any member of the Society who shall be deemed to have been guilty of any conduct prejudicial to the Society or rendering him unfit to remain a member thereof; Provided that at least two-thirds of the members of the Council present in person shall be in favour of such action and; Provided further that before any decision is taken, the member in question shall be afforded an opportunity to state his case in person or writing.

c. A member may resign from his membership of the Society by notice in writing to the Secretary to that effect provided he is not in arrears with his subscriptions for more than one month and that no such resignation shall be valid until the member resigning receives an acceptance of his resignation in writing from the Secretary.

GOVERNING BODY

9. The Society shall be controlled by and the management of its affairs shall be entrusted to a Council constituted as follows :-

a. A representative of each participating* administration, to be nominated by the Government of the administration concerned from among the ordinary members of the Society.

b. A representative to be nominated by the Engineer-in-Chief, Army Headquarters, India, from among the ordinary or associate members of the Society.

c. A representative of the Central Public Works Department of the Government of India to be nominated by the Chief Engineer of that Department from among the ordinary members of the Society.

d. The Consulting Engineer to the Government of India (Road Development) for the time being.

* Participating administrations are those States of the Indian Union and Union Territories who participate in the activities of the Indian Roads Congress by guaranteeing to send a specified number of senior delegates to the General Sessions (or if no delegates are sent, to pay the delegation fees for those delegates) and, in addition, subscribe to the funds of the Society.

e. The Director, Central Road Research Institute, India.

f. Past Presidents of the Society, for a period of three years after they vacate their presidentship.

g. (i) Six ordinary, or associate members of the Society or representatives of associate members elected under Rule 5–c(ii) (not being public servants) to be elected annually at the time of the Annual General Meeting by a board consisting of all such members present at the meeting.

(ii) One ordinary, or associate member or a representative of associate members elected under Rule 5–c(ii) excepting those given representation under Rule 9–b, 9–e and 9–g(i) to be elected annually at the time of the Annual General Meeting by a board consisting of all associate members or representatives of associate members elected under Rule 5–c(ii), but being public servants, present at the meeting.

Provided that in the event of any dispute as to the composition of the board the dispute shall be referred to the President of the Society for decision and his decision shall be final; and provided further that in the event of the votes of the said board being equal in respect of two or more candidates, a fresh election shall be held in respect of such candidates, and if upon such fresh election there are still equal votes in respect of any candidates, the decision shall be taken by drawing lots.

h. One ordinary or associate member of the Society to be elected annually at the time of Annual General Meeting by a board of district board engineers and district board assistant engineers who are members of the Society, but are not under the administrative control of the Chief Engineer of the territory in which they are serving, and are present at the meeting.

i. One ordinary or associate member of the Society to be elected annually at the time of the Annual General Meeting by a board of municipal, improvemont trust and cantonment engineers who are members of the Society and are present at the meeting.

j. Four ordinary or associate members of the Society or representatives of associate members elected under Rule 5–c(ii) who shall all have been members of the Society for at least five years to be elected by the Annual General Meeting; Provided that members elected from any one territory shall not exceed two.

PRESIDENT AND VICE-PRESIDENTS

10. The Council shall at its first meeting after each Annual General Meeting elect a President and not more than three Vice-Presidents of the Society from among its own members, who shall hold office and continue to be members of the Council till a new Council has been elected. The President shall have power to fill any vacancies in the office of the Vice-Presidents that may occur between two General Meetings.

SECRETARY AND TREASURER

11. a. The Council shall appoint a Secretary on such terms as it deems fit. The President shall have power to make changes in the personnel of this office whenever such changes are necessary.

b. The Consulting Engineer to the Government of India (Road Development) for the time being shall be ex-officio Treasurer of the Society.

12. The Council shall hold office untill the newly elected Council referred to in Rule 9 takes charge.

13. The Council shall have power:

a. to fill any vacancies on the Council that may occur between two General Meetings of members elected under Rule 9 g, h, i, & j, and

b. to add to its number by co-opting not more than ten members of the Society; such co-opted members shall also have voting powers except for the purposes of Rules 24 and 26.

c. to invite any member, ordinary or associate, or any other person, to a particular meeting; such persons shall have no voting powers.

14. Any nominated member of the Council as aforesaid may nominate, by written notice to the Secretary, a member of the Society to represent and vote for him as a member of the Council.

15. The President, or in his absence a Vice-President to be nominated by the President, shall preside at all meetings of the Council; otherwise the meeting shall elect one of the Vice-Presidents present as a Chairman. The Chairman shall have a casting vote.

16. If at any time the President for the time being is absent from India, or is unable to perform the duties of his office, he shall nominate a Vice-President to act for him. In the event of the President failing to nominate one of the Vice-Presidents as aforesaid, the Vice-Presidents shall elect one of themselves to perform the office of the President.

17. The Council shall meet when possible at least once a year as defined in Rule 7-c at such time or times as the President may direct and one of such meetings shall be at the time of the General Session of the Society ; and on the requisition of at least ten members, the President shall call a meeting of the Council provided that instead of actually meeting, the President may direct that the Secretary refer the matter specified in the requisition for decision by post as hereinafter provided. At meetings of the Council twenty shall form a quorum.

18. The Secretary shall, on the orders of the President, refer any matter for the decision of the Council by sending to each member of the Council by Registered Post with acknowledgment due, a Memorandum setting forth the question or questions to be decided and specifying a date not less than thirty days from the date of posting of the Memorandum by which the votes of members of the Council shall reach him. Upon receipt of not less than twenty votes by the date specified, the Secretary shall record the decision of the Council as decided by the majority of the votes received by the said date and communicate such decision to the members of the Council. If less than twenty votes are received by the said date it shall be presumed that no decision has been made. In the event of the votes received by the Secretary as aforesaid being equal, the President shall have a casting vote.

EXECUTIVE COMMITTEE

19. The President, the Vice-President, the Treasurer and the Secretary shall form the Executive Committee with powers, subject to the approval of the Council, to direct and manage the affairs of the Society, to keep the activities of the Society under review, and to report to the Council from time to time. The Executive Committee shall have power to co-opt not more than two members with power to vote. Three shall form a quorum, one of them being either the President or a Vice-President. The President or, in his absence, a Vice-President shall preside. If, in the absence of the President, more than one Vice-President is present the members attending the meeting shall elect one of the Vice-Presidents as a Chairman. The President or Chairman shall have and exercise, in addition to his vote, a casting vote in the case of an equality of votes.

COMMITTEES

20. The Council shall appoint the convenors of all committees and subcommittees except as otherwise provided in this Rule. The Executive Committee or the President under authorization from the Executive Committee shall appoint the other members of such committees or subcommittees in consultation with the respective convenors as far as possible. The Executive Committee or the President under authorization from the Executive Committe shall have the power to appoint such special committees including their convenors as may be deemed necessary from time to time. The number of members in each subcommittee or a division of a committee shall not be less than three and will not ordinarily be more than five. The Consulting Engineer to the Government of India (Road Development) shall be ex-officio member of all such committees or subcommittees in addition to the personnel appointed under this Rule. Any committee or subcommittee constituted under this Rule shall have power to co-opt not more than two members.

MEETINGS OF THE SOCIETY

21. There shall ordinarily be a General Session of the Society once a year at such time and place as the Council shall decide. At this Session there shall be a General Meeting for the purpose of disposing of the following business :

a. To receive the report of the Council and the audited accounts for the previous year, or years ending 30th September ;

b. To elect, under Rule 9, members of the Society to serve on the Council until the next General Meeting as aforesaid ;

c. To appoint Auditors ; and

d. To transact such other authorized business as the President shall allow.

At such General Session, the Council may arrange for Papers to be read on subjects of professional and technical interest and for discussion thereon and for works to be visited.

22. The President shall preside at all General Meetings of the Society or shall nominate a Vice-President or in their absence nominate some other member of Council to preside in his place. In the absence of the President and of the Chairman nominated by the President at any meeting, the members present shall elect a Chairman. The Chairman shall have a casting vote.

23. Fifty members present in person shall form a quorum of the General Meeting.

ALTERATION AND INTERPRETATION OF RULES

24. These Rules and Regulations shall not be altered, extended, or abridged without the approval of at least two-thirds of those present in person at a meeting of the Council and at least 30 days notice shall have been given of such meeting and of any proposal to alter, extend, or abridge these Rules and Regulations.

25. In the event of any differences of opinion arising as to the interpretation of the Rules and Regulations, the decision of the Council shall be final and binding.

FRAMING AND ALTERATION OF THE BYE-LAWS

26. The Council shall have power to make, add to, abridge, and amend such Bye-laws as may appear to the Council to be necessary for the conduct of the Business of the Society, and as shall be consistent with the Memorandum and Rules and Regulations of the Society.

BYE-LAWS

Chapter I.

(i) Definitions in these Bye-laws.

Chapter II.

(i) Application for Membership.
(ii) Rights and Privileges.
(iii) Use of the Name of the I.R.C.
(vi) Change in Name and Address.
(v) Arrears.
(vi) Life Membership Reserve.
(vii) Presidential Address.

Chapter III.

(i) Budget and Appropriation—General Procedure.
(ii) Form of the Budget Estimates.
(iii) Appropriation.
(iv) Re-appropriation and incurring of Expenditure not budgetted for.
(v) Powers to sanction Expenditure budgetted for.

Chapter IV.

(i) Investment.

Chapter V.

(i) Office.

Chapter VI.

(i) Conditions of Service and Employment of Staff.

Chapter VII.

(i) Powers of Officers—President.
(ii) Vice-Presidents.
(iii) Treasurer.
(iv) Secretary.
(v) Call of Meetings.
(vi) Resolutions for general Meeting.

(vii) Invitation to Council meetings.

(viii) Conduct of Meetings

(ix) Voting at Meetings.

(x) Procedure for taking action on the Minutes of Committees.

(xi) Rules and Regulations for the Contribution, Selection and Publication of Technical Papers and Essays.

(xii) Discussion of Papers.

(xiii) Record of Proceedings.

(xiv) Award of Medals and Prizes.

(xv) Publications.

(xvi) Copyright.

(xvii) Conduct of Business at General Sessions.

CHAPTER I

DEFINITIONS IN THESE BYE-LAWS.

1. a. 'Bye-laws' means the Bye-laws framed by the Council of the Indian Roads Congress.

   b. 'Society' means the Indian Roads Congress.

   c. 'Council' means the governing body for the time being of the Indian Roads Congress.

   d. 'Executive Committee' means the Committee appointed by the Council to direct and manage the day to day affairs of the Indian Roads Congress.

   e. 'Treasurer' means the Treasurer for the time being of the Indian Roads Congress.

   f. 'Secretary' means the Secretary for the time being of the Indian Roads Congress.

   g. 'Year' means the financial year of the Society as defined in Rule 7–c.

   h. 'Employees' means officers, office staff, technical staff and inferior staff of the Indian Roads Congress, other than those whose salary is paid from contingencies.

   i. 'Bank' means the State Bank of India or any other scheduled Bank approved by the Executive Committee of the Indian Roads Congress.

CHAPTER II

APPLICATION FOR MEMBERSHIP.

2. a. Application for admission as an Ordinary or Associate Member shall be made on prescribed Forms, and addressed to the Secretary, Indian Roads Congress.

   b. The Council shall take such steps as may in its opinion be necessary to ascertain the suitability of the applicant. The Council may refuse to enrol any person as an Ordinary or Associate Member without assigning any reason.

RIGHTS AND PRIVILEGES.

3. a. The rights and privileges for Ordinary and Associate Members shall be as follows:

   (i) Members (ordinary and associate) who are not in arrears of subscription or other dues will be eligible for supply free of cost of a copy of the Proceedings and such other publications as the Council may decide. Members enrolled in any year shall have this privilege in respect of the proceedings and publications issued in that year. Such members may, at the discretion of the Council, be supplied previous proceedings and publications, if available, at a concessional rate as the Council may decide from time to time.

   (ii) Members can have access to the Library of the Society for purposes of reference and shall be eligible to take on loan therefrom such book(s) under Rule framed for the purpose.

   (iii) Members may apply to the Secretary for technical information on road engineering subjects.

   (iv) Members may attend meetings of technical Committees and Subcommittees with the approval of the Chairman of the Committee or Subcommittee. Such members shall have no right to participate in the Proceedings.

USE OF THE NAME OF THE I.R.C.

4. No Member of the Indian Roads Congress shall be permitted to use the title "M.I.R.C." or any other

similar title for personal or commercial benefit. Membership of the Society does not confer any qualifying educational degree.

CHANGE IN NAME AND ADDRESS.

5. Members shall intimate to the Secretary all changes in their addresses as they occur. The Secretary shall be competent to admit such changes.

ARREARS

6. No member whose subscription is more than thirty days in arrears, after the date on which it is due, or who is owing any money to the Society shall be entitled to attend or take part in any meeting, receive any publications of the Society, exercise his vote at any meeting or ballot, or nominated as a candidate for any office in the Society.

LIFE MEMBERSHIP RESERVE.

7. The fee paid for commutation for life membership shall after deduction of Rs 10 for initial expenses be transferred to a separate life membership Reserve, and invested as in Rule 2-k of the Memorandum of Association, to be used for such purposes as the Council may from time to time decide.

PRESIDENTIAL ADDRESS.

8. At each General Session the Retiring President shall deliver an address dealing with matters of interest to the Society.

CHAPTER III

BUDGET AND APPROPRIATION.

GENERAL PROCEDURE

9. Not later than 1st August of each year, the Secretary in consultation with the Treasurer shall have prepared detailed budget estimates of receipts and expenditure for the ensuing financial year. The Secretary shall submit the budget estimates in the first instance to the Executive Committee, before 1st September. Budget estimates as finally accepted by the Executive Committee will be placed before the next meeting of the Council for approval.

FORM OF THE BUDGET ESTIMATE.

10. a. The estimates will be prepared as under:

Estimates of annual receipts and expenditure on various accounts (Head of classification to be fixed according to the source of income and main heads of expenditure.)

b. The estimates shall include:

(i) Actual receipts and expenditure of the preceding year.

(ii) Original budget estimates for the current year.

(iii) Revised budget estimates for the current year.

(iv) Proposed budget estimates for the ensuing year.

c. Large variations in the amounts of any item or items shall be fully explained in a separate note.

d. No new scheme involving fresh expenditure shall be included in the Budget unless it has been specifically approved by the Executive Committee.

APPROPRIATION.

11. a. The funds of the Society shall not be appropriated for expenditure on any item which has not been approved by competent authority under these Bye-laws.

b. The funds provided in the sanctioned estimates shall be deemed to be at the disposal of the Treasurer, who will have power to appropriate sums therefrom to meet expenditure on such items as have been approved by the competent authority.

c. The Treasurer may delegate to the Secretary such power under rule 11-b above as he may deem necessary.

12. For purposes of financial control, the allotments under expenditure shall be divided into sub-heads known as units of appropriation. The primary units of appropriation will ordinarily be "Establishment", "Office equipment", "Printing", "Purchase of Paper", "Postage", "Contingencies", "General", etc., secondary units subordinate thereto being opened, as may be required.

RE-APPROPRIATION & INCURRING OF EXPENDITURE NOT BUDGETTED FOR.

13. Expenditure of emergent and essential character not provided for in the budget, shall be incurred only with the permission of the Treasurer in writing. All such expenditure shall be reported to the Executive Committee at its next meeting.

14. The Treasurer shall have powers, within the scope of the allotment, to re-appropriate funds from one primary unit of appropriation to another provided the item of expenditure does not exceed Rs 2,000. For items exceeding Rs 2,000 authority for re-appropriation will vest in the Executive Committe.

POWERS TO SANCTION EXPENDITURE BUDGETTED FOR.

15. a. Within the Budget allotments, the Treasurer may sanction the incurring of expenditure.

b. A sanction to incur expenditure will not become operative until funds have been provided to cover it.

CHAPTER IV

INVESTMENT.

16. The moneys of the Society may be invested in such manner as may be decided from time to time by the Executive Committee. Such investments shall ordinarily be:

a. in promissory notes, debentures, stock or other securities declared to be trust securities by the Government of India.

b. in fixed deposits with any scheduled bank approved by the Executive Committee.

17. All investments shall be made in the name of the Society.

18. All purchases, sales or conversions of such investments shall be effected on the authority of the Executive Committee and all contracts, transfer deeds or other documents necessary for purchasing, selling or altering the investments of the Society's funds shall be executed by the Secretary on behalf of the Society.

19. For safe custody the receipts and documents will be deposited with the Bank and will be verified once in six months with the Register of Securities maintained for the purpose and a certificate of verification will be recorded by the Secretary.

CHAPTER V

OFFICE.

20. The Society shall maintain a general office at such place as the Council may decide, to conduct the transactions of the Society. (For the time being this office is located in New Delhi).

CHAPTER VI

CONDITIONS OF SERVICE AND EMPLOYMENT OF STAFF.

21. a. **Pay scales.**

The pay scales of the staff shall be the same as those sanctioned from time to time for the staff of the attached offices of the Central Government.

b. **Allowances.**

Allowances including Dearness, House Rent, Compensatory, Insurance Benefits, Travelling and Daily Allowances and any other allowances for employees of the Society shall correspond to those applicable to the servants of the Central Government from time to time.

c. **Leave Privileges.**

Leave privileges for the employees of the Society shall be governed by the corresponding provisions of the Fundamental and Supplementary Rules applicable to the employees of the Central Government from time to time.

d. **Contributory Provident Fund.**

(i) Service under the Society shall not entitle its employees to any pension. But the Society shall establish and maintain a Contributory Provident Fund for the benefits of its employees.

(ii) The Countributory Provident Fund of the Society shall be regulated in accordance with the Contributory Provident Fund Rules (India) as modified from time to time by the Executive Committee.

CHAPTER VII.

POWERS OF OFFICERS.

PRESIDENT.

22. The President shall have the power to act on behalf of the Council, in cases which in his opinion require urgent action, subject to report to the Council.

VICE-PRESIDENTS.

23. A Vice-President when serving the office of the President under Rule 16 of the Memorandum of Rules and Regulations of the Society shall exercise the President's powers in the absence of the President.

TREASURER.

24. The Treasurer who shall be the Consulting Engineer to the Government of India (Road Development) for the time being, shall have charge of all funds of the Society. In addition, he shall exercise powers similar to those of the Head of a Department of the Central Government.

SECRETARY.

25. The Secretary shall generally conduct the ordinary business of the Society. He shall keep a record of all transactions of the Society. He shall be responsible for all correspondence, accounts, and Office work of the Society. He shall attend all meetings of the Society and shall have business thereat correctly and fully reported. He shall have powers of appointment in the Office in consultation with the Treasurer. He shall also have powers of suspension and removal but these shall only be exercised with the prior written approval of the Treasurer.

CALL OF MEETINGS.

26. The Secretary, or in his absence the officer working in his place, is authorized to call a meeting of the Council or the Executive Committee or the General Body of Members on behalf of the President.

RESOLUTIONS FOR GENERAL MEETING.

27. If a Member desires to move a resolution or submit a proposal for the consideration of the General meeting, such resolution or proposal should reach the Secretary at least two months before the General meeting.

INVITATION TO COUNCIL MEETINGS.

28. a. The Executive Committee shall have power to invite members to the Council meetings.

b. Convenors of Commitees and Subcommittees, if not members of the Council, should be invited to attend the Council meeting at which they have resolutions to propose or at which the subject with which they are connected has to be discussed.

CONDUCT OF MEETINGS.

29. The Chairman of any meeting shall regulate and keep order in the proceedings.

VOTING AT MEETINGS.

30. Votes at any meeting may be taken by a show of hands or by ballot at the discretion of the Chairman.

PROCEDURE FOR TAKING ACTION ON THE MINUTES OF COMMITTEES.

31. The Executive Committee shall lay down the procedure for taking action on Minutes of Committees and Subcommittees.

32. Copies of the Minutes of the Executive Committee should be issued to all Members of the Council as soon as they are confirmed by the Committee. Confirmation may be obtained by circulation to the Members of the Executive Committee.

RULES AND REGULATIONS FOR THE CONTRIBUTION, SELECTION AND PUBLICATION OF TECHNICAL PAPERS AND ESSAYS.

33. The Executive Committee shall frame the Rules and Regulations for the contribution, selection and publication of Technical Papers and Essays.

34. Members of the Society are eligible to contribute technical Papers for publication in the Indian Roads Congress Journal.

35. Contributions from non-members for the furtherance of the objects of the Society, if of exceptional merit, may also be accepted. Such acceptance from a non-member will carry honorary membership for the Author for the year of publication provided the Executive Committee are satisfied that the contributor is not eligible for election as an ordinary member.

36. Papers submitted for dicussion at the General Sessions of the Congress shall be considered by a Committee consisting of the President and Treasurer who may, at their discretion, also take the advice of the Papers Committee, and decide whether the Papers should be published in full with the written or oral discussions, or with the consent of the Author in an abridged form, or in an abstract form or otherwise as it may determine. The Papers Committee shall, however, invariably be consulted on the award of Medals, Prizes, etc.

37. The Secretary, Indian Roads Congress will act as the Editor and Publisher of the Indian Roads Congress Journal. He will edit the Papers to be published in the Journal. He shall have power to use his discretion in deleting superfluous material, etc., and adding fresh matter to improve the quality of the Paper.

DISCUSSION OF PAPERS.

38. The President shall appoint a Chairman and a Recorder (both being Members of the Indian Roads Congress) for each Paper read at the General Sessions and assign duties to the Chairmen and Recorders so appointed.

RECORD OF PROCEEDINGS.

39. a. The proceedings of all meetings shall be recorded under the orders of the Chairman. Copies of the record of the remarks made by any member at a General meeting shall be sent to him for correction as soon as reasonably possible after the Session at which the remarks were made. If these are confirmed or corrected within 21 days of despatch they may be incorporated in the published proceedings: provided that the editor shall have power under the general control of the Council to reject additions or corrections which in his judgement do not represent what the member said and publish what he considers was said. If they are not returned within 21 days, the editor of the proceedings shall, under the general instructions of the Chairman, have power to make such additions and corrections to the recorded remarks of any member as may be necessary in his judgement to secure an accurate record.

b. Any member, whether present during the discussion or not, may send to the editor within 15 days of the discussion any comments on the subject matter of any Paper or on the subject of any remarks in the course of any discussion and such comments may, in the discretion of the editor, be included in the record of the proceedings under a separate head entitled "Correspondence."

AWARD OF MEDALS AND PRIZES.

40. a. The Council may accept donations or set apart funds for the purpose of award of medals* and prizes for specified purposes.

b. The Council have reserved the right to award more than one Medal in any one year or to withhold the award of any Medal in any year without assigning any reason.

PUBLICATIONS.

41. a. In addition to the proceedings of General Meetings, the Council shall have power :

(i) to issue any publication likely, in the opinion of the Council, to promote the objects of the Society, such as Technical Reports, Bulletins, Pamphlets, etc. ;

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* The following Medals and Prizes are available for award :

(i) *The Mitchell Medal* : This is a bronze medal to be awarded annually 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 Indian Roads Congress.

(ii) *The Indian Roads Congress Medal* : This is also a bronze medal to be awarded annually for Papers considered by the Council of the Indian Roads Congress to be of a decidedly more than average merit.

(ii) to accept advertisements on payment for insertion in any publication of the Society and to issue advertisements in any publication;

(iii) to make payment for articles published;

(iv) to fix the price of any publication; and

(v) to determine whether any publications shall be issued to members and associates free of cost or at reduced rates.

COPYRIGHT.

42. All Papers accepted for discussion at meetings and all matter included in the proceedings and publications of the Society shall be the property of the Society and no member shall publish or otherwise make use of any matter, printed or verbal, of the proceedings or publications save with the consent of the Council given under the hand of the Secretary.

CONDUCT OF BUSINESS AT GENERAL SESSIONS.

43. The Executive Committee shall from time to time frame the Rules and Regulations for the conduct of Business at General Sessions.

Minutes of the Business Meeting of the

INDIAN ROADS CONGRESS

held at Shillong on the 15th May 1957

The Twenty-first Annual General Meeting of Members was held at Shillong on Wednesday, the 15th May 1957 at 10-30 A.M. In all 272 Members and 10 invitees (names and particulars at pages 551-558) attended the Session.

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

The minutes of the last Business Meeting held at Nagpur on the 11th January 1956, as printed at pages 465 to 502 of the Journal of the Indian Roads Congress, Volume XX—Part 4, January 1957 were confirmed.

3. Audit Report.

(i) The Audit Report for the period 1st October 1955 to the 30th September 1956, pages 559-561, was recorded.

(ii) It was decided to re-appoint M/s. Walker, Chandiok and Co., Chartered Accountants and Auditors, Delhi to audit the accounts of the Indian Roads Congress

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

The Report of the Council (pages 563-588) was taken as read and approved. It was decided that in future the report should be circulated to members immediately after it is approved by the Council.

5. Resolutions of thanks.

The following resolutions were passed:

(i) The Indian Roads Congress thank the Government of Assam for their kind invitation to hold the twenty-first Session of the Indian Roads Congress and for the excellent arrangements made in connection therewith.

(ii) The Indian Roads Congress thank Shri Saiyid Fazl Ali, Governor of Assam for his inspiring Address to the Session of the Indian Roads Congress and for his permission to print his Address.

(iii) The Indian Roads Congress thank Shri Bisnuram Medhi, Chief Minister, Assam for inaugurating the

Twenty-first Session of the Congress and for kindly declaring open the Technical Exhibition organized by the Indian Roads Congress and for his encouraging speeches made on those occasions and for his permission to print the speeches.

(iv) The Indian Roads Congress thank Shri Jawahar Lal Nehru, Prime Minister, for his very instructive message to the Congress.

(v) The Indian Roads Congress thank Shri M. Ananthasayanam Ayyangar, Speaker, Lok Sabha for his good wishes for the Indian Roads Congress.

(vi) The Indian Roads Congress thank the Speaker of the Assam Legislative Assembly for his permission to hold the Session in the premises of the Assembly Chamber and for placing the rooms of the building at the disposal of the Congress.

(vii) The Indian Roads Congress thank Shri C.P.N. Singh, Governor of the Punjab for his very inspiring 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 inspiring message to the members of the Indian Roads Congress.

(ix) The Indian Roads Congress thank Sardar Swaran Singh, Minister for Steel, Mines and Fuel, Government of India for his best wishes for the success of the Session.

(x) The Indian Roads Congress thank Shri K.C. Reddy, Minister for Works, Housing and Supply, Government of India for his wishes for the success of the Session.

(xi) The Indian Roads Congress thank Shri Humayun Kabir, Minister in the Ministry of Communications, Government of India for his good wishes for the success of the Session.

(xii) The Indian Roads Congress thank Shri Satish Chandra, Deputy Minister, Commerce and Industry, Government of India for wishing the Session a success.

(xiii) The Indian Roads Congress thank Shri K. Santhanam, Chairman, Finance Commission, Government of India for his instructive message to the Congress.

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

(xv) The Indian Roads Congress thank the Institutions and other well wishers who have sent messages of good will and encouragement.

(xvi) The Indian Roads Congress thank Shri Y. Guyon for attending the Session, contributing a Paper to the Congress and for giving advice to the Committees of the Congress.

(xvii) The Indian Roads Congress thank the Institution of Civil Engineers, England and the Bureau of Public Roads, U.S.A. for sending Shri J. C. Macgregor and Shri Van Dyke to represent them at the Session.

(xviii) The Indian Roads Congress thank Shri B. Chaudhury, and Shri A.Z. Ahmed, Chief Engineers, Shri K. Barua, Additional Chief Engineer, Shri B.M. Chakravarty and Shri S.M. Dutt, Superintending Engineers, Shri K.D. Lahkar, (Local Organising Secretary, Indian Roads Congress), Shri D. Borgohain, Under Secretary, P.W.D., Shri K.C. Barua, Shri D.K. Kataki, and Shri S.N. Mazumdar, Sub Divisional Officers and other officers and staff of the Public Works Department, Assam for the efficient arrangements made by them for the Session and for the convenience of the delegates.

(xix) The Indian Roads Congress thank Kalaparisad of Shillong for kindly arranging a Cultural Show for the delegates.

(xx) The Indian Roads Congress thank the parties of Manipuri troupe for entertaining the delegates.

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

(xxii) The Indian Roads Congress thank the Director, Publicity, Assam for giving publicity to the proceedings of the Session.

(xxiii) The Indian Roads Congress thank the firms and Government Departments who participated in the Technical Exhibition organized on the occasion of

the Session, arranged demonstrations of Road Making Machinery, and offered technical films for being screened.

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

(xxv) The Indian Roads Congress thank the various newspapers, periodicals including the Road Safety in India for giving prominence to the proceedings of the Indian Roads Congress.

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

Messrs. Goverdhan Lal, B. V. Vagh, C. M. Bennett, C. J. Fielder, and Dr. F. P. Antia 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.	C. J. Fielder
M. P. Apte	E. A. Nadirshah
A. D. Dhingra	P. D. Shivdasani

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

L. C. Verman, Dr.

h. Representative of District Board Engineers.

[redacted] I. C. Desai

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

Shoba Ram.

j. Representative selected by the General Body.

R. N. Dogra	R. K. N. Iyengar, Dr.
S. K. Ghosh	H. G. Verma.

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	B. Chaudhury
	Bihar	B. Prasad
	Bombay	W. X. Mascarenhas
	Himachal Pradesh	Nomination awaited
	Jammu & Kashmir	D. N. Gupta
	Kerala	V. Gopalakrishna Ayyar
	Madras	K. K. Nambiar
	Madhya Pradesh	H. R. Gupta
	Mysore	H. Ananthachar
	Orissa	B. S. Jootla
	Punjab	D. P. Nayar
	Rajasthan	Kishori Lal
	Uttar Pradesh	M. S. Bisht
	West Bengal	R. C. Roy
9-b.	Engineer in-Chief, Army Headquarters.	Brig. S. K. Bose
9-c.	Central P.W.D.	M. L. Nanda
9-d.	Consulting Engineer (Road Development) Govt. of India.	H. P. Sinha
9-e.	Director, Central Road Research Institute.	S. R. Mehra

10. **Past Presidents.**

9-f.

P. L. Varma
H. P. Mathrani

11. Reprinting of important I. R. C. Papers.

The question of reprinting some of the important I. R. C. Papers which had become out of stock was discussed. It was decided that the matter may be examined by the Executive Committee.

12. Burning of tar as fuel in the steel factories.

The General Body of Members considered a resolution moved by Shri C. C. Bagchi suggesting that the Council of the Indian Roads Congress be requested to take suitable steps to prevent the burning of tar as fuel in steel factories. It was decided that the use of tar as fuel in steel factories in relation to the needs of roads of the country be examined by the Council.

LIST OF MEMBERS WHO ATTENDED THE TWENTY-FIRST SESSION OF THE INDIAN ROADS CONGRESS HELD AT SHILLONG IN MAY, 1957.

S. No.	Name of State etc.	No. of delegates who attended the I. R. C. Session.
	ABSTRACT	
1.	**Government of India:**	
	(a) Ministry of Transport & Communications, Deptt. of Transport, (Roads Wing) ...	23
	(b) Engineer-in-Chief's Branch ...	3
	(c) C.P.W.D. and N.E.F.A. ...	9
	(d) Railway Board ...	1
	(e) Union Public Service Commission ...	1
2.	**Planning Commission** ...	1
3.	**Central Road Research Institute** ...	10
4.	**Hindustan Steel Limited** ...	1
5.	**Andhra Pradesh** ...	5
6.	**Assam** ...	49
7.	**Bihar** ...	15
8.	**Bombay** ...	44
9.	**Delhi** ...	5
10.	**Himachal Pradesh** ...	2
11.	**Kerala** ...	4
12.	**Madhya Pradesh** ...	8
13.	**Madras** ...	11
14.	**Manipur** ...	3
15.	**Mysore** ...	6
16.	**Orissa** ...	6
17.	**Punjab** ...	7
18.	**Rajasthan** ...	5
19.	**Tripura** ...	1
20.	**Uttar Pradesh** ...	20
21.	**West Bengal** ...	39
22.	**France** ...	1
23.	**Pakistan** ...	1
24.	**U. S. A.** ...	1
	Total ...	**282**

LIST OF MEMBERS WHO ATTENDED THE 21st ANNUAL SESSION OF THE INDIAN ROADS CONGRESS HELD AT SHILLONG IN MAY, 1957.

S. No.	Roll No.	Name.
		1. GOVERNMENT OF INDIA
		(a) Ministry of Transport & Communications, Deptt. of Transport, (Roads Wing)
1.	*Invitee*	Anantapadmanabhan, C. S.
2.	773	Bhargava, T. N.
3.	2040	Bhattacharyya, M.
4.	1446	Bhalla, R. S.
5.	266	Bhagat, D. G.
6.	758	D'Costa, A. J.
7.	2198	Gajria, H. B.
8.	879	Goverdhan Lal
9.	2083	Keswani, N. H.
10.	605	Krishnan, K. S.
11.	747	Lal, M. B.
12.	1146	Menon, M. D.
13.	1878	Navaney, M. K.
14.	950	Nagarsheth, M. P.
15.	885	Poonen, P. C.
16.	890	Patel, B. P.
17.	724	Rajagopalan, S. K.
18.	*Invitee*	Ranganathan, K.
19.	1532	Sehra, P. T.
20.	1280	Sadarangani, T. G.
21.	191	Sinha, H. P.
22.	723	Subrahmanyam, J.
23.	918	Trehan, J. M.
		(b) Engineer-in-Chief's Branch
24.	1818	Bose, Brig. S. K.
25.	*Invitee*	Deb, A. K.
26.	16-Associate	Das, Col. B. N.
		(c) Central P. W. D. and N. E. F. A.
27.	1619	Bhandari, V. D.
28.	2257	Chakraborty, J. C.
29.	2210	Keswani, J. W.
30.	2228	Khubchandani, B. G.
31.	915	Mittal, O. P.
32.	237	Mehta, N. N.
33.	2216	Rao, N. S. L.
34.	2221	Sharma, M.
35.	2236	Tiagi, A. S.
		(d) Railway Board
36.	43-Associate	Sood, K. C.

S. No.	Roll No.	Name.
		(e) Union Public Service Commission
37.	491	Varma, P. L.
		2. PLANNING COMMISSION
38.	*Invitee*	Khanna, S. N.
		3. CENTRAL ROAD RESEARCH INSTITUTE
39.	*Invitee*	Bhupindar Singh
40.	2241	Bawa, N. S.
41.	833	Iyengar, Dr. R. K. N.
42.	1857	Khanna, Tejbir, S.
43.	277	Mehra, S. R.
44.	2202	Natarajan, T. K.
45.	1913	Rao, N. Mohan
46.	1345	Swaminathan, C. G.
47.	2183	Swami, S. A.
48.	847	Uppal, Dr. H. L.
		4. HINDUSTAN STEEL LIMITED
49.	2053	Ganapathy, C. P.
		5. ANDHRA PRADESH
50.	246	Durrani, N.
51.	326	Mohomed Usman
52.	29	Narasimham J. S.
53.	1013	Rao, B. K. V.
54.	771	Raghavaiah, M.
		6. ASSAM
55.	2256	Ahmed, H.
56.	*Invitee*	Ahmed, A. Z.
57.	889	Barua, K.
58.	2278	Barua, U. N.
59.	2258	Baruah, P. K.
60.	2229	Bhattacharjee, P. C.
61.	1247	Barua, H.
62.	2251	Barua, K. C.
63.	64-Associate	Barua, D. P.—Representing M/s. Builders Brothers, Gauhati.
64.	2280	Bhattacharjee, R.
65.	2042	Borgohain, D.
66.	2227	Chaudhury, S. C.
67	963	Choudhury, P. R.
68.	789	Chakraverty, B. M.
69.	2270	Choudhury, S. D.
70.	2288	Choudhury, A. K. Roy
71.	941	Choudhury, B.
72.	157	Datta, D. C.
73.	1895	Das, Sita Ram
74.	2027	Datta, S. M.
75.	2220	Das, D. R.

S. No.	Roll No.	Name.
76.	2252	Das, S. S.
77.	2287	Das, K. K.
78.	2201	Ghose, U. C.
79.	2267	Gohain, H.
80.	2275	Gupta, N. Das
81.	1960	Islam, S.
82.	2237	Kundu, A. C.
83.	1968	Kharkongor, F.
84.	2163	Kataki, D. K.
85.	2282	Kakati, H.
86.	1632	Lahkar, K. D.
87.	1802	Majumdar, K. L.
88.	2254	Mathur, V. K.
89.	2271	Medhi, P. K.
90.	945	Pal, S. C.
91.	55-Associate	Rajkhowa, P.—Representing M/s. Assam Oil Co. Ltd., Digboi.
92.	2246	Roy, H. E.
93.	2253	Raju, V. K.
94.	2231	Sahariah, Y. C.
95.	2274	Saikia, M. N.
96.	1961	Sarmah, G. C.
97.	2232	Sen, S. C.
98.	1844	Sarma, B. D.
99.	2259	Sahabanik, S. K.
100.	2266	Son, S. C.
101.	1452	Sharma, P.
102.	1967	Sarkar, S. P.
103.	2281	Zaman, M.
		7. BIHAR
104.	412	Datta, A. K.
105.	1286	Ghosh, Taradas
106.	2212	Lall, A. B. B.
107.	2234	Prasad, Birendra
108.	1250	Prasad, N. K.
109.	733	Prasad, Bhagwat
110.	1291	Sinha, Nilkanth
111.	1992	Sinha, D. K.
112.	1902	Sinha, S. P.
113.	1708	Sahay, S. N.
114.	1855	Sahay, B. N.
115.	2032	Sinha, D. N.
116.	856	Sircar, Dr. S. K.
117.	2071	Sinha, S. B. P.
118.	1300	Varma, D. N.
		8. BOMBAY
119.	32-Associate	Antia, Dr. F.P.—Representing M/s. Cement Marketing Co. of India Ltd., Bombay.
120.	1241	Antia, K. F.
121.	1189	Amin, M. P.
122.	1522	Apte, M. P.
123.	1852	Bawishi, V. M.
124.	383	Batlivala, H. S.

S. No.	Roll No.	Name.
125.	1395	Borwankar, S. G.
126.	2222	Bhakta, R. M.
127.	1877	Cassad, D. P. R.
128.	614	Dhingra, A. D.
129.	1322	Desai, C. N.
130.	1336	Daftary, N. D.
131.	2166	Desai. T. D.
132.	1739	Desai, I. C.
133.	1965	Desai, R. B.
134.	858	Gandhi, J. H.
135.	663	Gupchup, N. S.
136.	1858	Ghia, R. T.
137.	80	Griffiths, W. A.
138.	2205	Harris, C. D.
139.	1129	Iyengar, C. L. N.
140.	1474	Jagus, P. J.
141.	2033	Jayawant, M. B.
142.	2223	(Miss) Joshi, Shakuntala
143.	315	Joshi, S. B.
144.	2214	Joshi, S. R.
145.	1657	Kale, M. D.
146.	2217	Kanethkar, N. V.
147.	1002	Mehta, M. A.
148.	1482	Modi, I. K.
149.	1946	Mascarenhas, W. X.
150.	1723	Natu, S. V.
151.	342	Nicolaides, E. P.
152.	2265	Navare, V. V.
153.	23	Nadirshah, E. A.
154.	2272	Oza, G. B.
155.	1528	Patkar, B. B.
156.	1944	Raju, V.
157.	1506	Shah, S. G.
158.	2014	Sahasrabuddhe, S. C.
159.	1432	Sujan Singh
160.	1148	Shivdasani, P. D.
161.	1854	Vyas, I. D.
162.	84	Vagh, B. V.
		9. DELHI
163.	58-Associate	Chandrasekhara, C. S.—Representing Indian Standards Institution, Delhi.
164.	1888	Chakraverti, N.
165.	2208	Dawar, A. R.
166.	2230	Madhavan, T. P.
167.	Invitee	Sehan, Surjan, S.
		10. HIMACHAL PRADESH
168.	2279	Tandon, Tara Chand
169.	961	Udham Singh
		11. KERALA STATE
170.	1599	Ayyar, V. V. Gopala Krishna
171.	1437	Koya, K. V. Ahamed

S. No.	Roll No.	Name.
172.	1663	Kumaran, M.
173.	2238	Mathew, K. George
		12. MADHYA PRADESH
174.	1741	Bhattacharya, P. B.
175.	1575	Ghatpande, G. S.
176.	1643	Gupta, H. R.
177.	2243	Husain, M. M.
178.	1070	Jaywant, L. K.
179.	782	Kumar, G. L.
180.	2245	Saksena, R. K.
181.	2286	Wasan, O. P.
		13. MADRAS
182.	2190	Annamalai, A.
183.	2037	Karnik, A. V.
184.	1717	Mahadevan, S. H.
185.	1901	Malya, M. R.
186.	664	Mudaliar, T. S. Kethara
187.	1792	Nambiar, P. G.
188.	268	Nambiar, K. K.
189.	1125	Padmanabhan, C. V.
190.	1881	Rao, K. Sreenivasa
191.	2264	Raju, V. D. Seshagiri
192.	1671	Syed Abdul Latheef
		14. MANIPUR
193.	1448	Krishnan, E.
194.	2262	Mukherjee, B. M.
195.	2261	Singh, H. A.
		15. MYSORE
196.	1043	Daver, F. K.
197.	1641	Ganapathy, G. S.
198.	2283	Joshi, K. M.
199.	2268	Murthy, C. R. Keshava
200.	2284	Rao, K. V.
201.	2269	Sivarudrappa, B. S.
		16. ORISSA
202.	204	Bennett, C. M.
203.	886	Gupta, Govinda
204.	304	Jootla, Baboo Singh
205.	2204	Mukherjee, P. K.
206.	2277	Patanik, B. C.
207.	489	Sheth, K. L.
		17. PUNJAB
208.	2124	Bahl, Y. N.
209.	2108	Dharm Pal
210.	457	Dogra, R. N.

S. No.	Roll No.	Name.
211.	2276	Grover, S. P.
212.	2176	Mintzer, Olin W.
213.	154	Nayar, D. P.
214.	504	Sharma, D. C.
		18. RAJASTHAN
215.	827	Bhargava, I. D.
216.	864	Mathur, C. B. L.
217.	1764	Malhotra, J. M.
218.	1972	Mehta, Kesri Singh
219.	2191	Sharma, M. C.
		19. TRIPURA
220.	307	Sen, A. K.
		20. UTTER PRADESH
221.	1664	Bhargava, N. C.
222.	213	Bagchi, C. C.
223.	2233	Bipin Chandra
224.	2242	Braganza, V.
225.	205	Bisht, M. S.
226.	896	Charan, S. K.
227.	2244	Dikshit, S. C.
228.	2081	Ghatak, J.
229.	942	Garg, S. K.
230.	1926	Kala, B.
231.	2235	Mital, R. P.
232.	859	Patel, A. T.
233.	490	Shobha Ram
234.	1423	Srivastava, A. K.
235.	2061	Shitala Sharan
236.	960	Sinha, K.
237.	45	Srivastava, M. P.
238.	1166	Uma Kant
239.	505	Verma, H. G.
240.	1576	Vidyarthi, S. D.
		21. WEST BENGAL
241.	2248	Banerjee, Amitava,
242.	2273	Bose, H. K.
243.	1456	Banerjee, S. N.
244.	1628	Bose, A. K.
245.	2260	Bose, C. M.
246.	15-Associate	Bhattacharjee, B.B.—Representing M/s Heatly Gresham, Calcutta.
247.	2255	Banerjee, S. P.
248.	66-Associate	Banerjee, H. C.—M/s. Gannon Dunkerley Ltd., Calcutta.
249.	962	Banerjee, J. K.
250.	1426	Chatterjee, P. C.
251.	2247	Chanda, S. K.
252.	45-Associate	Chatterjee, D. — Representing M/s. Shalimar Tar Products Ltd., Calcutta.
253.	2239	Chaudhury, T. R.
254.	2285	Chakraborty, S. K.

S. No.	Roll No.	Name.
255.	2263	Dutta, P. K.
256.	41-Associate	De, K. C. — M/s. Bengal Chemical, Calcutta.
257.	15	Datta, A. K.
258.	2250	De, P. L.
259.	231	Fielder, C. J.
260.	936	Gupta, S. N.
261.	1030	Ghosh, A. K.
262.	808	Ghosh, S. K.
263.	863	Gupta, P. N. Sen.
264.	1462	Ghosh, D. N.
265.	2067	Jali, L. M.
266.	2249	Mukherjee, M. K.
267.	*Invitee*	Macgregor, J. C.
268.	38-Associate	Mathur, U.—Representing M/s. Marshall Sons, Calcutta.
269.	316	Mitra, T.
270.	1309	Majumdar, S. N.
271.	67-Associate	Mahadevan, M. R. — Representing M/s. United Provinces Commercial Corporation, Calcutta.
272.	488	Nagarkar, D. B.
273.	2160	Pradhan, S. N.
274.	21-Associate	Patel, L. R.—Representing M/s. William Jacks & Co., Calcutta.
275.	766	Roy, R. C.
276.	1562	Rao, S. Subba.
277.	1785	Shah, Z. S.
278.	2246	Sen, S. K.
279.	65-Associate	Wahi, K. M.—Representing M/s. Agrind Fabrications, Calcutta.
		22. FRANCE
280.	*Invitee*	Guyon, Y.
		23. PAKISTAN
281.	1549	Doctor, P. K.
		24. U. S. A.
282.	*Invitee*	Dyke, A. J. Van.

INDIAN ROADS CONGRESS

BALANCE SHEET AS AT 30TH SEPTEMBER, 1956.

(Excluding Transport-Communications Monthly Review).

LIABILITIES		Rs A. P.	Rs A. P.
SUNDRY LIABILITIES			
Creditors for Expenses	...	5,039 15 0	
Incometax payable on salaries	...	13 4 0	
Shri McKelvie's Silver Salver Fund	...	120 13 6	
Advance for Publications	...	31 6 0	5,205 6 6
Subscription received in Advance from :			
Ordinary Members :			
1956—57 621 6 0			
1957—58 106 0 0			
1958—59 40 0 0		767	
Associate Members :			
1956—57	...	245 0 0	1,012 6 0
MITCHELL MEDAL FUND (Invested as per contra)	...		2,154 4 0
BUILDING, MUSEUM & TECHNICAL FUND			
Balance as per last Balance Sheet	...	1,46,414 12 0	
Add : Amount of Life Membership	...	1,102 0 0	
Interest on Investments	...	5,547 7 3	
Appropriated from Income & Expenditure Account	...	3,146 8 9	1,56,210 12 0
PROVIDENT FUND DEPOSITS			28,232 8 0
PROVIDENT FUND INTEREST DISTRIBUTABLE			
Balance as per last Balance Sheet	...	386 3 4	
Add : Interest earned	...	663 14 0	
		1,050 1 4	
Less Distributed	...	597 5 0	452 12 4
AMOUNT HELD IN SUSPENSE			145 0 0
CHEQUES ISSUED BUT NOT ENCASHED			3,430 13 6
DUE TO T. C. M. R.			8,700 14 3
RESERVE FOR BAD & DOUBTFUL DEBTS			10,000 0 0
INCOME & EXPENDITURE ACCOUNT			
Balance as per last Balance Sheet	...	1,22,304 2 2	
Add : Balance being Excess of Income over Expenditure as per annexed Income & Expenditure Account	...	5,460 14 6	
		1,27,765 0 8	
Deduct : Appropriated to Building, Museum & Technical Fund	...	3,146 8 9	1,24,618 7 11
Total	...		3,40,163 4 6

(Sd.) J. SUBRAHMANYAM,
2-1-57
Secretary.

We have audited the Balance Sheet of the INDIAN ROADS CONGRESS (excluding Transport-Communications Monthly Review) as at 30th September, 1956, 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 the 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.,

Kashmere Gate,
Delhi.

ASSETS		Rs A. P.	Rs A. P.
EQUIPMENT			
Balance as per last Balance Sheet		6,916 11 3	
Additions during the year	...	1,327 11 3	
	...	8,244 6 6	
Less : Written off			
Depreciation written off 1 8 0 / 785 15 9		787 7 9	7,456 14 9
LIBRARY BOOKS			
Balance as per last Balance Sheet		2,114 0 9	
Additions during the year	...	342 12 0	
	...	2,456 12 9	
Less : Depreciation written off	...	245 12 9	2,211 0 0
DRAWING MATERIALS			
Balance as per last Balance Sheet		21 10 0	
Less : Written off 0 4 0	...		
Depreciation written off 1 8 0		1 12 0	19 14 0
STOCK-IN-HAND			
(Certified as to quantities & values by the Secretary)			
Journals		50,747 12 0	
Paper	...	7,519 7 0	58,267 3 0
SUNDRY DEBTORS			
Subscriptions in arrears from Ordinary Members	...	10,117 10 0	
Outstandings - Publications	...	2,115 15 0	
Subsidies Receivable	...	27,500 0 0	
Advertisement Charges (of which Rs 360-12-0 are considered bad & doubtful)	...	2,052 12 0	
Session Expenses Receivable :			
Transport Charges (of which Rs 275/- considered doubtful) 400 0 0			
Delegation Fees 3,530 0 0		3,930 0 0	
Compensatory Allowance Receivable from Staff		196 0 0	
Due from Central Railway, Bombay	...	283 4 0	
Due from V. N. Parikh against Session Expenses	...	9 11 0	46,205 4 0
INTEREST ACCRUED ON INVESTMENTS			12,407 8 0
INCOME TAX DEDUCTED AT SOURCE			145 8 0
INVESTMENTS			
Rs 6,000/- 5 years Post Office Certificates		6,000 0 0	
Rs 54,000/- 12 years National Savings Certificates	...	54,000 0 0	
Rs 62,000/- 10 years Treasury Savings Deposit Certficates	...	62,000 0 0	
Rs 21,300/- 3% Loan 1963-65	...	20,271 10 0	
Rs 11,100/- 3½% National Plan Loan 1964	...	10,984 2 0	
Rs 3,000/-3½% National Plan Bonds 1967	...	2,955 0 0	1,56,210 12 0
ADVANCES			
Deputy Controller, Stationery & Printing, Calcutta	...	2,249 14 0	
Staff (against Cycle Purchased)	...	291 6 0	
Government of India, Ministry of Transport (Roads Wing, Establishment of Bullock Cart Committee)	...	72 5 0	2,613 9 0
PROVIDENT FUND			
12 years National Savings Certificates		24,200 0 0	
Interest accrued thereon to 30th Sept., 1956	...	1,870 0 0	
Balance with State Bank of India	...	7 4 0	
Loans Advanced	...	2,334 0 0	28,411 4 0
MITCHELL MEDAL FUND			
Rs 1,600/- 3% Loan 1963-65		1,652 14 11	
Interest accrued thereon	...	16 0 0	
Balance with State Bank of India	...	485 5 1	2,154 4 0
CASH & BANK BALANCES			
With State Bank of India		22,475 5 9	
Cheques pending realisation	...	1,151 6 0	
Cash with Cashier for retiring R. R.	...	350 0 0	
Stamps in hand	...	83 8	

INDIAN ROADS CONGRESS

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 30TH SEPTEMBER, 1956.

(Excluding Transport-Communications Monthly Review)

EXPENDITURE		Rs A. P.	Rs A. P.	INCOME		Rs A. P.	Rs A. P.
To Opening Stock of Journals as on 1st October, 1955	...	50,840 4 0		By Subscriptions :			
,, Paper Consumed	...	12,081 3 9		Ordinary Members	...	28,965 0 0	
,, Printing Charges	...	17,616 3 6		Associate Members	...	3,500 0 0	
		80,537 11 3		Life Members	...	80 0 0	
							32,545 0 0
Less : Closing Stock of Journals as on 30th September, 1956	...	50,747 12 0	29,789 15 3				
,, Establishment	...		27,848 5 0	,, Entrance Fees :			
,, Local & other Allowances	...		17,224 7 0	Ordinary Members	...	2,075 0 0	
,, Honorarium to Secretary	...		1,200 0 0	Associate Members	...	360 0 0	2,435 0 0
,, Bank Charges (Net)	...		197 14 9	,, Sale of Publications	...	10,026 7 0	
,, Provident Fund Contribution	...		1,773 0 0	,, Advertisements	...	6,634 0 0	16,660 7 0
,, Audit Fee	...		600 0 0	,, Subsidies (including arrears.)	...		44,000 0 0
,, Postage & Telegrams	...		5,319 15 6	,, Interest	...		16 7 6
,, General Printing & Stationery	...		1,497 4 6	,, Receipts on account of :			
,, Miscellaneous	...		1,419 11 9	Delegation Fees	...	9,050 0 0	
,, Commission on Advertisements — 1954-55				Transport Charges etc.	...	1,665 0 0	
,, Uniforms to Class IV Servants	...		15 0 0	Lodging charges recovered	...	823 4 0	11,538 4 0
,, Publicity Account	...		443 3 0	,, Miscellaneous Income	...		338 4 0
,, 20th Session Expenses	...		500 0 0				
,, Subscriptions to other Societies	...		7,508 10 9				
,, Bad Debts written off	...		350 0 0				
,, Equipment written off	...		5,350 0 0				
,, Depreciation written off	...		1 12 0				
,, Balance being Excess of Income over Expenditure carried to Balance Sheet	...		1,033 4 6				
	...		5,460 14 6				
Total			1,07,533 6 6	Total			1,07,533 6 6

Kashmere Gate,
Delhi.
Dated, this 3rd day of January 1957.

(Sd.) J. SUBRAHMANYAM,
2—1—1957
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, 1956.

EXPENDITURE		Rs A. P.	INCOME		Rs A. P.
To Paper Consumed	...	4,736 8 6	By Sales & Subscriptions of the Journal	...	4,139 6 6
,, Printing Charges	...	6,126 3 0	,, Advertisements	...	8,725 14 0
,, Postage	...	1,378 10 0	*Note*:—Subscriptions for unexpired period have not been adjusted in the accounts.		
,, Miscellaneous Expenses	...	7 15 0			
,, Bank Charges	...	54 12 0			
,, Balance being Excess of Income over Expenditure carried to Balance Sheet	...	561 4 0			
	Total ...	12,865 4 6		Total ...	12,865 4 6

BALANCE SHEET AS AT 30TH SEPTEMBER, 1956.

LIABILITIES		Rs A. P.	Rs A. P.	ASSETS		Rs A. P.	Rs A. P.
SUNDRY CREDITORS				**BOOK DEBTS**			
For Expenses	...		50 0 0	For Advertisement (of which Rs 222-1-0 considered doubtful)	...	2,110 9 0	
				For Sale of Journal	...	97 2 5	2,207 11 6
SURPLUS ACCOUNT				**DUE FROM GENERAL ACCOUNT**	...		8,700 14 3
Balance as per last Balance Sheet	...	10,909 4 9		**STOCK IN HAND** (Certified as to quantities & values by the Secretary)	...		611 15 0
Add: Balance being excess of Income over Expenditure as per annexed Income & Expenditure Account	...	561 4 0	11,470 8 9				
	Total ...		11,520 8 9		Total ...		11,520 8 9

(Sd.) J. SUBRAHMANYAM,
2—1—1957
Secretary.

We have audited the Balance Sheet of the INDIAN ROADS CONGRESS (Transport-Communications Monthly Review) as at 30th day of September, 1956, 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.

Kashmere Gate,
Delhi.
Dated, this 3rd day of January 1957.

(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 GENERAI BODY OF MEMBERS FOR THE PERIOD 1ST JANUARY TO THE 31ST DECEMBER 1956.

[*The report covers the period from the 1st January to the 31s December 1956 though a few matters referred to in it are carrie beyond the latter date for convenience and completeness of record*].

1. GENERAL

The Twentieth Session of the Indian Roads Congress wa held at Nagpur in Junuary 1956 when 240 members and 7 invitee attended the Session. The 8 Papers published in the Journal o the Indian Roads Congress, Volume XX-parts 1 to 3, were rea and discussed. Four Committees and seven Subcommittee were reconstituted to deal with various engineering and adminis trative problems. The Executive Committee held three meeting at New Delhi on the 21st April, 1956, 22nd November, 1956, an the 9th and 10th April, 1957.

2. ADMINISTRATION

Shri P. L. Varma, Chief Engineer, P. W. D. Punjab, wa elected President at the Nagpur Session. Shri H. P. Mathran continued to function as Honorary Treasurer till 11-10-195 when he retired. In his place, Shri H. P. Sinha, Consultin Engineer to the Govt. of India (Road Development) took ove as Honorary Treasurer of the Society under Rule 11-b of th Memorandum of Association, Rules and Regulations, etc. Shr Goverdhan Lal, Additional Consulting Engineer to the Govt. o India (Roads) continued to work as Honorary Deputy Treasurer

Shri J. Subrahmanyam continued as Honorary Secretary.

3. OFFICE

The office continued to function in New Delhi. It disposed of 9,465 receipts and issued 18,760 letters during the perio under report.

The staff worked satisfactorily.

4. MEMBERSHIP

(i) The number of members on the rolls on the 30th September 1956 was 1493 (1458 ordinary and 35 associates). During the year there were 180 new admissions and 65 removals from the rolls. The removals were the result of: resignations 17; deaths 6; non-payment of arrears of subscription 42.

(2) **Life membership:** During the Congress year, 1st October 1955 to the 30th September 1956, 8 members enrolled as life members. The number of life members on the 30th September 1956, was 133. 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:

S. K. Dutta	P. Lakshminarasu
Murthi V. N. Sripada	Sohan Lal
Rashdhari Prasad	S. E. Akhtar
V. N. Rangaswami	S. M. Kar
P. R. Nagabushnam	

6. BUDGET

The budget for the year 1956-57 and the "Actuals" for 1955-56 were approved by the Executive Committee at their meeting held on the 22nd November 1956. The estimates have been placed before the Council at the 48th meeting. The actuals for 1955-56 show a surplus of Rs 28,669 against an estimated deficit of Rs 24,949.

The total contribution received from the Governments of India and States during the year ending the 30th September 1956 amounted to Rs 57,500. 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 24,500, have been received after the 30th September 1956.

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 approching States for fresh sanctions as a result of the reorganisation of States has been examined and they will be addressed shortly.

The arrears of subcriptions at the beginning of the Congress year 1955-56 amounted to Rs 12,352-8-0 which were due from 222 members. The names of 42 members, who had failed to pay, were removed from the rolls. Consequently, a sum of Rs 5,350 standing as arrears against these members was written off by the Executive Committee during the year 1955-56.

A sum of Rs 2,885 was realised from 70 members.

After adding the arrears for 1955-56, the total of arrears on the 1st October 1956 stood at Rs 10,117-10-0 due from 203 members. Efforts are being made to realize the arrears.

7. AUDIT

At the Twentieth Session at Nagpur it was decided to appoint M/s Walker, Chandiok and Co., Chartered Accountants and Auditors, Delhi, to audit the accounts of the Congress for 1955-66. The report was examined by the Executive Committee on the 9th and 10th April 1957. It was also placed before the Council at their 48th meeting on the 11th May, 1957.

8. PUBLICATIONS

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

The following three publications, which had been out of stock, were again printed.

(1) Nagpur Report

(2) Route-Marker Signs for National Highways

(3) Type Designs for Highway Milestones.

The balance of the publications on the 30th September 1956 was as under:

Name of Proceedings	*Volume*	*Balance*
I. R. C. Proceedings	I to VII-part 1 & VIII	Sold out
Do.	VII-part 2	46
Do.	IX-part 4	119
Do.	IX (Bound)	101
Do.	X-parts 1 to 3	Sold out

Name of Proceedings	*Volume*	*Balance*
I. R. C. Proceedings	X-part 4	228
Do.	X (Bound)	Sold out
Do.	XI-parts 1 & 2	21
Do.	XI-parts 3 & 4	25
Do.	XI-part 4	166
Do.	XII-part 1	6
Do.	XII-part 2	405
Do.	XII-part 3	387
Do.	XII-part 4	458
Do.	XII-part 5	422
Do.	XII-parts 1 to 3 (Bound)	360
Do.	XII-parts 4 & 5 (Bound)	173
Do.	XIII-part 1	276
Do.	XIII-part 2	363
Do.	XIII-part 3	712
Do.	XIII-part 4	Sold out
Do.	XIII-parts 1 & 2 (Bound)	530
Do.	XIII-parts 3 & 4 (Bound)	102
Do.	XIV-part 1	289
Do.	XIV-part 2	379
Do.	XIV-part 3	295
Do.	XIV-part 4	414
Do.	XIV-parts 1 to 4 (Bound)	473
Do.	XV-part 1	741
Do.	XV-part 2	328
Do.	XV-part 3	335
Do.	XV-part 4	399
Do.	XV-parts 1 to 4 (Bound)	508
Do.	XVI-part 1	Sold out
Do.	XVI-part 2	100
Do.	XVI-part 3	123
Do.	XVI-part 4	149
Do.	XVI-parts 1 to 4 (Bound)	625
Do.	XVII-part 1	51
Do.	XVII-part 2	126
Do.	XVII-part 3	Sold out
Do.	XVII-part 4	156
Do.	XVII-parts 1 to 4 (Bound)	687
Do.	XVIII-part 1	Sold out
Do.	XVIII-part 2	6

Name of Proceedings	*Volume*	*Balance*
I. R. C. Proceedings	XVIII-part 3	30
Do.	XVIII-part 4	124
Do.	XVIII-parts 1 to 4 (Bound)	855
Do.	XIX-part 1	Sold out
Do.	XIX-part 2	21
Do.	XIX-part 3	Sold out
Do.	XIX-part 4	50
Do.	XIX-parts 1 to 4 (Bound)	96
Do.	XX-part 1	88
Do.	XX-part 2	80
Do.	XX-part 3	164
Road Research Bulletin No. 1		130
Road Research Bulletin No. 2		165
Nagpur Report		1003
Paper on "Water-Bound Macadam"		Sold out
Type Designs for Boundary and Furlong Stones		3719
Route-Marker Signs for National Highways		15
Dimensions and Weights of Road-Design Vehicles		1489
Recommended Practice for the Location and Layout of Roadside Motor-Fuel Filling Stations		827
Standard Specifications and Code of Practice for Road Bridges – Section I – General Features and Design		3788
Paper No. 167 - "Design of Small Bridges and Culverts"		310

It is noticed that the demand for the last Part of every Volume is smaller than 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 complete 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 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 their 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 305 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 1956 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) Bearings for bridges
(2) Box culverts
(3) Cement concrete mixes for RCC bridge piers
(4) Dial deflectometers
(5) Instruments for measuring the roughness of roads
(6) I. R. C. Standard Specifications and Code of Practice for Road Bridges in India
(7) Location and siting of petrol pumps
(8) Manhole covers on main roads
(9) Masonry arches

(10) Prevention of sand dunes on road
(11) Lighting Standards for roads
(12) R. C. C. slabs and T-beams
(13) Road maps
(14) Road junctions
(15) Road milage
(16) Sight Distances
(17) Stone metal specifications
(18) Strengthening arch bridges
(19) Suspension bridges
(20) Traffic counters
(21) Type designs of village name-boards, furlong stones and road traffic signs
(22) Water-bound macadam

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 Institutions 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 XXI-part 1 of the Journal of the Congress. Lists of additions to the two libraries are published monthly 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.

125 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 1,500. Members have to be urged to make more use of these libraries. Photostat copies of any articles can be supplied on payment.

11. MEDALS AND PRIZES

The Executive Committee, in their meeting during the Session at Nagpur, accepted the recommendations of the Papers

Subcommittee for the award of Medals for Papers read at the Nineteenth Session and announced the following awards :

(1) "The Indian Roads Congress Medal" to Shri P. C. Varghese for his Paper No. 171 "A New Approach to the Analysis of Stability of Slopes," published in Vol. XIX-part 1 of the Journal of Indian Roads Congress.

(2) "The Indian Roads Congress Medal" to Col. S.K. Bose for his Paper No. 179 on "The Influence of a Superimposed Layer in Increasing the Load Bearing Capacity of a Rigid Pavement" published in Vol. XIX-part 3 of the Journal of the Indian Roads Congress.

The following Papers were highly commended :

Paper No. 172— "Bituminous Treatment of Brick Metal Water-Bound Macadam Surfaces in U. P." by D. C. Chaturvedi.

AND

Paper No. 177— "Design and Construction of Prestressed Concrete Bridge Across River Palar" by K. K. Nambiar.

2. COLLECTION OF PARTICULARS OF BRIDGES

The Indian Roads Congress have been collecting particulars of bridges of lengths of 100 feet 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. As soon as compilation is complete, the question of its publication will be taken up.

3. 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.

Shri H. P. Sinha continued to represent the Indian Roads Congress on the Engineering Division Council of the Indian Standards Institutions.

The following continued to represent as the principal and alternative representatives of the Indian Roads Congress on the Building Division Council of the Indian Standards Institution.

Principal Representative	—Shri S. B. Joshi
Alternative ,,	— ,, H. P. Sinha

In April 1957, Shri M. S. Bhatia was nominated as the alternative representative in place of Shri H. P. Sinha.

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

EDC : 2—Cement	...Shri E. P. Nicolaides
EDC : 20—Drawings	...Shri H. P. Sinha
EDC : 7—Bitumen & Tar Products	Shri K. K. Nambiar Shri Brijmohan Lal
BDC :— Terminology Notations and Drawings Sectional Committee	Shri J. M. Trehan (Principal representative) Shri J. Subrahmanyam (Alternative representative)
BDC : 7-Structural Steel Sectional Committee	Shri D. S. Desai (Principal representative) Shri M. P. Nagarsheth (Alternative representative)
BDC : 14—Bridges Sectional Committee	Shri J. Chambers (Principal representative) Shri D. S. Desai (Alternative representative)

The following are the principal and alternative representatives of the Indian Roads Congress on Tar and Tar Products Subcommittee :

Principal representative	—Shri S. N. Gupta
Alternative ,,	—Shri G. C. Khanna

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

(4) The Board of Engineering Research on which the Indian Roads Congress was represented has since been abolished.

(5) Expert Panel to guide the indigenous development of Road Making and Constructional Equipments.

The Government of India, Ministry of Heavy Industries have formed an "Expert Panel" to gather data to guide the indigenous development of Road Making and Constructional Equipments. Shri K. K. Nambiar has been nominated as the representative of the Indian Roads Congress on this Panel.

(6) Executive Council and Scientific Advisory Committee for the Central Road Research Institute.

The following represent the Indian Roads Congress Executive Council—President, Indian Roads Congress.

Scientific Advisory Committee —Shri Goverdhan Lal.

14. TECHNICAL ACTIVITIES

(1) Specifications and Standards Committee

The Committee held meetings on the 9th and 10th January 1956. The following subjects were discussed.

(i) Standardising the Affinity Test

(ii) Specifications for ¾-in. Light Chipping Tar Carpet.

(iii) Paper on "The Influence of a Superimposed Layer in Increasing the Load Bearing Capacity of a Rigid Pavement" by Col. S. K. Bose.

(iv) Recommended Practice for the Design and Layout of Cycle Tracks

(v) Recommended Practice for the Location and Layout of Motor-Fuel Filling Stations.

(vi) Hindi Equivalents for Highway Engineering Terms.

Under item (i) the question of standardising the Affinity Test was entrusted to a Subcommittee and the report is awaited.

Item (ii). A specification for ¾-in. light chipping tar carpet is under consideration.

Item (iii). The Committee discussed the Paper on "The Influence of a Superimposed Layer in Increasing the Load Bearing Capacity of a Rigid Pavement" by Col. S. K. Bose. The Research Organization Division had been requested to initiate action in regard to (a) research on methods of strengthening cement concrete pavements to form the basis of suitable specifications, (b) collection of data regarding temperature stresses in concrete pavements under Indian conditions, and (c) development of heat resisting bituminous pavements.

Item (iv). The Central Road Research Institute and the Punjab P. W. D. have 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. On receipt of the information a standard for the Design and Layout of Cycle Tracks will be finalised.

Item (v). As desired by the members of the Committee, the request of the Oil Companies asking for a relaxation in the I.R.C. Standard on "Recommended Practice for the Location and Layout of Motor-Fuel Filling Stations" was placed before the Chief Engineers' meeting. They recommended that the Specifications & Standards Committee might consider suitably amending the specifications previously fixed by them.

Item (vi). The Committee noted further comments received on Hindi Equivalents for Highway Engineering Terms.

Some members of the Committee have sent lists of subjects on which standards and specifications were required. These will be considered by the Committee.

The following subjects are under consideration of the Committee:

(i) Design of Road Intersections at Grade.

(ii) Testing Road Aggregates.

(iii) Standard Form for Recording Traffic Census.

(iv) Specifications for Water-Bound Macadam.

(2) Bridges Committee

Of Sections I & II of the Bridge Code released by the Committee, for printing, Section I dealing with General Features

of Design has since been printed and a good number of copies have been sold out. The printing of Section II dealing with "Loads and Stresses" has not, however, been possible since the Committee desires to reconsider some of its Clauses. Sections of the Bridge Code dealing with the following subjects have been under study:

(i) Prestressed Concrete.

(ii) Steel Structures.

(iii) Masonry Structures.

(iv) Reinforced Cement Concrete.

(3) Technical Subcommittee

(a) Test Track Division

The Subcommittee held its meetings on the 7th January, 3rd February, 17th December 1956 and on the 25th March 1957. The Local Committee of the Test Track Division also held a meeting on the 27th July 1956.

The first three meetings of the Subcommittee and a meeting of the Local Committee were held in connection with the 1955 series of tests that were carried out at the Test Track at Calcutta to observe the comparative performance of the 4 different types of stabilized soil base courses.

The following four test sections were laid in the straight portions of the track. The base of each consisted of 9 in. thick stabilized course with different materials in 2 layers, the bottom layer being 6 in. thick and the top layer 3 in. thick.

1st section—Soil stabilized with sand.

2nd section—Moorum stabilized with sand.

3rd section—Soil and sand stabilized with socofix.

4th section—Soil and sand stabilized with cement.

The wearing course over all the test sections consisted of a 1½ in. thick tar carpet.

At the Test Track Division meeting held on the 3rd February 1956, the members inspected the cross trenches dug in the test sections and observed as follows :

No deformation of the subgrade below the stabilized pavement was found.

Top 3 inch layer of all the base courses should be removed. Regarding test section No. 3, the bottom 6 inch layer also should be removed and relaid if a binder other than Socofix was found to be the best after laboratory test. A tar carpet using one inch graded metal should be laid over the stabilized pavement.

The carpet should be matured for at least 15 days before ironing out the surface and steel tyred test carts should be started after inspection of the surfaces by the local members of the Subcommittee.

It was also decided that the plate bearing tests should be carried out on the existing stabilized pavements and on the relaid layers of the stabilized pavements.

Layers of the stabilized pavements were relaid and the surface was ironed out by pneumatic tyred test carts. The local members of the Subcommittee after inspection of the surfaces decided that tests should be started immediately but the surface was to be maintained in a proper condition.

The tests were completed on the 27th October 1956. Cross trenches were dug out in each of the Test Sections up to the sub-grade level. At the Test Track Division meeting held on the 17th December 1956, the members after inspection of the trenches drew the following conclusions:

Test section No. 1—The sand-soil stabilized pavement can be used in place of soling but there should be at least a minimum 3-in. consolidated layer of water-bound macadam course in between the surfacing and the stabilized base.

Test section No. 2—The results were somewhat better than Section No. 1, but the Committee thought that there should be a sandwitched course of at least a 3-in. consolidated layer of water-bound macadam course in between the surfacing and stabilized base.

Test section No. 3—This section did not prove successful. It was felt that if more time was given to the surfacing for aeration and for volatalization of oils and also if compaction was done in layers not more than 2 in. thick, the results might be better. But it was felt that the process would be prolonged and expensive. As such it was not considered practical.

Test section No. 4—The results of the sand-soil-cement stabilized pavement were very satisfactory. The correct surfacing to be laid over this type of stabilized pavement should be evolved.

The Subcommittee also discussed the shifting of the Test Track to a new site. The question of having a straight track-way on a diversion of the Diamond Harbour Road for carrying out experiments under actual traffic conditions in the same way as on Delhi-Mathura Road, is under consideration.

(*b*) *Research Organisation Division*

The Subcommittee held meetings on the 11th January 1956 and the 12th December 1956. At the meeting held on the 11th January 1956, the Subcommittee discussed the following research notes:

(i) Effect of kankar on the compaction and stability of soils;

(ii) Stress strain characteristics of some typical Punjab soils;

(iii) Sand bituminous stabilization for road construction.

While discussing item (iii) above, it was thought that where the subgrade was sand, a carpet could be laid directly over it (without any stabilized sub-base) by providing brick-on-end edging on both sides to confine the sand under the carriage-way and rolling the confined sand. The Director, Central Road Research Institute was requested to carry out laboratory experiments to study the specification. A note on the subject received from the Director, Central Road Research Institute is being examined.

The recommendation of the Subcommittee regarding the earmarking of funds for research was considered by the Council at their 47th meeting held at Nagpur on the 12th January 1956. The following resolution passed by the Council has been forwarded to the Government of India.

> "Resolved that the Indian Roads Congress should request the Government of India, to take requisite action to ensure that at least 1 per cent of the Central Road Fund allocation of each State be earmarked for equipment and maintenance of road research and testing laboratories in the States".

As desired by the Subcommittee, 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 under report. The position was reviewed by the local members of the Subcommittee at their meeting held on the 16th July 1956. At this meeting, it was decided that the annual reports (research) should be studied and a general report prepared for discussion at the Indian Roads Congress Sessions. The Director, Central Road Research Institute, agreed to undertake the preparation of the general report which will be discussed by the local members of the Subcommittee prior to its publication in the Journal for discussion at the Indian Roads Congress Session. The first general report on road research has been approved by the local members of the Research Organisation Division at a meeting on 5-4-1957. This is published in Volume XXI-part 3 for discussion at the Session of the Congress at Shillong.

As recommended by the Subcommittee, the Central and State Governments and other authorities have been requested to send some research workers as delegates to the annual Sessions of the Congress.

The Subcommittee decided at their meeting, held on the 12th December 1956, that the following research notes along with the comments and replies of Authors be published in the Journal of the Indian Roads Congress:

(i) "Effect of Size on Compressive Strength of Soil Blocks" by H. L. Uppal.

(ii) "Further Studies of Water-proofing of Alkaline Soils by Linseed Oil Cake" by B. R. Sen, Manohar Lal and B. L. Dhawan.

(iii) "Laboratory Investigations on the Effect of Addition of some Surface Active Agents to Stabilized Soil Mixtures" by I. S. Uppal and O. P. Wason.

(iv) "Effect of Kankar on the Compaction and Stability of Soils" by D. C. Chaturvedi, Manohar Lal and J. P. Bhatnagar.

These research notes along with the comments of the members and replies of Authors have since been published in Volume XXI-parts 1, 2 and 3 and Road Research Bulletin No. 3.

The recommendation of the Specifications and Standards Committee regarding the Paper on "The Influence of a Superimposed Layer in Increasing the Load Bearing Capacity of a Rigid Pavement" was considered.

The Central Road Research Institute and the Madras Road Research Station agreed to conduct research on temperature stresses in rigid pavements under Indian conditions. The Central Road Research Institute has already been investigating methods for strengthening concrete pavements and their resistance to abrasion.

It was decided that the specifications for the development of heat-resisting bituminous pavements should be obtained from the manufacturers of tar and bitumen and passed on to the Central Road Research Institute for further action.

As decided by the Subcommittee at their meeting held on the 14th May 1955, more information has been called for from the Engineer-in-Chief on his note on "Rapid Road Construction". After this information is received, the note will be circulated to members.

The list of research problems prepared by the Subcommittee will be sent to research laboratories.

(4) Soil Research Subcommittee

The Subcommittee held meetings on the 10th January 1956 and the 11th February 1957.

As decided by the Subcommittee at their meeting held on the 20th June 1955, information about the specifications for stabilized soil base courses and wearing courses current in different regions of the country was called for and passed on to the Central Road Research Institute for drafting specifications.

As decided by the Subcommittee, the State P. W. Ds., the Engineer-in-Chief, and some firms of repute were requested to send lists of minimum equipment necessary for soil stabilization in connection with investigations in the laboratory and construction in the field. Some information has already been received. The preparation of a suitable list of equipment necessary for soil stabilization work will be taken up in due course.

The Subcommittee has decided that, in reporting on gradation of soils, a summation curve should be given, as recommended in the Central Board of Irrigation and Power Publication No. 42.

The Subcommittee decided at their meeting held on the 10th January 1956 that a note on "Evolving a simple method

of designing the thickness of flexible pavements" should be prepared by the Central Road Research Institute and circulated to members for comments. At the Subcommittee meeting held on the 11th February 1957, the Director, Central Road Research Institute, informed the Committee that the subject was being studied at the Institute and a draft note would soon be ready.

The question of initiating studies to evolve a simple method, suitable for Indian conditions, of finding the bearing capacity of soils for deep foundations is also under the consideration of the Subcommittee.

As recommended by the Subcommittee, the specification on the use of soil-cement blocks in place of stones for urgent protection work in rivers, issued by the Central Board of Irrigation and Power, was circulated to Road Department of States for field trials and to various road research stations for trial and comments.

As decided by the Subcommittee at their meeting held on the 11th February 1957 the record of studies made in the Indian Roads Congress on the classification of soils for road purposes has been passed on to the Central Road Research Institute for preparing of a final draft.

The Committee also decided to examine whether the classification of soils for road purposes could be fitted into the I.S.I. Standards. It was also decided that nomenclature like clay, loam, etc., for different types of soils, normally available in India, should be incorporated in the note.

It was decided by the Subcommittee that the Central Road Research Institute should be requested to study the economy of the use of Seaman Pulvimixer by conducting full scale experiments.

The other subjects considered by the Subcommittee were :

(i) Report on the soil-cement sub-base for approaches to the Musi Causeway (Hyderabad) by Shri J. S. Narasimham.

(ii) A note on "Swell pressures developed by plastic clay" by Shri J. S. Narasimham.

(iii) A note on "Progress of soil research and its application in road development works in West Bengal" by Shri S. N. Gupta.

(iv) Report of the work done at the R. & B. Research Institute, West Bengal, 1954-55.

(v) A note on " Fixation of optimum size of particles of black cotton soil for stabilizing it with cement for sub-grades."

It was decided by the Subcommittee that item (v) should be referred to the Central Road Research Institute for study and further action.

(5) Education Subcommittee

The Subcommittee held a meeting on the 7th January 1956. On the recommendation of the Council, a copy of the syllabus for Highway Engineering Course prepared by the Education Subcommittee was forwarded to the Ministry of Education with the request that necessary steps should be taken for its introduction in Engineering Colleges. The Ministry of Education circulated the syllabus to the various Universities and their views were considered by the All-India Board of Technical Studies in Engineering and Metallurgy at its meeting held on the 26th May 1956. The recommendations of this Board were considered by the Central Committee of the All-India Council for Technical Education at its meeting held on the 14th July 1956. The Committee agreed with the views expressed by the Board that further increase in the content of the subject of Highway Engineering in the curriculum of the 1st degree course in Civil Engineering, as envisaged by the Indian Roads Congress, was not necessary and that specialised training in the subject should be imparted as a post-graduate course.

The Subcommittee discussed the organising of Refresher Courses for Highway Engineers working in Highway Departments. It was resolved that there should be no objection to the starting of such courses at Roorkee, Madras and also at Chandigarh.

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

The Subcommittee discussed the differences between the post-graduate courses in Highway Engineering of the Engineering College, Chandigarh and the Indian Institute of Technology, Kharagpur. The Subcommittee felt that they were of a minor nature and that a better appraisal of the courses would be possible at a future date.

The Executive Committee at their meeting held on the 22nd November 1956 expressed the view that the Education Subcommittee should draft a standard syllabus for a post-graduate course in Highway Engineering.

The Subcommittee think that a certain amount of basic training on highway technique should be included in the diploma courses for overseers and supervisors. The Subcommittee therefore agreed to frame a suitable syllabus for this purpose.

(6) Provincialization of Local Bodies Engineering Services Subcommittee

The Subcommittee held a meeting on the 10th January 1956. Some of the recommendations made by the Subcommittee are :

(i) The Indian Roads Congress should pursue the matter with the Planning Commission and the Ministry of Transport on the basis of the remarks contained in the Presidential Address on pages 11-12 regarding the service of the Highway Engineers.

(ii) State Governments which have not provincialized all their D. L. B. engineer services should be addressed on the subject.

As decided by the Executive Committee at their meeting held on the 4th September 1954, the Planning Commission were requested to bring to the notice of all States the excellent arrangements existing for the control of Local Public Works in Madras and advise the States to provincialize the engineering services of the Local Bodies under their jurisdiction in the manner Madras has done.

The Planning Commission had been in correspondence with the Government of India, Ministry of Transport, Roads Wing on the subject. As a result of this, the Ministry of Transport have recently addressed the State Governments. The Government of India are of the opinion that the Special Officer appointed for undertaking a study of the development of rural road communications should examine the proposal made by the Indian Roads Congress for the provincialization of the engineering services of Local Bodies. They have also expressed the view that the existing arrangements available with Local Bodies for the maintenance of roads in their jurisdiction are not in all cases adequate. A good deal of work has been done in the First Plan period on the construction of roads in municipal and rural areas under various programmes and it is continuing and is likely to increase in the Second Plan. In order that this work might not be wasted, proper arrangements for the maintenance of roads would have to be made. The Government of India have supported the view that the solution to this problem would be the provincialization of the engineering services of Local Bodies.

(7) Manufacture of Road-Making Machinery and Mechanization Subcommittee

The Subcommittee held a meeting on the 10th January 1956.

The Subcommittee noted the progress made in regard to the manufacture of diesel road rollers in India and suggested that suitable steps be taken to ensure that the industry was established along with phased manufacturing programme.

The Subcommittee noted that the Government of India had decided to establish another unit for the manufacture of Marshall type steam road rollers in order to cope with the demand for steam road rollers in the country and to ensure adequate supply of spare parts for road rollers already working in the country. The Subcommittee suggested that suitable steps be taken to expedite establishment of this industry.

The Subcommittee noted that the question of the manufacture of Baxter type stone crushers in India was under consideration with the Government of India. The Subcommittee decided to investigate the possibility of setting up another unit of stone crushing industry in the country.

The Subcommittee also noted the progress made in regard to the manufacture of various other items of Road Making Machinery.

As desired by the Subcommittee, Shri W. A. Griffiths has sent a Paper on bulk distribution of bitumen. This has been published as a Paper in Volume XXI-3 of the Journal of the Indian Roads Congress and will be discussed during the Session.

(8) Road Transport Operation Cost Committee

This Committee 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; (ii) the economy resulting from road improvements.

The Committee after a study of the data received in response to a questionnaire issued by them and taking into consideration the results of extensive experiments conducted in the U. S. A. on the effects of speed, nature of road surface, frequency of stops, etc., on operating cost had expressed the view that the various operators were working under widely different conditions and consequently the figures supplied by them were not comparable. It was, therefore, decided that two major State transport undertakings should be requested to carry out scientifically designed experiments under controlled conditions.

The details of a suitable design for the experiment were presented in the form of a Paper published in Volume XX-2 of the Journal of the Indian Roads Congress. The Paper was discussed at the last Session held at Nagpur in January 1956. It was also circulated widely among technical experts for comments.

The Committee at its meeting held on the 10th January 1956 considered the various written comments as well as discussions on the Paper. The Committee agreed to take into account all constructive suggestions. Necessary modifications in the design of the experiments were made and communicated to the U.P. and Bombay State Transport Undertakings who are conducting the experiments. The U. P. State Transport has put seven new Leyland 40-seater buses on six routes *viz.*, one concrete, four black-topped and one water-bound macadam, all with good surfaces. Bombay State Transport has put four new vehicles Kew Dodge type on four separate routes having surfaces of concrete (good), black top (good), water-bound macadam (good and bad). Daily data on milage travelled, consumption of fuel, lubricants, spare parts (inclusive of tyres and tubes) and average speed maintained each day are being collected. The Committee have received the data for 12 months from U.P. and for 6 months from Bombay. Analysis of the data is in hand.

(9) Cement Concrete Road Surfacing Subcommittee

A meeting of the Subcommittee held at Srinagar on the 18th June 1955 examined the record of the Panel Discussion on cement concrete road construction. The answers to the questions have been circulated to the members of the Council before publication.

(10) Road Transport Development Committee

Two meetings of the Committee were held at Nagpur one on the 7th and the other on the 9th January 1956. At these meetings the terms of reference for the Committee's work were discussed in detail and a draft prepared. As requested by the Subcommittee, Shri B. V. Vagh prepared a note on "Goods Transport in the Second Five-Year Plan" and it was circulated among the members of the Committtee for their comments.

The Committee again met on the 28th February 1957 and discussed the note and the comments thereon. The various recommendations made by the Subcommittee will be considered by the Executive Committee.

(11) Revision of Rules Committee

The Executive Committee, at their meeting held on the 21st April 1956, appointed a Committee to suggest changes in the

Memorandum of Association, Rules and Regulations of the Society, necessitated by the re-organization of States. A meeting of the Revision of Rules Committee was held on the 9th April 1957. The recommendations of the Committee were considered by the Executive Committee at their meeting in the afternoon of the same day. The Memorandum of Association, etc., was finalised by the Council at their 48th meeting.

15. MISCELLANEOUS

(1) PAPERS

Twenty-three Papers were received during the year. Five were already in hand. Out of these 28 Papers, nine were accepted for publication, nine were rejected, and ten are under consideration for the next session.

The first and foremost objective of the Society is advancement of the science of road building, towards which contribution of good Papers by members is essential. Members should be requested constantly to bear in mind that the knowledge they have 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 contibuting articles to the Transport-Communications Monthly Review.

(2) TEST VALUES OF ROAD STONES

The Government of India, Ministry of Transport 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—20TH SESSION

The Executive Committee at their meeting held on the 21st April 1956 considered the various suggestions made in the Presidential Address of the 20th Session. It was decided that the President in consultation with Shri K. K. Nambiar, Chief Engineer (Highways), Madras State should draft memoranda on

the following subjects:

(i) Establishment of non-lapsing funds for financing all road development and maintenance programmes.

(ii) Creation of an All-India Service of Engineers.

As decided by the Executive Committee, the suggestions made in the Presidential Address will also be discussed by the Council.

(4) PROPOSED NATIONAL GROUP OF THE INTERNATIONAL ASSOCIATION FOR BRIDGE AND STRUCTURAL ENGINEERING

The question of organising a National Group of the International Association for Bridge and Structural Engineering has been under consideration with the Government of India, Ministry of Transport, Roads Wing, and the Indian Roads Congress for some years. The aim of such a group will be to promote knowledge of bridge and structural engineering by arranging periodical discussions, publishing technical Papers, etc. In addition it will work as an agent of the parent body and transmit to members the Papers and other literature received from the International Association. The idea of organizing such a National Group has been well received by the engineering profession in India. Preliminary enquiries reveal that nearly 25 P.W.D. establishments and engineering associations and 300 individuals are willing to become members.

The matter was discussed at the Chief Engineers' meeting held on the 12th February 1953 and they decided that the National Group be organized by the Indian Roads Congress. The Executive Committee, therefore, set up a Committee to draft a constitution for the said Group. A draft constitution has been circulated to the members of the Committee for their comments. It is expected that this will be finalised shortly.

(5) PANEL DISCUSSION—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 have been passed on to the Central Road Research Institute for preparing a note on the subject for discussion by the Specifications and Standards Committee.

(6) ESTIMATES COMMITTEE OF LOK SABHA

The Estimates Committee of the Lok Sabha asked for the views of the Indian Roads Congress on problems connected with the expansion of National Highways and other roads in India. As decided by the Executive Committee, Shri P. L. Varma, the President, appeared before the Estimates Committee.

Appendix

LIST OF JOURNALS

1. Modern Castings and American Foundryman.
2. American Highways.
3. Annual Reports of the Institution of Engineers (India), Bombay Centre.
4. Automobile News.
5. Better Roads.
6. British Constructional Engineers.
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. De Ingenieur in Indonesia (In Dutch).
20. De l'Institut Technique Du Batiment et Des Travaux Publics (in French).
21. Engineering News of India.
22. Highways and Bridges and Engineering Works.
23. Highways Current Literature.
24. Highway Research Abstracts.
25. Indian Journal of Power and River Valley Developments.
26. Indian Minerals.
27. Insdoc List of Current Scientific Literature.

28. Irrigation and Power (Journal of the Central Board of Irrigation and Power).
29. Indian Railways.
30. Indian Standards Institution Bulletin.
31. Indian Construction News.
32. Journal of New Zealand Engineering.
33. Journal of Scientific and Industrial Research.
34. Journal of the Institution of Engineers (Australia).
35. Journal of the Institution of Engineers (India).
36. Journal of the Institution of Highway Engineers, U.K.
37. Journal of the Institution of Military Engineers, India.
38. Journal of the Institution of Municipal Engineers, U.K.
39. Journal of the Institute of Transport, U.K.
40. Journal of the Institute of Science.
41. Journal of the Japan Society of Civil Engineers, (In Japanese).
42. Link Belt Speeder News.
43. Magazine of Concrete Research.
44. Main Roads.
45. Motor Transport.
46. News-Letter of I. R. T. D. A.
47. Premier Automobile Journal.
48. Proceedings of the Institution of Civil Engineers, London.
49. Power Engineer.
50. Public Roads.
51. Quarterly Technical Bulletin (Indian), (Ministry of Railways).
52. Reinforced Concrete Review, U.K.
53. Road Abstracts, Road Research Laboratory, U.K.
54. Road International.
55. Roads and Road Construction.
56. Science and Engineering.
57. Shovel News.
58. State Transport Review, Bombay.
59. Strassen und Tiefbau (In German).

60. Strasse und Autobahn (In German).
61. Strasse und Verkehr (In German).
62. Surveyor and Municipal and County Engineer, U.K.
63. Texas Engineering Experiment Station News, U.S.A.
64. The Crushed Stone Journal (American).
65. The Highway Magazine.
66. The Indian Concrete Journal.
67. The Indian and Eastern Engineer.
68. The Engineering Journal (Canada).
69. The Structural Engineer, U.K.
70. The Texas Highways.
71. U.N.E.S.C.O. Bulletin for Libraries.
72. World Construction.
73. Wegen (Belgium).
74. Western India Automobile Magazine.

Minutes of the 49th Council Meeting of the INDIAN ROADS CONGRESS held at Shillong on the 16th May 1957.

The Council met with Shri P. L. Varma in the Chair.

Present :

F. P. Antia, Dr.
M. P. Apte
V. D. Bhandari
V. V. Gopalakrishna Ayyar
M. S. Bisht
S. K. Bose, Brig.
C. S. Chandreskharan
B. Chaudhury
A. D. Dhingra
R. N. Dogra
N. Durrani
C. J. Fielder
Goverdhan Lal
H. R. Gupta
R. K. N. Iyengar, Dr.
C. L. B. Mathur
S. R. Mehra
E. A. Nadirshah
K. K. Nambiar
D. P. Nayar
B. Prasad
Shoba Ram
R. C. Roy
P. D. Shivdasani
H. P. Sinha
H. G. Verma
J. Subrahmanyam—Secretary.

The following co-opted Members attended :

A. Z. Ahmed
K. F. Antia
K. Barua
D. G. Bhagat
C. M. Bennett
S. B. Joshi
S. N. Majumdar
A. K. Sen
Sujan Singh

The following attended by invitation :

C. S. Anantapadmanabhan
R. S. Bhalla
Y. Guyon
K. D. Lahkar
Udham Singh
J. M. Trehan
B. V. Vagh
B. N. Das, Col.

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 48th Council Meeting.

The Minutes of the 48th Council Meeting held at Shillong on the 11th May 1957 were confirmed after making a few modifications.

3. Office-Bearers.

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

President	...	M. S. Bisht
Vice-Presidents	...	(i) B. Chaudhury
		(ii) C. J. Fielder
		(iii) Kishori Lal
Honorary Secretary	...	A. J. D'Costa.

At this stage, the newly elected President, Shri M. S. Bisht took the Chair.

The Council appreciated the good work done by the out going office-bearers. The Council also passed with acclamation the following resolution in appreciation of Shri J. Subrahmanyam's services.

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

4. Venue of the next General Session.

The Council decided to hold the next Session of the Indian Roads Congress at New Delhi in January 1958. The Executive Committee was authorized to fix the dates and programme of the Session. The Council also accepted the suggestion of the Chief of the Transport Division, ECAFE, received through the Govt. of India, Ministry of Transport, to hold a Seminar on Low Cost Roads at the time of the next Session of the Indian Roads Congress.

5. Committees and Subcommittees.

It was decided that all the present Divisions and Subcommittees appointed by the Council should be called Committees. Subcommittees would generally be such bodies as may be appointed by the Committee.

The Convenors of Committees were appointed as under :

(1)	Specifications & Standards Committee	... Goverdhan Lal
(2)	Bridges Committee	... S. L. Bazaz
(3)	Test Track Committee	... T. Mitra
(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	... V. Raju
(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 Subcommittee 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)	Prevention of Ribbon Development Committee	... H. P. Sinha
(16)	Community Project Road Maintenance Committee	... K. K. Nambiar

A new Committee on Traffic Engineering was created and Shri D. G. Bhagat was appointed Convenor of the Committee.

6. Provincialization of Local Bodies Engineering Services.

The Council expressed the view that the State Governments themselves were likely to take into consideration the length of service and other factors while fixing the seniority of Engineering personnel of Local Bodies in State cadre at the time of provincializing such services. The Council felt that the I. R. C. should emphasise the need to have a common cadre of Local Board Engineers under the State Chief Engineers.

7. Report of the Road Transport Development Committee.

The Council considered the report of the Road Transport Development Committee suggesting ways and means to increase the road transport capacity both on a long range basis and for implementation of the second Five-Year Plan. The Council decided that the report should be examined by the Executive Committee.

8. Co-ordination of Engineering Research.

The Council of the Indian Roads Congress considered the following recommendations in regard to the co-ordination of engineering research made by the Panel of Scientists appointed by the Planning Commission :

(i) The National Buildings Organization, the Railway Board, the Indian Roads Congress and the Central Board of Irrigation and Power should organize meetings of Research Committees once a year to which representatives of various organizations, Universities and technical Colleges interested in the respective fields should be invited. At these meetings, research work done during the year should be reviewed, programme and priorities discussed and allocation of priorities considered.

(ii) For co-ordination of the activities of these various organizations, the C. S. & I. R. should organize a joint meeting of the Board of Scientific and Industrial Research and these organizations once a year.

The Council supported the above mentioned recommendations of the Panel of Scientists and desired that the Government be appraised of the action being taken by the Indian Roads Congress towards the co-ordination of road research in the country.

The Indian Roads Congress have taken action on the recommendation mentioned at (i) above and the first general report was discussed during the Session.

It was also agreed that in future Universities and Colleges should be addressed to send delegates to the Sessions.

9. Application of results of engineering research.

The Council discussed the question of allocation of funds for large scale field experiments to popularize new techniques evolved as a result of laboratory research. They were of the view that it was essential that the estimates for every constructional and development work should include a provision of 1½ per cent of its cost for large scale experimental construction. The amount so obtained should be put into a separate fund for financing all large scale experimental works.

Further, the Council felt that in order to achieve results an Assessment Committee consisting of representatives of the executive and research agencies and experts in the specialised fields should be set up preferably under the auspices of all-India technical bodies such as the Indian Roads Congress, the National Buildings Organisation and the Central Board of Irrigation and Power, to evaluate research results, to decide on large scale trials and constructional work and to recommend allocations for these experiments from the above mentioned funds. It was generally felt that the amount so obtained should be spent within the State from which it is derived.

10. Burning of tar as fuel in the steel factories.

The Council decided that the Consulting Engineer to the Government of India (Road Development) should be requested to prepare a note examining the possibilities of ensuring the preservation of as much tar as possible for road works. The note should then be examined by the Executive Committee.

11. Miscellaneous.

The Council accepted a suggestion of Dr. F. P. Antia that the Executive Committee be requested to consider as to how best it would be possible to bring the local Members and the public into contact with the activities of the Congress when the Session is held.

INDIAN ROADS CONGRESS—TWENTY-FIRST SESSION 1957

CHERRAPUNJI

Cherrapunji has so far been known as the wettest place in the world, being situated at an altitude of 4,450 ft and having an annual rainfall of nearly 500 inches. Cherrapunji is 32 miles South of Shillong and connected to Shillong by an all weather black-topped road suitable for partly double and partly single way traffic. With the opening up of communications it has been now known that Mawsynram, a place west of Cherrapunji, has an annual rainfall of about 700 inches.

Cherrapunji, a long time back, used to be the Capital of Assam and the ruins of the old Government house are still there.

Though it is one of the wettest places the irony is that there is hardly sufficient water for use of the people in winter. This is due to absence of any vegetation in the hills nearby.

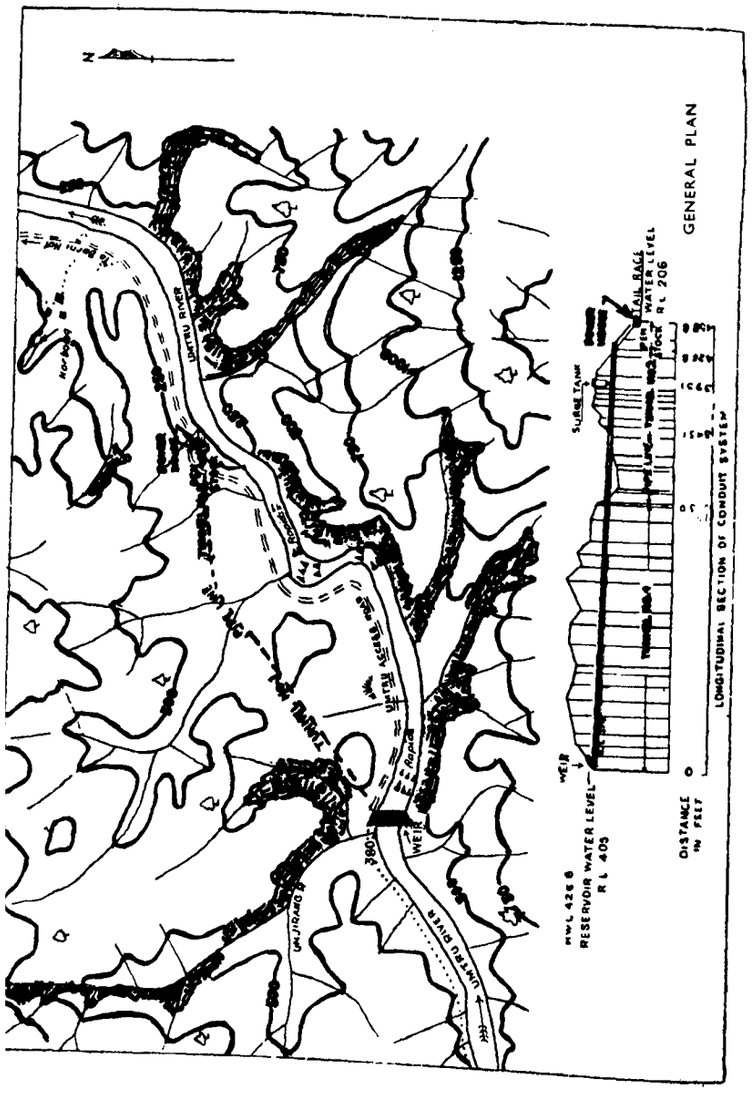
Near about Cherrapunji coal is available in surface seams. There is plenty of lime stone in the surrounding area and visitors can see the lime kilns by the roadside.

Due to partition the people of the border who carried on trade previously with the plains, now in Pakistan, have been adversely affected and quite a few number of roads had to be made for export of their produce to places in the Indian Territory. The Mawsmai-Shella Road is one of these. It runs along the hill slope from a point about 5 miles from Cherrapunji and ends at Shella at a distance of 31 miles from Cherrapunji.

A ropeway is proposed to be constructed from Shella upto Amingaon for transport of local products and lime stone for proposed cement factory near about 14 miles from Shillong on Shillong-Cherra Road.

The Mawsmai-Shella Road was taken up for construction about 4 years ago. Except some bridges and consolidation on some miles all other works have been completed. The crest width is 12 ft and the metalled width 8 ft. Cost per mile excluding cost of 3 bridges not yet sanctioned is near about Rs 80,000 per mile.

There is a ropeway line of about 8 miles length connecting Cherrapunji with Bholaganj, a place at the foot of the United



Khasi & Jaintia Hills District and near the Pakistan border. This ropeway line carries coal from Cherra to Bholaganj and fish and other eatables from Bholaganj to Cherrapunji. This coal is carried by other means of communication from Bholaganj to the cement factory at Chattack now in East Pakistan.

The ropeway line is run by diesel oil engine. This was constructed by M/s. Gillenders Arbuthnot about 27 years ago and was owned by them till a few years back. Now it has been purchased by a local firm.

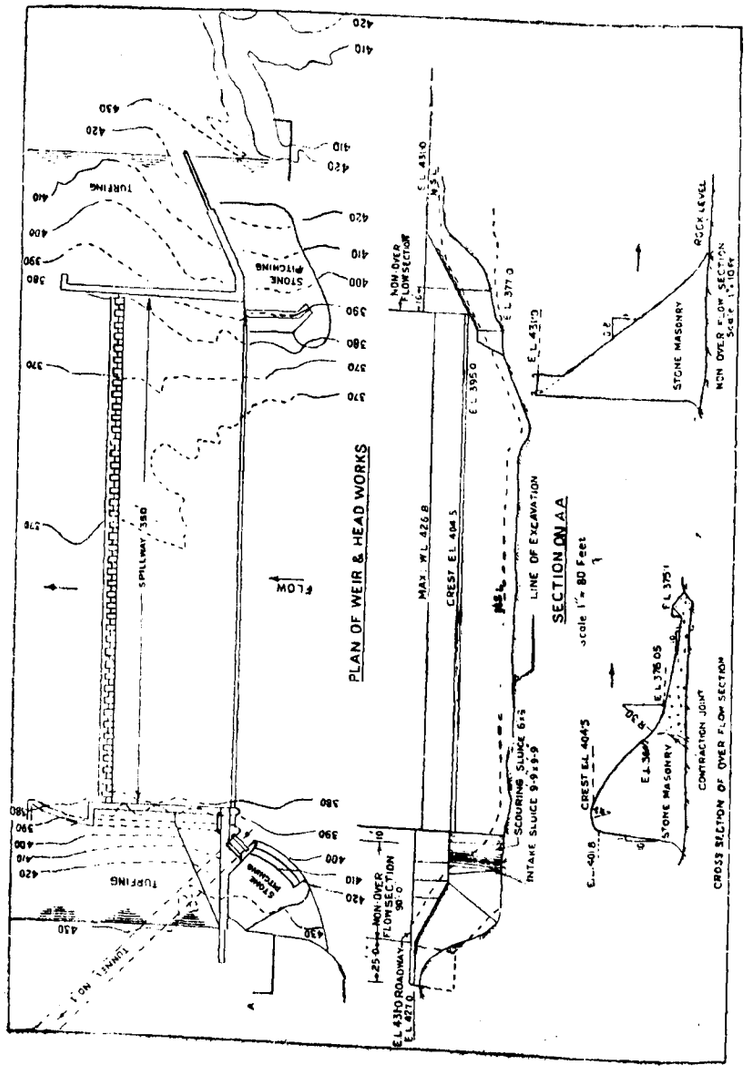
UMTRU PROJECT

The Back-Ground Story

Assam, with its heavy rainfall and extensive hill ranges, has tremendous hydro-power potential. Unfortunately this vast source of power has remained unharnessed. As a result, potentially the richest State in India has the lowest production of electricity so far, the figure being a mere 0.74 KWH. per head. In fact, the Umtru Project, a small project by present day standards, is the first sizeable hydo-electric project undertaken in the State. But it is hoped this will serve as a pilot project to be followed up by much bigger projects in the near future.

The Umtru river which has a catchment area of 369 sq. miles at the dam site, rises in the Khasi & Jaintia Hills just north of Shillong. It is a tributary of the Kalang, and is called the Digaru in the Kamrup District. It crosses the Gauhati-Shillong Road once in mile 47 and again at Burnihat, 16 miles from Gauhati. Five miles upstream of Burnihat, the river has a series of rapids and a drop of 170 feet is obtained there in a length of just over a mile. The present Umtru Project is designed to make use of this drop, utilising only a minimum flow of 200 cusecs in the river, a very small storage being provided to tide over short periods when the minimum flow in the river falls below 200 cusecs in dry days. Three generators of 2800 KWs each are installed to give a total installed capacity of 8400 KWs.

The project is by and large a gift to the Government of India by the Canadian Government under the Colombo Plan. The equipment is supplied by the Canadian Government as the dollar counterpart of the aid, and there is also a rupee counterpart, making a total aid of Rs 150 lakhs. The Government of



India are extending a loan to the State Government to finance the project. The cost of the project as it stands now is approximately rupees two crores.

The Project in Outline

The features of this small scheme are diverse and interesting and are similar to those of many larger projects. At the head of the rapids, there is a masonry diversion dam and the water required for power generation is carried through a 4,600 ft long conduit system to the power house located over a mile down the river. The diversion dam, straight gravity type, is built in random rubble masonry with dressed stone facing. The spillway, Ogee overflow type, has a similar construction. The downstream apron of spillway is built in concrete laid on masonry and the energy dissipation blocks are built in reinforced concrete. Though the very minimum flow in the river is of the order of 140 cusecs only, the maximum design flood is as high as 1,50,000 cusecs, requiring a spillway length of 350 ft. The maximum height of the dam over the deepest foundation is 78 ft in the non-overflow section which is 26.5 feet higher than the overflow section. The intake duct is provided in the body of the dam near the left abutment and merges into the conduit tunnel beyond the dam section. A 6 ft × 8 ft sluice duct has been provided adjacent to the intake to keep the river bed in front of it free from silt deposit. The dam and appurtenant works are founded on granite gneiss, strong and fresh masses of which were exposed on the bed of the river itself.

The conduit system consists of two tunnels 2730 ft and 828 ft long connected by a steel pipeline 701 ft long, and a 347 ft long high pressure steel penstock running from the second tunnel to the power house. In No. 2 tunnel is located a 116 ft high surge tank having an internal diameter of 32 ft. The tunnels have horse-shoe shape with 9 ft-9 in. diameter. No. 1 tunnel is lined with concrete throughout while No. 2 tunnel is partly lined with concrete and partly with a steel liner in addition. The steel pipe line has a diameter of 9 ft-9 in. The high pressure penstock has a diameter of 8 ft and branches into 3 Nos. 4 feet diameter pipes, each feeding a turbine. All steel pipes are made of $\frac{1}{2}$ in. thick boiler plates.

The power house, founded on rock, has an uncommon feature. To avail of the maximum possible head, it had to be designed as an almost completely submerged structure, the entry inside being provided through the roof. The walls of the power house, built in reinforced concrete, are therefore made fully waterproof by providing copper sheets at every construction

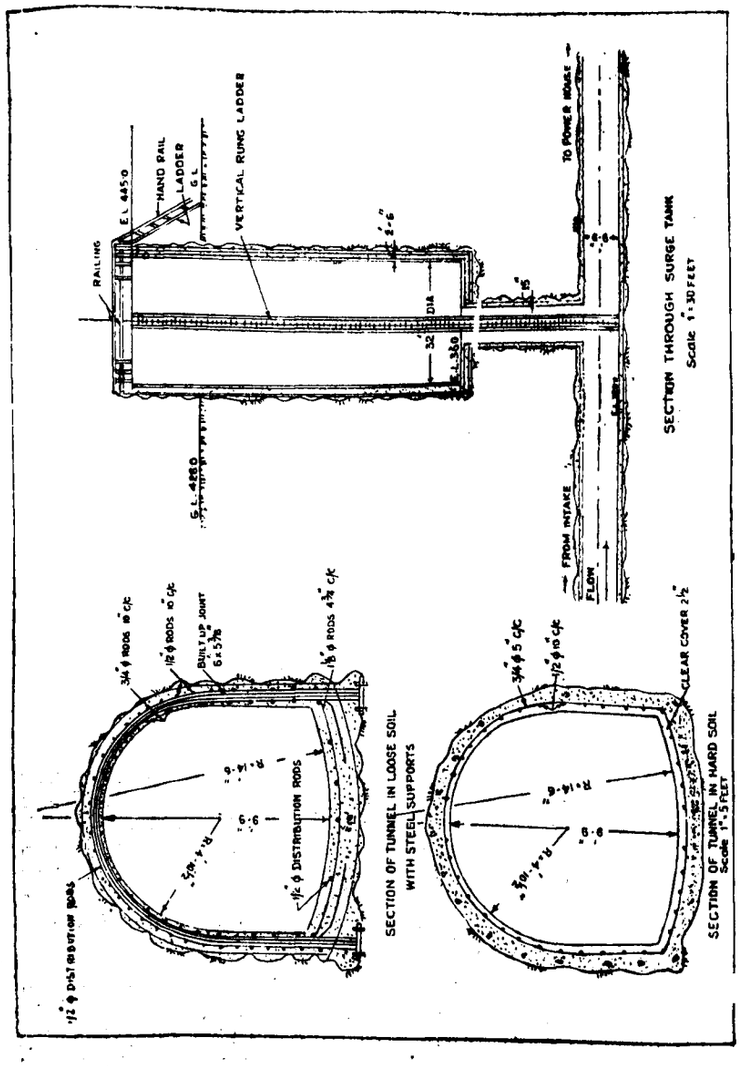


Photo 1.

The placid river above the rapids. (This is the site of the dam. The Cofferdam for diversion may be seen.)

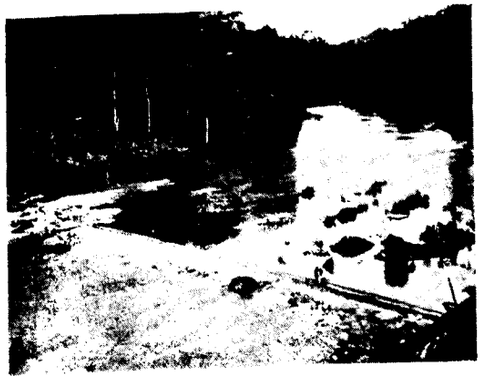


Photo 2.

The first job on the weir is excavation for foundation. (The bed is of granite gneiss.)

Photo 3.

Masonry weir under construction (Intake duct is seen in the foreground.)

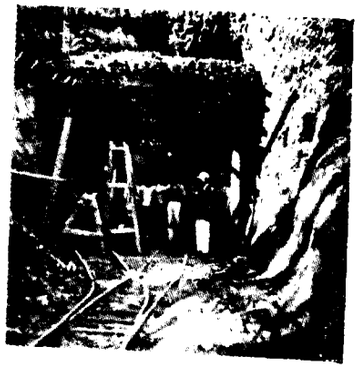


Photo 4.
The beginning of No. 2 tunnel draft face

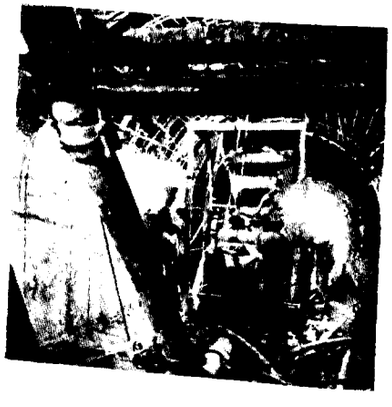


Photo 5.
Concreting tunnel overt with pneumatic concrete placer

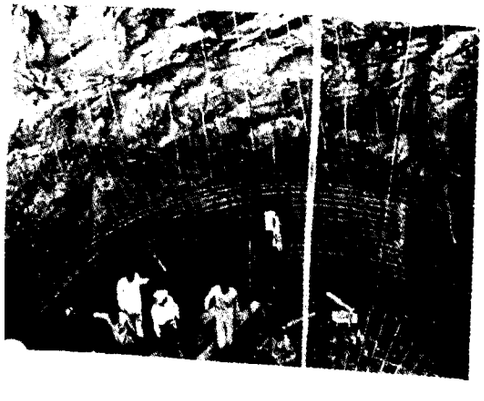
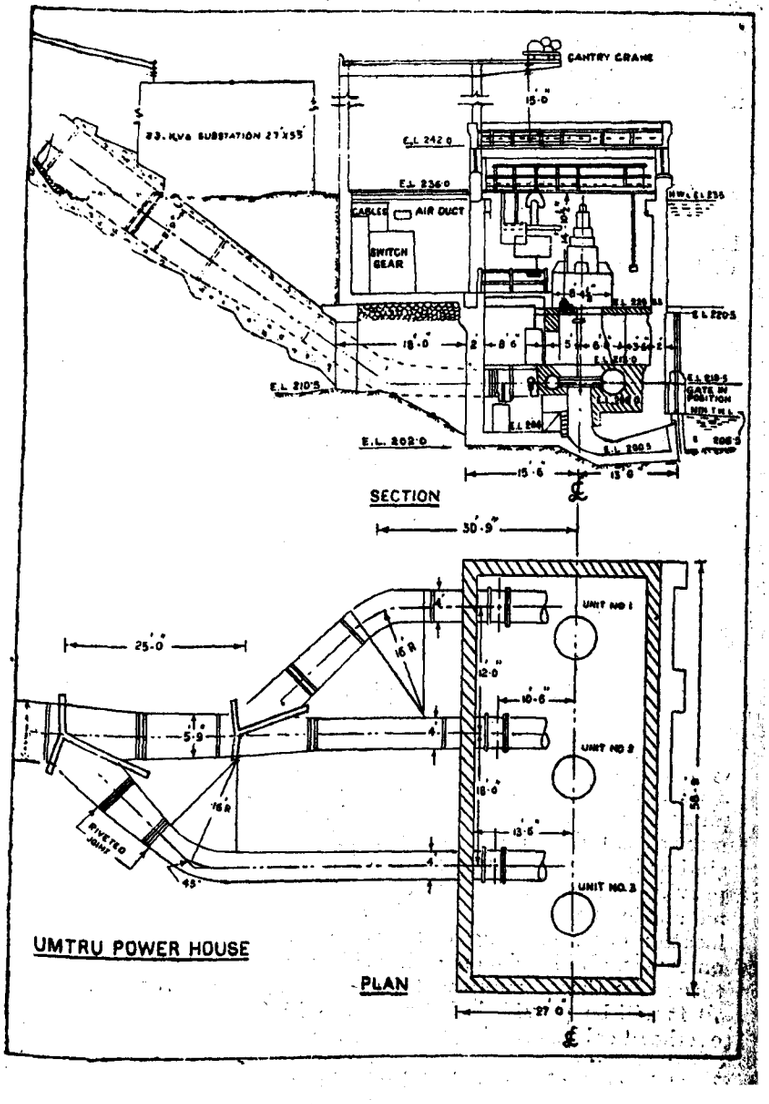


Photo 6.
A view of the R.C.C. walled surge shaft during construction



joint and by adequate quality control of the concrete used. Rigorous waterproofing specification for the roof has also been adopted to prevent any leakage from heavy rain. For taking equipment inside the power house a gantry crane has been provided on a portal above the power house roof to lift the equipment from the terrace and lower it inside through a roof hatch.

Power Generation

The three turbines installed are Francis reaction type 37 in. diameter, 3500 BHP., 500 RPM., vertical type, operating under 175 ft of a net effective head and manufactured by Canadian Vickers, Canada. The generators are 2800 KW., 500 RPM, 3500 volts, air cooled type, manufactured by Canadian General Electric Co. The aggregate machine capacity of 8400 KW generated at 3.3 KV, 50 cycles, 3 phase is stepped up to 34.5 K V in a bank of 3 single phase transformers of 3500 KVA each, delta/star connected, and conveyed through a 33-KV transmission line having sal wood supports of 35 to 40 ft long over a route length of approximately 20 miles to the Gauhati terminal station. The A. C. S. R. conductor with a normal span ranging from 300 to 350 ft has been used.

A second transmission line with a bigger size conductor in A. C. S. R., is being laid parallel to the first line.

At Gauhati sub-station, power is being tapped off at 11 KV for various load centres like State Electric Supply, Gauhati University, A. I. R., Air-field, Palasbari etc.

The most important feeder in the system is the Gauhati city feeder line where about 25 per cent of the entire generating capacity will be used. Three transformers, each having a capacity of 666 KVA have been installed to meet a load demand of 2000 KVA for the city of Gauhati. Three—333 KVA single phase transformers have also been installed in this sub-station to meet a load demand of 1000 KVA for other load centres. A similar bank of transformers of 4000 KVA capacity will be provided on the third high tension-line from the Gauhati terminal station to the north bank of the Brahmaputra river. The location of the crossing of the river Brahmaputra has been fixed on two small hillocks on either side of the river at Pandu. The towers for these cables will be 100 ft high and a clearance of 70 ft will be provided between the high flood water and the overhead cables crossing the river for passage of steamers etc.

The cost of the project including transmission upto Gauhati area will be Rs 2.0 crores. Cost of generation, on full development, will be about one anna per unit at Gauhati. The power

from the project will be supplied to the greater Gauhati area to meet the growing demands of the town, the Railway, the A.I.R., the Air-port, the University, the Engineering College and the various industries.

Salient Features

Dam:

1.	Catchment area of the Umtru at the dam site	...	369 sq. miles.
2.	Average annual rainfall	...	104 in.
3.	Mean inflow from catchment	...	1400 cusecs.
4.	Minimum natural flow	...	140 cusecs.
5.	Maximum design flood	...	1,50,000 cusecs.
6.	Natural bed level of river	...	367.00 above M.S.L.
7.	Maximum design flood level	...	426.8 ,,
8.	Crest level of dam		
	(a) Overflow section	...	404.5 ,,
	(b) Non-overflow section	...	431.0 ,,
9.	Minimum draw-down level	...	390.0 ,,
10.	Height of dam above deepest foundation		
	(a) Over-flow section	...	51.5 ft.
	(b) Non-overflow section	...	78.0 ft.
11.	Type of dam	...	Straight gravity.
12.	Type of spillway	...	Ogee overflow.
13.	Earthquake forces allowed in design	...	0.3G.
14.	Energy dissipation	...	Sloped apron with dentated end sills.
15.	Length of spillway	...	350 ft.
16.	Length of non-overflow section		
	(a) Right bank	...	60 ft.
	(b) Left bank	...	75 ft.
17.	Length of cut-off-walls	...	25 ft.

Conduit System

Tunnels:

Length of No. 1 tunnel	... 2730 ft.
Length of No. 2 tunnel	... 828 ft.
Length of steel pipe line	... 701 ft.
Length of No. 2 tunnel steel lined	... 163 ft.
Length of high pressure penstock	... 347 ft.
Size of tunnels	... 9 ft-9 in. dia. horse-shoe shape.
Thickness of concrete lining	... 0 ft-8 in. to 1 ft -0 in.
Dia. of steel pipe line	... 9 ft-9 in.
Dia. of penstock	... 8 ft-0 in. branching into 3 Nos. 4 ft dia. pipes.

Surge Tank:

Height above top of tunnel	... 116 ft.
Diameter	... 32 ft-0 in.
Diameter of riser shaft	... 9 ft-9 in.
Thickness of wall	... 2 ft-6 in.

Quantities

Excavation:

Weir	... 14.0 lakhs cu. ft
Tunnels and pipe line	... 7.1 ,, ,,
Power house	... 0.8 ,, ,,
Surge tank	... 0.8 ,, ,,

Masonry:

Weir	... 8.0 ,, ,,

Concrete:

Weir	... 1.5 ,, ,,
Tunnels and pipe line	... 3.7 ,, ,,
Power house	... 0.7 ,, ,,
Surge tank	... 0.3 ,, ,,

Power System

Generating Station

1. *General*:

Units in power house	... 3—2800 K. W. each.
WR^2	... 1,47,000 lb ft.^{2}

2. *Power House*:

Dimensions—overall	... 82 ft—6 in. × 45 ft—0 in.
Dewatering—No. of pumps	... 2 Nos.
Air conditioning	... Induced draft ventilating system in the power house.
Communication	... Inter telephone system throughout.
Cranes 1 No.	... 19 tons—lift 28 ft.
1 No.	... 15 tons—lift 35 ft.

3. *Hydraulic Control*:

Trash rack	... 1 No. reinforced concrete structure with fabricated steel grill.
Penstock openings	... 1 No. 10 ft × 10 ft square opening transitioned to horse-shoe shape with 9 ft—9 in. top diameter in reinforced concrete. High pressure steel penstock 8 ft dia. branching into 3 Nos. 4 ft dia. pipes.
Gates	... 1 No. 12 ft-7 in. × 10 ft-2¾ in. weighing 6.6 tons. Hoisting — Mechanical & electrical.
Draft tube:	
Openings	... Transition from circular to rectangular 11 ft × 4 ft—one opening per unit.
Gates	... Only 1 No. for all three units.

Turbines:

Number	...	3
Output	...	3500 H.P.
Head	...	175 ft.
Normal speed	...	500 R.P.M.
Run-away speed	...	917 R.P.M.
Wt. of runner with shaft	...	3 tons.

Alternators:

Number	...	3
Output	...	2800 K.W. each.
Voltage	...	3300 volts.
Ventilation	...	Air cooled.
Wt. of Stator	...	9 tons.
Wt. of Rotor	...	13 tons.

Switch-yard:

3.3 K. V. stepped up to 34.5 K. V.

Transformers—3500/3700 K. V. A. single phase—3.3/34.5 K. V. ... 4 Nos.

75 KVA—3 phase 3.3/11 K.V. ... 2 Nos.

Oil circuit breaker:

500 MVA—34.5 K.V. 800 amp. 5 cycles ... 2 Nos.

Air circuit breaker:

150 MVA—1200 amps. ... 3 Nos.

250 MVA—2000 amps. ... 1 No.

Fire protection—automatic fire protection in the sub-stations with quartzite thermostat automatic alarm and water spray.

Transmission Line—(initial):

20 miles of 33 K.V.

14 miles of 11 K.V.

Main Receiver and Sub-station:

Transformer—666 KVA—single phase	...	4 Nos.
333 KVA—single phase	...	4 Nos.
Oil circuit breaker—500 MVA	...	4 Nos.

A Note on

SUGGESTIONS FOR ALTERNATIVE MEANS OF COMMUNICATIONS BETWEEN GAUHATI AND SHILLONG

A ROPEWAY OR A MONO-RAIL FOR SHILLONG-GAUHATI ROUTE

By

GEORGE GILFELLON

Regarding the Assam Goverment's proposal to erect a ropeway connecting Shella and Pandu at a cost of Rs 2 crores it is submitted that ropeways as a commercial and economic proposition for long distances through jungle are old fashioned and obsolete in modern practice, except for river crossings and very special purposes.

The existing "Cherra-Chatak Ropeway" was erected some 20 odd years back when a ropeway was a new idea. As transport has vastly advanced since then in cheapness and utility, the only places where ropeways run these days are on short runs in mountain winter resorts for skiers, etc.

The proposed ropeway between Pandu and Shella will be the longest in the world, over some 100 miles long. It will also be very difficult to operate for the people running it, as it is impossible for one engine to pull a steel cable over 100 miles distance. It would, therefore, have to have a relay of several ropeways and power prime movers. The Cherra-Chatak ropeway, it is understood, has made little profit since it was installed for the following reasons: The ropeway can only handle a small amount of traffic. Being exposed to the elements, the wear and tear is heavy and maintenance costs are very high. Thousands of yards of expensive heavy steel cable have to be scrapped—being worn out below the safety limit from time to time. As the ropeway only travels some 3 miles an hour and averages a height of 12 to 15 feet it is impossible to guard the whole length and, apart from a loss in contents of some 5 per cent 'en route' fallen from jerking of suspended open buckets, a further loss is possible by tempering with long bamboos. Also stretching of cables on hot days and contraction at night give endless trouble.

MONO-RAIL SYSTEM

In place of the proposed new ropeway it is suggested the Government first consider the latest "Mono-Rail" transport system installed in Germany, France and England, which is replacing to some extent the normal surface Railway system. This system is easy to erect, maintain and run, and is also faster both for passengers and freight. It is clean, safe and comfortable consisting of electric lit enclosed coaches taking say upto 100 passengers per coach. It will be cheap to operate as electric power is available nearby from the new Umtru Power Plant.

The "Mono-Rail" system is a single rail running overhead supported at intervals by arched steel supports cemented in ground foundations. The coaches are suspended under this single rail on wheels attached to the coach; the wheels are driven by electric motors controlled by the coach motor-man with powerful brakes braking on the rails; the electric power is supplied to the motors either via the insulated rails itself or via cables attached to the rails. This is a fool proof system of even speeds of coaches leaving at set intervals, but speeds of 200 miles per hour have been possible on long stretches on level ground in France and Germany.

The cost of installing the system is not heavy and it is only necessary to do the minimum of clearing of the jungle tracks in the first instance just for alignment purposes and fitting of over head arches and rails; the first coach through could then do the final clearing cheaply.

The system could connect Shillong and Gauhati and Pandu via Shella or any other intervening station to be decided upon and may be with a "feeder" line from Gauhati to the Gauhati aerodrome. When completed it would be the latest method of transport, with raised platforms for passengers entering or leaving the coaches at stations also supplied with lighting etc. from the same mono-rail circuit.

Depending on the amount of traffic, both passenger and freight, estimated now and likely in the future, experts will have to arrive at a decision whether to have double "Mono-Rail" tracks or, a single track "Mono-Rail" with arrangement of timings on the same lines as the up-down timings used at present on the Gauhati-Shilling motor road. The time taken would average say 1½ hours as against 4 hours by road. The single rail could be installed first and the double rail added afterwards when funds are available, if costs are too high for a double track in the very first instance.

There are several factors in favour of the "Mono-Rail" system and so after obtaining the necessary permission from the Patentees of the "Mono-Rail" system in London, and on payment of the royalties for the same, the firm could send their experts to supervise the manufacture of the specialised units and erection of the "Mono-Rail" system. As the work could be done in India, by Indian workmen, this would save foreign exchange and help India in her industrialisation programme.

The Govt. should, therefore, seriously consider the above scheme before deciding to spend 2 crores on an obsolete ropeway travelling slowly, with freight only, and with all the factors against it as already mentioned above. Although the ropeway will be cheaper than road transport, the "Mono-Rail" system will have the following further advantages in its favour: there will be no loss in transit with the cheap Umtru Power supply connection; passengers could travel at say one pice a mile and freight at say -/8/- a maund from Shillong to Pandu and still make a handsome profit, probably getting the capital outlay back in say 5 years from the start. The time taken from Shillong to Gauhati should not be more than 2 hours up with a gradual slope and 1½ hours down against 4 hours by road. This would be god-send boon to the growing capital of Shillong and attract more tourists and business-men to the capital as most people detest the present weary 4 hours road journey to and from Shillong and Gauhati.

Should the Government decide on the "Mono-Rail" system being installed, the buses etc., on the Shillong-Gauhati Road could be diverted to new routes, and the road used for heavy freight traffic such as coal, potatoes, rice, etc. and the normal private car traffic only.

It is of interest to note that the "Ruhr Schelly-yerkehr Mono-Rail Railway" (Suspended Coach Type) has been running efficiently for the past 20 years in Germany—without accidents, connecting all the bigger towns and at average speeds of 50 miles per hour. But the Assam Government should take advantage of advanced designs and instal the latest elevated (non-suspension type) "Mono-Rail" system, like the "Schellenberg Mono Railway" which has been running efficiently in Germany for the past 3½ years and uses diesel-engine driven electric dynamo driving a motor power coach pulling 3-30 passenger coaches leaving at 5-minute intervals.

This system has a single rail, supported on pedestals some 80 yards apart. The coaches travel on a single row of flanged

wheels. The coaches are designed with heavily weighted sides below the rail and their centre of gravity maintains balance and equilibrium. A double rail system suspended with wheels is also used.

With reduced friction, running costs are much below conventional type railway systems and test trial speeds of 240 miles per hour have been made, which is impossible on the latter system.

The working speed could be any speed depending on the up-down gradients and bends and distances between stations allowing for stopping which should be very smooth, the brakes being metal to metal magnetic, breaking on the rail (there are also emergency compressed air brakes). Acceleration is smooth and good, the coaches picking up a speed of zero to 50 miles per hour in 25 seconds which saves time in a fast efficient service.

NARROW GAUGE RAILWAY

The next best scheme would be a narrow gauge surface railway track like the one to Darjeeling (some 20 years old) which climbs by steam engines some 6000 feet or more, or the one in the Nilgiris (Coimbatore-Ootacamud) 7000 feet, or still one more example at Keran, Eritrea to a higher elevation, using diesel engines, on a narrow gauge track. Plenty of crude oil is available in Assam, to fuel diesel engines, which could be used and which can pull up a train on any gradient below 40 to 1 and would have been the only units to be imported from abroad, the rail, coaches, etc. being manufactured and available in India. Before an investment on any scheme requiring vast sums of money is made, consideration of the latest modern practice likely to stay as such for several decades should be taken into account. As oil has replaced coal in all locomotives and prime movers throughout the world, diesel engines are recommended for the latter scheme.

Pending the decision either of a Mono-rail or narrow gauge Rly. connection between Shillong-Gauhati, the Govt. should purchase a few 25 seater Helicopters as used in England, which should do the above journey in one hour. They could be used for freight from Shella also. Or the Govt. should purchase a few Scottish Twin Pioneer British Mono-Planes which are being demonstrated in India shortly. This plane can take 16 passengers or carry about 2 tons freight, take fuel for 500 miles, has a ceiling height of 21,000 ft, requires a runway of 150 yards only and lands at 50 miles an hour. It should be ideal for the above service and should take under one hour for the journey.

Another suggestion: why not survey a direct route between Shillong and Gauhati and, like the new Kashmir Road, tunnel where necessary, and if possible make a 4-track (instead of the usual 2-track road) 24-hour road, 2 tracks for up and down light car and vehicle traffic, and 2 tracks for up and down heavy slow traffic, the former taking approximately $1\frac{1}{2}$ hours for the trip and the latter 2 hours. Places like Shella could be connected to the above road by a direct feeder road to its nearest point. With present day modern cutting and tunnelling machines, the work could be quickly and cheaply done.

Paper No. 198.

"INDIAN BRIDGES"

By

M. YVES GUYON

1. In the matter of construction, every country has its own imperatives which make comparisons between works in different countries rather difficult. However, it is interesting to compare the results obtained in India in the field of prestressed concrete bridges with those obtained in European and American countries.

2. Fig. 1 is extracted from a Paper read by the Author in London some months ago[1]. It shows the quantities of materials per sq. ft. as compared to the span, for different types of prestressed concrete bridges. In this diagram, the bridges have been arranged in different groups, namely, simply supported bridges, continuous beams with equal spans, continuous beams with unequal spans, portals, and bow-strings. The Figure gives, for these different classes, the average thickness of concrete, i. e. the ratio of total amount of concrete to covered area and the weight of high tensile steel in lb per sq. ft.

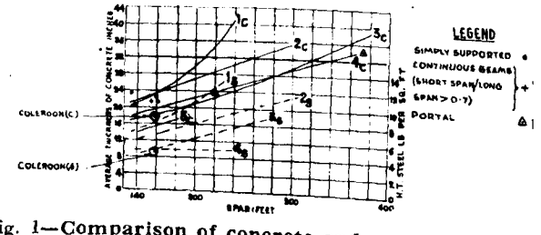


Fig. 1—Comparison of concrete and steel quantities in terms of span. Suffix c refers to concrete, suffix s to steel.

Curves 1: simply supported
" 2: continuous beams with equal spans
" 3: " " " unequal spans
" 4: portals
" 5: bow-strings

3. The outstanding Paper[2] by Shri K. K. Nambiar and Shri P. G. Nambiar on the Coleroon bridge gives data which make

it possible to place the quantities for this bridge on the curves in Fig. 1 (point *C* of Fig. 1). For its 159-ft span, the average thickness is 17 in. and the weight of high tensile steel is 4.8 lb per sq. ft. This leads to the conclusion that Coleroon bridge would almost be the lightest of all those structures which have been constructed in that kind at least in the Freyssinet system (and it does not seem comparison with other systems would be worse).

4. The Coleroon bridge is a statically determinate structure. The graph in Fig. 1 shows that for this type of bridge, the average thickness of concrete will normally be about 23 in. and that the amount of high tensile steel about 8 lb per sq. ft., i. e. 35 and 66 per cent respectively more than those actually used for the Coleroon bridge.

5. However, it should be said that the Coleroon bridge is not a normal statically determinate bridge. In fact, it acts, at least partially (under its own weight and under uniformly distributed live loads) as a continuous beam with equal spans, due to the hinges which have been provided in every span at the sections of zero moments. This does not affect the previous comparison so far as concrete is concerned, since in this range of spans, Fig. 1, the average thickness of concrete is almost the same both for bridges of class 1 *C* as well as those of class 2 *C*. However, the quantity of steel is reduced by about 28 per cent in the case of continuous span, being only about 6.7 lb per sq. ft. against about 8.2 lb (see curve 2s, Fig. 1) required for bridges of type 1 *C*.

6. A comparison with Joazerio bridge - a bridge in Brazil of the same kind as the Coleroon, leads to the same conclusions. This bridge has a span of 147 ft instead of the 159-ft span of the Coleroon bridge. The amount of high tensile steel is 6.2 lb per sq. ft. and would probably be, for a span of 159-ft, $6.2 \times 1.1 = 6.8$ lb per sq. ft., which shows a saving of about 30 per cent.

7. Of course, the differences of regulations for loadings are slightly responsible for the differences pointed out, the French loadings for which the bridge is designed being in particular fairly heavier than the Indian and the American loadings. But, since for bridges in this range of span, live load is never more than 1/3rd of the total loads, the influence of live load on the design is rather small.

8. In the Coleroon bridge, these remarkable results are obtained without an excessive $\frac{\text{depth}}{\text{span}}$ ratio. For mid-span, this

ratio is 6 ft 3 in. ÷ 159 ft = 1/255, while for French bridges ranging from 150 to 170 ft in span, the ratio is, on an average, 1/22. The economy is due to the design, the hinges provided in the spans having the same effect as a double cantilever system with a central simply supported beam, of which the span would be the total span less two times the 32-ft cantilever, i. e., 159 − 64 = 95 ft. Thus for this reduced span, the ratio $\frac{\text{depth}}{\text{span}}$ is 6 ft 3 in. ÷ 95 = 1/15, hence the saving of steel without any inconvenient encroachment on aesthetics or lateral stability.

9. Some other comparisons, from the general point of view, may be made, and these lead to interesting conclusions. In France, gaps to be crossed are generally moderate. Of the bridges which have been built in the past 7 years, 75 per cent have only one span. This naturally demands a great diversity in the length of span. The average number of spans per bridge is less than two. For Indian bridges—at least for those which the Author had to deal with—the average number of spans is 8; the average span is 35 metres (106 ft), although 50 per cent of the bridges have spans around 48 metres (145 ft), and 14 per cent around 20 metres (65 ft). In other words, the greater width of gaps allows a greater standardization, since a standard span may be more easily taken as a common devisor for large gaps than for small ones. This is a considerable advantage, because it enables standardization, not only of the forms and of the launching girders, but also of all the operations.

10. This may be the main consideration which may lead one to prefer a standardized simple construction to more elaborate structures which would secure perhaps some economies of material, but not of money. And thus the Indian view point would be the same as the American—save skill and labour first—instead of the European method which is generally directed towards saving material. In fact, it is not difficult to reconcile the two points of view. The Coleroon bridge, since it secures, at the same time, possibility of standardization and economies in quantities, shows that this is possible. Therefore, it could be said that this type of bridge is specially well adapted to Indian conditions.

11. Before discussing the possibility of other kinds of bridges, the Author would like to raise a few minor questions. His remarks are not to be regarded as an adverse criticism, but only as a contribution, based on personal experience, to a desirable discussion. Having had occasion to examine a number of Indian designs and make minor modifications in them, he thinks that he could give the results of

his reflections here. These refer mainly to thicknesses of webs, to the values of principal tensile stresses, to the necessity of increasing the thickness of the webs in the zones of heavy shear—all these questions being more or less connected—and to the spacings of diaphragms.

12. About the thickness of webs, the Author has given an empirical rule in the above mentioned Paper[1] read in London. In his opinion, 4 in. + 1 in. per 3 ft of depth should be considered as an absolute minimum and this minimum should not be less than 6½ in. when cables of 40 tons are used. This thickness is required not for strength, but for facilities of pouring concrete and to avoid certain risks of cracks at the level of cables or at the junctions of webs and members, *i.e.*, in the zones of the webs where the resistance is minimum or where the stresses are maximum. Of course, out of hundred beams with thinner webs ninety-nine may be all right but the hundredth may have cracks, the reason for which no body may understand. It is, however, probable that these are due to differential shrinkage, this shrinkage occurring quicker on the webs, which are thin, than on the more rigid frame constituted by the webs and the diaphragms. This differential shrinkage would be equivalent, if the webs are too thin, to a shrinkage of some 1/10000 in the web alone. It is true to say that a perfect job could be achieved whatever be the thickness of the web, with tensioned stirrups. This has been done at Esbly bridge. But so far it could hardly be done in current structures and we are obliged to accept a compromise.

13. About principal tensile stresses, they should not exceed 100 lb per sq. in. and in the Author's opinion, stirrups should always be provided in the webs although some regulations do not insist upon them in certain cases. About the increasing of the thickness of the web in the heavy shear zone, *i.e.*, at their extremities for bridges simply supported in the first panel (between the support and the first diaphragm), this should be done progressively, avoiding an abrupt increasing of this thickness just near the support. The better way seems to be to increase it linearly in the first panel, from the running thickness up to some 1.5 times this thickness at the support (this 1.5 is given only as an indication).

14. As to the diaphragms, they do not have to be too numerous. To a certain extent a large span bridge should have the same number of diaphragms as a small span bridge, since the second could be considered as a model at a reduced scale of the first, which means that if we are satisfied with spacings of 20 ft for a 100-ft span, we could admit 30 ft for a 150-ft span. It is a question of local deflection under the live load. It would be

found that four intervals are generally enough, five at th maximum.

15. Passing now to the discussion of the possible types of bridges, it is merely a question of launching and of the quality of foundation soil.

About launching the problems are big, but there are no real difficulties, for beams weighing up to 120 tons.

Regarding foundations, they are generally difficult in India for large rivers and this probably does not allow the use of types of bridges which, otherwise, would prove economical, for instance, portal bridges.

It should, however, be said that, more and more in France and in Europe, the tendency is directed towards the portals; either by casting the beams monolithic with the piers or by organizing the supports in a suitable manner (examples: Nimy Blaton in Belgium; St. Michel bridge in Talouse). Very light structures have been thus designed and built. For instance, in the above mentioned Paper read in London, the example of Laboa bridge in Equatorial Africa, a portal with sloped legs, has been given; for 144-ft span the average thickness has been 13 in. including foundation. Although this cannot be exactly compared with a bridge for a heavy traffic, this lightness is remarkable, since this average thickness is about only twice the thickness of deck provided between the main beams of an usual bridge. But foundation was particularly easy, a granite sheet rock being encountered at the level of the bed in the river.

16. It seems that in the case of Indian bridges, such favourable conditions, at least for large crossings, will be seldom met and that no horizontal thrust could be admitted for a standardized type. But advantages of the same nature, although perhaps smaller, may be found in other ways.

17. What costs in prestressed concrete is the variation of moment; which means that by all means, fixity of the ends must be sought to be obtained. The Author has shown, some years ago, in a Paper [3] that continuous beams with unequal spans (long flexible span rather than rigid short spans) secures this fixity. But continuity would require absence of settlement. If this cannot be guaranteed, continuity may be replaced by cantilevers and hinges, as in the Coleroon bridge. This means a construction of the type schematically shown in Fig. 2, *i.e.*, short spans l_1 with a double cantilever of span a, one on each side, and a central beam of span b simply supported on the cantilevers. The short span could be cast in situ with cantilevering

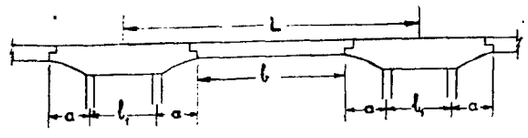


Fig. 2

steel forms, and the central beam b launched. The ratio between spans has to be worked; it could be said that a short span l_1 of 30 ft seems to be convenient, and the spans a of cantilevers could easily, with suitable cantilevering forms, be up to 30 to 36 ft; the span of the central beam could be up to 100 to 120 ft. These are approximately the spans of Casalmaggiore bridge which is now under construction along these lines on the Po in Italy. There are in this bridge four main beams spaced 8 ft 9 in. apart; the depths are 6 ft 3 in. for the central beam, 12 ft 9 in. for the short span. The weight of each central beam to be launched is 65 tons. (If the two supports of the short span are on a same caisson of foundation for the Po bridge, they are separated and made with Benoto piles), the distance between foundations, centre to centre, could easily reach 220 ft and could even be increased since the weights to be handled are smaller than those usual in India. Increasing of the central beam b is, however, limited by the stability of the short span in cases of unsymmetrical loading. Naturally, a solution is always a compromise and the comparison of the total costs is the only judge.

REFERENCES

1. "Long span prestressed concrete bridges constructed by the Freyssinet system"—The Institution of Civil Engineers, 5th February 1957.

2. Paper No. 192—"Design and construction of a prestressed concrete bridge across river Coleroon," K. K. Nambiar and P. G. Nambiar. *Journal of the Indian Roads Congress, Vol. XXI-2.*

3. "Development and research on prestressed concrete continuous structures"—Paper presented to a joint meeting of Society Engineering Civil France (British Section) and the Research and Development Division of CACA—12th December 1952.

Discussion on Paper No. 189*

"Load Testing of the Prestressed Concrete Bridge Across Bhima River at Takli on Sholapur-Bijapur Road"

By

S. V. NATU

Sunday, 12th May 1957

Shri M. S. Bisht (Chairman) introduced Shri S. V. Natu and called upon him to introduce his Paper.

Shri S. V. Natu said that the Paper described how on account of the metal sheaths having been tightly wrapped round the prestressing cables of spans 6 and 7, there was excessive friction between the two, which resulted in considerable deficiency in the extensions that were calculated to be obtained under the permissible cable stress to impart the design prestress at the critical section of the beam. There were three remedies to overcome this defect :

(1) To dismantle the defective spans outright, which of course was out of consideration on account of the very high cost of construction. Such a course was also unnecessary. Cost of each span was about Rs 50,000.

(2) To restress the cables after a lapse of time to allow most of the losses due to creep and shrinkage of concrete to take place and so to overcome them.

In restressing it was also thought that friction might be overcome to some extent.

(3) To strengthen the girders to the extent of the deficiency in the strength as required by design.

Before adopting remedy No. 3, it was decided first to try remedy No. 2, viz., restressing, being much less expensive, and spans 6 and 7 were accordingly restressed after 9 to 10 months of stressing. After restressing it was also necessary to load-test the spans in order to assess the quantum of prestress actually imparted.

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*Published at pages 25 to 48 of the Journal of the Indian Roads Congress, Volume XXI—1, February 1957.

The restressing results made it appear for a while that the deficit in the prestress had been wiped out. The Author explained a little further what exactly was meant by the residual or the locked up extension referred to in the Paper. If the extension obtained in stressing was say x inches and after release of the cable the whole of this extension of x inches did not disappear but the cable remained longer in length by say y inches, this y inches was the residual or locked-up extension indicating the stressed state of the cable for some length and to some extent somewhere in the body of the girder. The results of the load testing, however, revealed that the design prestress was not imparted to the girders and it was necessary to resort to remedy No. 3, viz., strengthening of the girders. Necessary extra cables were provided externally and they were stressed without difficulty. This also needed provision of suitable end blocks made of R.C.C.

One of the strengthened spans was also again load-tested to verify the effectiveness of the strengthening and the results revealed that the desired strengthening was actually effected. The cracks opened in the 2nd load-test under a load of 149 tons as against 76 tons before strengthening. This was exactly as calculated vide item 3(d) of Table 1 in the Paper. The Author pointed out the following printing errors which required correction:

Page 27, line 7:

Omit " 4 numbers of $\frac{1}{2}$ in. dia. rods at " and correct the sentence to read:

" These are reinforced with 4 numbers of $\frac{3}{4}$ in. diameter rods both at top and bottom."

Page 29, heading of col. 2 of Table:

The word " of " to be omitted in " End of stress ".

Page 37, para 4.4:

line 9: omit "necessary"

line 10: substitute " under " for the word " for "

Page 44, line 1:

Add the words " was actually so " after the words " locked-up extension".

Shri M. P. Apte referred to page 26, Figure 1, where it was indicated that $\frac{1}{4}$ inch diameter stirrups at 15 inch c/c were used. He desired to know whether this provision was adequate in view

of the fact that the shear was nearly maximum at the junction of the slab and beam, and that the slab, which was not prestressed, might have been concreted a long time after the concreting of the beams.

The working stress, given on page 27 of the Paper, for high tensile steel was 66.7 tons per sq. in. as against the ultimate stress of 100 tons per sq. in. Usually 60 tons per sq. in. was adopted as the working stress, as was also done in the case of Coleroon Bridge (Paper No.192). In order to understand whether the stress of 66.7 tons per sq. in. was reasonable, he desired to know what was the proof stress (0.2 per cent or 0.1 per cent) for the wires.

In para. 2.4 of the Paper, it was stated that the metal sheathing unfortunately got wrapped round the cables rather tightly. This presented a number of problems later on. He desired to know whether it was not worth while to examine the cause of such an unfortunate happening. Excessive vibration of the concrete might have been the cause of this trouble. It was stated on page 28 that both internal immersion type vibrators and external vibrators were used for compacting the concrete. In addition, compaction must have also been done by iron rods by manual labour as was the usual practice in India. The sheathing was made of 32 gauge plate which appeared rather very thin and delicate. So the sheathing might have been damaged during compaction.

On page 29, it was mentioned that the inspection of a few inner cones removed from the girders revealed that they were damaged by wear due to original use and subsequent release. There appeared to be no reason for such a damage and the matter required further investigation so that users might take precautions in the selection of proper cones.

On page 30, it was stated that it was to be concluded that the locked-up extension could be allocated towards the total extension of the cable by adding it to the restressed extension. This was not correct. Fortunately, the Author himself had rightly expressed on page 31 that the correctness of assuming the locked-up extension as contributing to the stress was doubtful. Shri Apte agreed with this. He felt that the locked-up extension was not uniform throughout the length of the span. It was quite probable that due to the small puncture in the sheathing or due to compression of the sheathing at certain points, the wires might have been locked-up at some particular points only and so the friction might not be uniform throughout the span. That also explained why 26 wires were broken in span 7 as mentioned on page 44. It was likely that the extension of the wires which was calculated for the whole length of the span would

not be applicable to the wires which were held up at intermediate points in the span.

The deflectometer given on page 32 was good. It would have been better if the 20 lb load applied there had been more advantageously substituted by a spring so that it could work better when the downward deflection would vanish after the removal of the live load.

The new methods adopted for strengthening the girders as given on pages 40 and 41 were ingenious and perhaps the first to be used in India. Shri Apte, however, warned that this idea should not form a precedent and precautions should be taken to avoid such occurrences on future works by providing sufficient margin in the original design itself. If extra wires provided were found to be unnecessary after completion of the stressing of the beams they could be pulled out from the beams later on. This method, however, should not be followed by designers to reduce the dead loads of structures in competitive designs.

The cables were attached to the bottom flange for strengthening the beam. As the widths of the bottom flange and web were quite different, it would not be possible to give a curvature to the cable of more than 6 to 10 degrees without serious increase of the dead load. If the cables in the original design had a bigger curvature, a change in the design might be necessary.

On page 41, it was mentioned that the anchor block used at the time of restrengthening was subjected to a shear stress of 370 lb per sq. in., which was taken care of by reinforcement acting as rivets. The provision of shear resistance by mere dowels was undesirable and the anchor block should have been designed according to the usual practice of R.C.C. design. It appeared that this method of design was chosen to reduce the thickness of the anchor block for facility of working of the jacks.

Mention was made on page 43 that under live load there was a change in stress of about 900 lb per sq. in. in the bottom fibre, etc. From the diagram on page 41 it was seen that the guniting was only $2\frac{1}{2}$ inches thick, the cover over the cables being less than one inch. Shri Apte felt that by alternate cracking and closing of such a small section of guniting, there was every chance of the guniting being flaked off and a time might come when it would have to be done again. Actually there was no need of doing any guniting at all because the cables were protected by sheathing and cement was also injected in the sheathing after the completion of the stressing and so painting of the cables would have served the purpose of guniting.

Shri E. A. Nadirshah observed that the Paper described in a very interesting manner the difficulties experienced in stressing some of the girders of the bridge across the river Bhima and the strengthening effected to overcome the deficiencies in the prestress. It brought to light how every minute constructional detail was of paramount importance in prestressed concrete works and showed how a little over-optimism in the manufacture of sheaths for cables actually resulted in extra expenditure on strengthening of eight of the girders.

On page 30, the permissible stress at the end had been assumed at 80 t.s.i. It would be interesting to know the basis on which this figure had been arrived at. If this stress was in the region of the flatter portion of the stress-strain diagram for the H.T.S. wire, obviously a high value of the total extension might be registered at the end without actually obtaining the required strain at the critical section. This was probably one of the contributing factors in causing the critical sections to be still deficient in prestress although safitisfactory total extensions were registered on restressing.

Use of lubricants to minimise friction had been mentioned on page 31 of the Paper. On this occasion this treatment did not help and was abandoned. Even if such a treatment was successful in reducing the friction it was not at all advisable to use any type of lubricants which would reduce or prevent the bond between steel and grout. A proper bond is of primary importance in obtaining a high ultimate load carrying capacity for the structure and hence to ensure sufficient factor of safety.

The breakage of wires in spans 6 and 7 during restressing indicated that there was an unequal distribution of the applied force and this should be particularly guarded against when dealing with high end stresses caused by high frictional losses.

One of the most effective methods developed for minimising the effects of friction goes to the credit of Professor Fritz. In this method, sudden jerks are given while stressing thus allowing the application of the highest permissible tension in stages without high losses due to friction and avoiding overstressing at the anchorage. It appeared that on this principle if stressing in a normal post-tensioned work was done in stages of releasing and restressing in quick succession, frictional problems such as the one encountered in the Takli Bridge could be overcome without resorting to strengthening.

Miss Shakuntala Joshi said that this Paper indicated the practical difficulties that are met with in prestressed concrete work. Calculated extensions were found on the basis of average

of prestressing force at centre and at the jacking end. The difference between the end force and the central force was of the order of 25 per cent and it would not be quite correct to take the average of the two for finding the elongation. The expression for the resulting prestressing force at a distance x from jacking end had an exponential form, and the elongation had to be found out by successive summation of the elongations along the length of cable.

$$\text{Total elongation} = \sum_{x=o}^{x=l} \frac{Tx}{AE} dx$$

On page 28, Author had stated that STUP's formula was used for finding frictional losses. In Oct. 1953, CACA in London had published results of their experiments on frictional losses.

Their general finding was:

$$V_x = V_o P_{re} - (k_x + \mu \alpha) - V_r$$

where Vo = Jacking force.

Vx = Force at a distance 'x' from jacking end.

k = Constant depending upon the type of duct, method of forming it and degree of vibration.

Pr = Factor allowing for friction in jack.

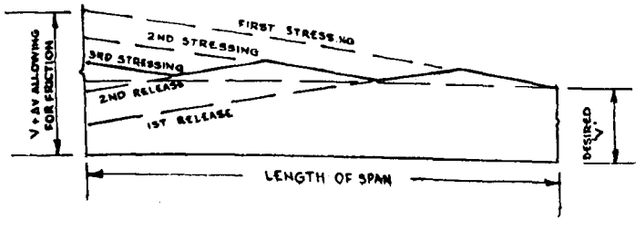
μ = Coefficient of friction between the cable and the sheath.

α = Changed curvature in radians.

Vr = Factor allowing for friction in the anchorage.

This formula was expected to be used for finding elongation and would give results different from that worked out in the Paper.

Members would be interested to know that some continental experts advocated successive stressing and release of jack as a method of arriving at an approximately constant force throughout the length of cable. Diagram of stress at successive operations is given below:



On page 31, the Author had mentioned that some of the wires had broken during restressing. This was a very important point. Experiments done on the construction of prestressed concrete bridges were being published in a series of articles in "Bautechnick" of Berlin. The first article of the series had appeared in Feb. 1957 and dealt with the behaviour of prestressing steel. Important observations were as follows:

(1) Breakages of wire occurred after the completion of prestressing operation sometimes even after a lapse of 8 days.

(2) Experiments were carried out in many laboratories to investigate the reasons of these failures. Testing to destruction of the samples of these broken wires showed that they possessed sufficiently high ultimate strength. It was then thought that in spite of their high breaking strength wires behaved like a brittle structure on site and this proved that they were subjected to multiaxial stresses on site.

(3) Some of the breakages were attributed to corrosion, surfacial imperfections and faults in drawing of wires, etc.

(4) It shows that testing of a sample of wire for breaking strength was not a perfect criteria for the quality of the material of the wire.

(5) An instrument called SD_4 apparatus was devised to detect the imperfections in the steel. Whole length of each wire could be tested before it was formed into cables.

Shri K. F. Antia wanted to know whether any test of the wire was carried out to ensure that it attained the specified ultimate strength.

The second point that required elucidation was the so-called 'locked-up extension'. He could visualise a locked-up stress. He, however, could not visualise a locked-up strain. The very nature of strain precluded the idea of any locking up. He had not been able to understand clearly what phenomenon was covered by this so-called locked-up extensions. If reverse friction or friction in the opposite direction prevented the wire from moving back, he did not consider that there was anything locked-up. The number of failures of the wire would lead one to suspect that one or more anchor points developed in the cable which prevented its reverse movement when released. Moreover, these anchor points resulted in excessive stressing of the wire between these points and the jack. This might have been the cause of failure of a number of wires.

The mixes specified were 1 : 1 : 2 and 1 : 1½ : 3 and, in addition, a strength of 5,000 lb per sq. in. had been specified. It was

suggested that either the mix or the strength should be given and not both. The mention of cube or cylinder when indicating strength would also avoid ambiguity.

The object of sheathing the extra cables was not also clear. These cables were outside the girder and were held in position by means of concrete blocks. Apart from small lengths of sheaths in these blocks the necessity for sheathing the remaining length was not evident particularly when these cables were subsequently gunited.

Regarding the question of releasing stress in the wire, the point was not clear to him. In order to release the prestressed wires an additional stress had to be put on them. Shri Antia felt that overstressing might perhaps have been the cause of failures of 20 wires.

He also wanted to know whether span No. 7 had been left without strengthening.

Shri E. P. Nicolaides stated that the bridge dealt with in the Paper was designed and constructed by his firm. He therefore would take the opportunity to explain how, through a mistake that occurred on the site, they had to face the difficulties of tensioning the first two spans of Bhima Bridge.

When work started at Bhima, they did not have on the site a sheath making machine and by a silly error in calculating the width of metal strip necessary for the sheath, the strip was cut rather narrow against the usual requirement of a sheath diameter larger than the cable; the man at site then proceeded in forming the sheath by hand, directly on the cable itself and so the first cables were provided with tight sheaths; furthermore, the cables so sheathed were stored at site for sometime before placing them in the beams and the storage naturally led to a further increase of friction between sheath and cable.

All these adverse conditions were traced back only when the prestressing of the first span was started and the friction was found to be excessive for attaining the required elongation without very high pressures at the jacks.

The problem of friction was there in every prestressed concrete structure tensioned with steel tendons passing through the concrete and therefore the accident reported at Bhima Bridge need not cause alarm.

Prestressed concrete bridges had been constructed for the last 17 years and were in use in India over 100 spans varying

from 60 to 150 feet; the span of Bhima was one of the largest and was the single case where excessive friction could not be overcome at first tensioning.

The breakage of wires during restressing might appear a serious defect; yet such breakages were not unusual in prestressing operations and had often occurred on other prestressed concrete jobs.

At Bhima span No. 6, eight wires had broken at restressing, out of a total of $92 \times 12 = 1104$ wires and thus the steel area was reduced by only 0.7 per cent; in span No. 7 with twenty six wires broken out of a total of $100 \times 12 = 1,200$, the reduction was 2.16 per cent and still quite small.

It was not intended to suggest that wire breaking should be condoned in prestressing operations and, while it led to a defect, the latter could and had been set right more than adequately as reported by the Author.

It was certainly not necessary to allow for an increase in the factors of safety at prestressing as a result of this mishap; it would be unreasonable to penalise all future prestressed concrete constructions for a mistake that took place once in so many years, after so many other successful cases and when a satisfactory correction of the defect had been possible.

On page 37 of the Paper, Shri Natu had stated that the straight line of the load deflection diagram given on page 38 had actually shown a kink at the load when the first cracks appeared. This was not quite apparent on the diagram, and it was doubtful whether at the first crack detection would be possible through a variation in the continuity of the load deflection curve. Shri Guyon, who had a vast experience on the subject, would surely be able to tell whether it would be possible from the load deflection curve to ascertain when the first crack had occurred. To his knowledge, there had been protracted and yet inconclusive dicusssions as to when the correct point of cracking might be reflected on the load deflection curve or otherwise established.

In his opinion, testing of structures where all the specification requirements had been met with during construction should be limited only to the design live load and no more; when the concrete cube strength, the steel resistances and elongations and all other specification requirements had been met on a structure, there was no reason for leaving the structure permanently weaker by testing it up to the cracking point, or, for that matter, even beyond its design load.

Shri Natu had given the test load at which the bridge was considered to have lost the assistance of the concrete tensile strength and he had taken for the latter a figure of 180 lb per sq. in. From the results of the cube strength of concrete, the figure of 180 lb per sq. in. would appear low. The load test carried out could not, in his view, establish that the concrete had a tensile strength of not more than 180 lb per sq. in. It should be borne in mind that the incidence of shrinkage in prestressed concrete members before prestressing was an important factor. Perhaps Shri Guyon would support him on this point. Shri Nicolaides was of the opinion that a few cables in all prestressed concrete beams should be allowed to be stressed as soon as the concrete was strong enough to carry 200 to 300 lb per sq. in.

Within three to four days after the concrete is laid, a considerable amount of shrinkage takes place, thus reducing the shrinkage obtained by calculations; even at 0.1 per cent this initial shrinkage strain would induce a tensile stress of 300 lb per sq. in. in the concrete of members restrained from moving freely; this, of course, could be the case with long prestressed concrete beams resting on a fairly rigid shuttering; over a length of 150 ft, the concrete should be free to contract by at least $\frac{0.1 \times 150 \times 12}{1000}$ = 0.18 in. and the shuttering might easily oppose this contraction, thus introducing tensile stresses of sufficient magnitude to accelerate cracking of the concrete, only by a further small increment of the tensile stress. It must also be remembered that the very dry and hot climate of India considerably aggravates the shrinkage problems. Another reason for early prestressing was the likelihood of small movements in the staging supporting such long lengths of very lightly reinforced concrete.

Shri D. P. Nayar in his comments stated that, as far as the design of the bridge was concerned, a thickness of web of 5 in. seemed to be rather on the low side. According to Shri Guyon's empirical formula the thickness of web should be 7 in. In the case of a bridge over river Ghaggar in the Punjab where the span of the beam was 87½ ft centre to centre of piers, against 150 ft in the present case, the thickness of the web was kept 5 in. although the number of beams was 7 as against 4 used in the case of bridge under discussion. This thickness was required for facility of pouring concrete and avoiding certain risks of cracks in the web. It was quite obvious, therefore, that the adopted thickness of 5 in. was adequate.

The diaphragms were rather closely spaced. Normally, the number of diaphragms was independent of the span of the beams and for a span of 150 ft a diaphragm spacing of 30 ft could be

considered sufficient. It was for consideration whether Govt. of India's recommendations for closer spacing of diaphragms should not be re-examined.

For a given longitudinal span the spacing of the longitudinal beams had very little effect on the total number of longitudinal wires. It followed that an excessive spacing of the main beams would require the location of too many wires in the tension region of each member. This would create difficulty when the wires had to be transferred from bottom to top. In the present case a large number of cables had to be accommodated for each beam because only 4 beams had been used for this bridge. If a larger number of beams was not considered advisable it would have been better if the use of 7 mm. wires for the cables had been investigated instead of 5 mm. diameter wires. Consequent reduction in the number of cables would have helped in proper positioning of the cables, thereby ensuring easy concreting and adequate bond.

It is very surprising that excessive frictional forces to the extent of 50 tons per sq. in. had developed in spans 6 and 7 when efforts were made to pull out the cables keeping the other end free. On the basis of .1 per cent of the end stress per foot of the cable for the wobble effect plus .4 per cent of the cable per degree of curvature for curvature effect, the total frictional force worked out to about 16 tons per sq. in., as against 40-50 tons actually experienced. This clearly indicated that the metal sheath used as a duct for the cable was defective and, most probably, damaged badly during concreting and vibrating operations. Some concrete or cement slurry might have entered the ducts causing the cables to set together against the metal sheaths. In such a situation filling of the duct with the lubricant could not have possibly reduced the friction. The very fact that the addition of the lubricant did not help much indicated that the ducts were damaged and blocked.

The damage reported in the case of inner cones by original use and subsequent release required detailed investigation. For proper functioning of the prestressed concrete beams so far dependence had been laid upon the type of cones used for fixing the cables after the prestress had been applied. In the case of any failure of the inner cone during the service of the bridge there was a great danger to its safety. Shri Nayar wanted to know if there were any methods of avoiding such damages occurring to the cones after they had been locked in position.

The minimum strength of 1 : 1½ : 3 mix had been stated as 5000 lb per sq. in. even though weigh batching was resorted to. In the case of the concrete of the same mix being used for the

Ghaggar Bridge which was being constructed in the Punjab State, although the method adopted was by volume the minimum strength after 28 days had been found to be 7000 lb per sq. in. It might be of interest to know if any laboratory investigations were carried out on the fineness modulus of sand and the aggregate and how the mix design was arrived at. It was possible that the sand used in the concrete on this bridge might have had a lesser fineness modulus than was required for a good quality concrete. The mix used for the diaphragms and the deck slab had not been stated. It might be presumed that 1 : 1½ : 3 mix was used for these parts also.

During the process of grouting, obstructions to the passage of grout were encountered and at places the grouting had to be done by tapping the sheath. The reasons for obstruction to the free flow of grout had not been given by the Author and certainly needed investigation. One possible explanation was that the duct was closed at various points on account of its having been badly damaged by rough handling or any dirt going into the central core helix. It would have been better if in the case of each individual cable the free passage of the duct was tested by making water flow from one end under pressure.

The large number of breakages observed in spans 6 and 7 needed investigation. It seemed that excessive force was applied during stressing which should not have happened considering that stressing was always controlled. It was presumed that wires used for cables were thoroughly examined before use and were not corroded. So far in the Punjab they had had no experience of such breakages.

If would have been of interest if during the load test investigation, efforts had been made to watch the behaviour of the beams by means of strain gauges.

The method adopted for strengthening by making use of extra cables seemed rather doubtful and quite risky. He was not quite sure whether they could straightaway depend upon the method of fixation and provide new cables on the old beams. Out of the two spans which were restressed the Author had stated that the performance of span No. 6 improved considerably but he had not given any possible reasons for non-improvement of the functioning of the beams in span No. 7.

Shri N. S. Gupchup stated that in the case of the Bhima Bridge a proper type of sheathing was perhaps not used, with the result that stretching of cables to the required extension became almost impossible owing to frictional resistance which increased very probably on account of some mortar or concrete having found its way into the sheathing. An attempt was thereupon made to restress the cables and in this process some of the wires snapped. It should not be concluded, however, from this—as some of the previous speakers seemed to have done that there was something inherently wrong with the prestressed concrete technique or that snapping of wires during stressing was a normal feature. Doubts had also been expressed about the quality of steel used.

Prestressed concrete had now passed beyond the experimental stage. A large number of bridges had been built and were being built at present in India. Thousands of cables had been stretched successfully. A bridge of the magnitude of that of the Bhima required about 1,000 cables and 12,000 wires.

It was very probable that in the case of the Bhima Bridge some of the cables were stretched beyond their ultimate strength during the restressing operation. This view was based on the data supplied by the Author in his Paper.

On page 31 of the Paper, the Author stated that for span 7 with a stress of 80 tons at the ends an extension of 9 9 in. was expected. A little further on the same page he stated that the cables of the span were observed to have a locked-up extension of 2.769 inches and that on restressing with an end stress of 77.73 tons, a further extension of 8.235 inches was attained. The total extension in the cables thus was 11.004 inches. The very fact that an end stress of 77.73 tons was necessary to stretch the cables by 8.235 inches meant that there was a considerable friction to overcome. Normally for this extention the stress required would be about 66 tons, $\left(\frac{8.235}{9.9}\right) \times 80$).

It was difficult to assess the actual end stress that was responsible to produce the locked-up extension of 2.769 inches ; some idea could, however, be formed of its magnitude and thus obtain the initial stress in the cable before restressing. Deducting the plastic set estimated by the Author as 0.4 inches, the elastic part of the locked up extension was 2.769 inches minus 0.4 inches = 2.369 inches. Stress to cause this extension would be about 20 tons $\left(2.369 \times \frac{80.0}{9.9}\right)$ To this must be added the stress required for overcoming friction. Even without it, the total stress in the cables on restressing worked out to 20 + 77.73 = 97.73 tons, which was almost very near to the ultimate strength. It was not at all surprising, therefore, that some of the wires snapped when overstressed in this manner. This was no reflection either on the prestressing technique or the quality of the steel.

In para. 4.5 on page 37, it had been stated that sudden increases and decreases were noticed at the end of periods of rest during unloading operations and that these were caused by changes in temperature. The explanation given was not satisfactory.

The first overnight increase was the deferred strain due to the loading applied to the span remaining on it during the night. It was thus additive. The reduction during the recess—which was of a short duration—was the result of the deferred negative strain as a consequence of the unloading operation. Had the recess been of longer duration, after a time there would have been an additive strain as a result of the load on the span at the beginning of the recess, as happened on the night following.

During unloading, the second overnight increase was a result of the deferred strain due to the applied load remaining on the span for whole of the night. It was additive because there was sufficient time for overcoming the tendency towards the negative strain as a result of the unloading process and to commence the positive deferred strain due to the stationary load remaining on the span throughout the night. The actual increase in deflection noted was thus an algebraic sum of the initial negative and the subsequent positive deferred strains.

Deferred strain is a phenomenon which was characteristic of concrete. It was dependent on both the magnitude of the applied load and its duration. It was thus a time cumulative effect.

Too much was often sought to be read in load tests on bridges. It was extremely doubtful if these tests served any useful purpose beyond indicating the qualitative nature of the behaviour that the bridge would undergo when loaded. Quantitative interpretation of deflections as measured could only be reliable provided all factors were taken into account and even then it was doubtful what the utility of such observation would be.

Sometimes loading tests were prescribed which were positively harmful. It had to be borne in mind that with prestressing, resultant stresses were not directly proportional to the external loading and even a small increase in the latter might cause a manifold increase in tension in some of the members.

He knew a case where it was prescribed that the slab of a bridge should be tested for a load 50 per cent above that for which it was designed. Even though this stipulation did not matter as far as the slab was concerned it definitely had an injurious effect on the beam, for, the tension in the beam, as a result of the test load, was much more than that either prescribed or that which concrete would take. It was, therefore, necessary in all such cases to keep in mind the main objective of such tests and not to overstep.

Shri Y. Guyon stated that there was no doubt that the difficulties met with in tensioning of the cables were only due to the wrong fabrication of sheaths; Shri Nicolaides had agreed with that. It was obviously necessary for the diameters of sheaths to be correctly provided. Sheathing machines had been devised for that purpose; they must be used and should not be replaced by hand labour. Prestressed concrete was not a difficult technique, but everything must be done in the proper way.

He agreed with Shri Nicolaides regarding the small percentage of broken wires compared with the total number of wires (1,200 in every span); eight ruptures in span 6 would not affect the safety; twenty-six in span 7 were somewhat more significant, not so much for safety (which after all would be reduced by 2 per cent only) but because they revealed that something went wrong.

It was quite possible as mentioned by Shri Antia that some cement grout might have leaked through into the sheaths and caused local bonding; consequently when trying to attain the required elongation, some wires might have elongated over shorter lengths between anchorage and points of bonding, with the result that the elongations reached the full rupture elongation over this shorter length. In France, the cables were always moved to and fro over 2 or 3 inches in their sheaths shortly after concreting to ensure that there was no bonding, or to break the same where it might have occurred accidentally.

Had the same case, as related in the Paper, occurred in France, he wondered whether he would have provided any reinforcement as done by Shri Natu. He had tried to follow through Shri Natu's calculations and, subject to correction, had found that the theoretical stress at bottom fibre should have been 218 K/cm² (3060 p. s. i.) under prestressing alone; the actual stress was 196 K/cm² (2750 p.s. i., i.e., 22 K/cm² (310 p. s. i.) less.

The stresses under full loads (prestress + permanent + live loads) should have been, at the bottom fibre, 180 p. s. i. in compression. Due to the reduction of prestressing, they could have reached 180 – 310 = – 130 p. s. i. (tension). As the safe tensile resistance of concrete had been assumed at 180 p. s. i., the safety against cracking would have been sufficient; the test results adequately proved this opinion; the design moment under live load was equal to that of a test load of 123 tons placed and distributed as described in the Paper, while the first cracking actually appeared at 125 tons.

Regarding Miss Joshi's contribution, he agreed with her that the computation of friction losses by a linear formula was not quite correct. The exponential formula, which Miss Joshi had given, viz., $T = T_o e^{Gx}$ was more accurate, but since Gx was small, the formula could be written approximately as $T = To (1 - Gx)$: or with $\frac{To - T}{To}$ as the relative loss of stress, the latter was equal to Gx. On the other hand, friction losses occurred not only at curves, but also on straight lines, due to the wobble effect in the cable layout and the consequent friction against sheaths. A convenient formula, in the metric system, was: Loss in prestress in per cent $= K (\alpha + x)$, α being the deviation measured from the anchorage in degrees, x the length (from the anchorage) in meters and K a coefficient depending on the nature of the sheaths, the wire surfaces and the care in execution. In France, K was generally taken as equal to 0.4 (per cent); for the proper computation of elongation, this formula might be applied to obtain the value of T at different distances x and deviations α from the anchorage; unit elongation for this value of T was given by the strain-stress diagram of the steel and a graphical integration gave the total elongation. This integration was only necessary when the initial tension at the jack was greater than the limit of proportionality (if any).

Further, Shri Guyon was not generally in favour of alternating the pressure on the cables serveral times with a view to obtain a theoretically better distribution of tension. In his view, the simpler way was always the best, and that was to tension the cables to a high enough degree—and it was never harmful to do so and let the losses be covered in that way.

He agreed with Shri Nicolaides that a kink in the load deflection curve was not likely to indicate the point of cracking. He had explained his views on this point in the second International Congress in Amsterdam. The only criterion which he considered as definite was visual inspection, naturally with the aid of magnifying instruments.

On the question of stressing some cables after a few days, he agreed also with Shri Nicolaides; it was an advantage against the effects of shrinkage. The time lag between casting and the first tensioning must be related to the concrete strength reached and the early stress should be applied accordingly, but he thought that 3 or 4 days would meet the Indian conditions.

On the question as to whether he would recommend a test in cases of accidents such as Bhima, Shri Guyon said that one should preferably avoid being placed in circumstances calling

for a test. He did not generally consider it advisable to test a structure beyond its service loads, except of course for scientific research, as it seemed useless to crack the structure, when actually it would most probably have done its service without cracking. In the present case, the overloading during the test was, in his view, harmful since the cracking load for the first test was 125 tons and for the second test 105 tons; it was true that the cracking resistance had been restored within safe limits through the extra cables added in the repair work, but, as mentioned above, it would have been preferable to do nothing in the way of repairs beyond giving possibly a warning against exceeding the design live load.

Shri C.G. Swaminathan* referring to the device for measuring deflection on page 32 stated that on the assumption that the leverage for the 20 lb counterweight was about 5 ft, only a weight of 100 lb was counterbalanced. He wondered as to whether the frictional effects at the fulcrum had been taken into consideration. Even if these effects were eliminated, it was not clear to him how an accuracy of 1/336th of an inch was obtained.

Secondly, it was said that there was a very good agreement between the dial gauge reading and the deflectometer readings. He did not agree that the agreement between the two might go to prove the accuracy of the recorded deflections, since, both the dial gauge and the deflectometer were likely to be erroneous as both would be influenced to the same degree by the end play of the post, friction at the fulcrum, loose bolt connections, etc. So he would prefer, in addition to the direct measurements either by the dial gauge or the recorder, to check the deflections with a set of strain gauges or by means of noticing the differences in levels periodically between the top of the nearest pier and the centre of the bottom of the beams by means of a theodolite kept on the nearest bank.

From the data given on page 39, it was found that the difference between the observed and calculated deflections was as high as 10 per cent. From the curves in Figure 3, one noticed that the difference went on increasing with increase in load. This might be the correct picture or it might probably be so because of the fact that the curves were the corrected ones in which the changes in the deflection had been distributed. He wondered whether this distribution was justified, just for the sake of getting a continuous curve. The curves could have been plotted on the actual data observed, including a set of horizontal portions to denote the changes in the deflections at a constant load. In such a case, the need for the assumption of a common point of deflection at the end of first unloading would not have arisen.

*This comment was received in writing.

Lastly, it was said in the Paper that the overnight change in deflection at a constant load of 50 tons was due to the fall in temperature. Although the period might have been only 12 hours, but since the structure was in a highly stressed state, it was doubtful whether there was a likelihood of volume flow taking place.

The Author, in reply to **Shri M. P. Apte,** stated that it was true that the slab was not cross prestressed but it was a prestressed flange of the T-beams. The ribs and flanges of the T-beams i.e., the girders and slab were cast almost simultaneously and the section of the deck was thus a monolithic one. The shear at the junction of the slab and the beam calculated under the prestressed condition nowhere exceeded 20 p.s.i. and was thus well within the permissible limit for concrete of 500 lb strength. The stirrups as provided were nominal ones and constituted an additional safety. Furthermore, at the junction of the beam and slab castellations were provided to take care of the shear at the junction as might be necessary on account of any constructional deficiency in casting the whole section truly monolithic. Shear value of these castellations was almost 13 p.s.i. and the shear value of the stirrups was about the same.

The proof stress of the high tensile steel wires at 0.1 per cent elongation was almost 90 t.s.i. The initial working stress was specified as 80 per cent of minimum ultimate stress by American Code and therefore the initial working stress of 66.7 t.s.i. adopted in the present case for 100-110 t.s.i wires was permissible.

There was no doubt that the possibility of damage to the sheaths during construction could not be ruled out. In the present case, however, the trouble was due to the metal sheaths having been built tight on the cable with no clearance between the two.

Regarding damage to the cones, the inner cones were not exactly damaged; it was only risky to use them again.

In order to avoid damage to the sheaths, concreting had been done carefully, particularly around the sheaths. Also, before actual stressing the cables were stretched from either end alternately until movement was noticed at the free end; thus any physical holding up of the cable was overcome. The breakage of wires was still a mystery and must be due to entirely other reasons not connected with the constructional defects leading to the excessive friction as was encountered.

The 20 lb load in the deflectometer could well be replaced by an equivalent spring but the Author felt there was no specific

advantage in that. The load helped to remove the play at the fulcrum as well as at the other arm, whether the movement of the beam was downwards or upwards. In either case the lever presses against the pins on the same faces.

The Author agreed with Shri Apte that there should not at any time arise the necessity of strengthening a new structure right at the beginning as at present. However, he felt that this method might be useful in strengthening old structures either weak or showing signs of weakness or defective R.C.C. structures.

Regarding curvature of the strengthening cables any curve as would normally be called for by the design could be given to these cables without least difficulty and without appreciable increase of the dead load. The extra dead load involved was just that of the cable itself and a strip of guniting to encase the cables. Arrangement for supporting the cables at the bends did not also constitute any appreciable weight.

The limit that had to be placed on the size of the end anchor-block for facility of working the jack made it utterly impossible to provide for the huge shear by usual R.C.C. design method. The behaviour of this end anchor-block had proved that the design as adopted had functioned absolutely satisfactorily beyond a shadow of doubt. The Author, however, did not see any objection why the design could not be worked on the principles of the design for rivetted joints. Concrete should be at par with any other elastic material in this respect.

Regarding Shri Apte's doubt regarding the behaviour of thin coat of gunite cover over the cables under alternate cracking and closing, the Author felt that there was no reason why guniting should flake off though there might be just hair cracks at places. This guniting was, however, to be kept under regular watch for a number of years for its behaviour. It was difficult to say if regular painting of the sheathed and cement grouted cables would have served the purpose of guniting. The sheaths were made of quite thin black iron sheets and scraping of old paint during paint renewal would have been very difficult without damaging the sheaths. In such circumstances it appeared that guniting was the proper course.

Replying to **Shri E. A. Nadirshah,** the Author stated that the lubricant that was tried to minimise friction between steel and grout was such as could be subsequently flushed out completely by water.

The reason for breakage of wires was still a mystery as already said. So long as the jack pressure was less than 100 t.s.i.,

there was no reason why any wire should break unless the particular wire alone, out of the 12 wires forming a cable, was blocked up at some point not far away from the jack ; but such an eventuality could not be correctly imagined even if a little slurry from the concrete did get access to the cable due to damaged sheath.

The method developed by Professor Fritz for minimising the effects of friction was of interest and more practical details of this method would be of great help.

In reply to **Miss Shakuntala Joshi**, the Author stated that the frictional effect in a post-tensioned prestressed concrete girder could be divided into two parts, viz., (1) length or wobble effect, and (2) curvature effect. Calculations made on page 30 assumed a uniform friction all along the length of the cable because of its high value and friction effect being of the nature of something like a bond between the sheaths and the cables in the case under consideration.

Friction being an empirical factor there were bound to be alternative formulae each with its own merits and demerits. All of them would not be wide off the mark.

Formula by STUP as on page 28 of the Paper had the advantage of extreme simplicity and ease of application.

Miss Joshi, no doubt, had given a fund of information which would be of great help. The information on the point of breakage of wires was of special interest.

Replying to **Shri K. F. Antia**, the Author stated that several samples from each consignment of high tensile wire received on the site of the job were tested and none of them had given a breaking stress of less than 100 t. s. i.

It was exactly the reverse friction or friction in the opposite direction preventing the wires from moving back that had constituted what was termed as locked-up extension. The term may not be quite an appropriate or accurate one but was intended to convey an idea of the stressed state of the cable even on its being freed from the end anchorages.

No doubt anchor points were likely to develop but, as already stated, before the cables were initially moved either way and it was difficult to imagine how only a wire or two out of the 12 wire-cable could get anchored by the slurry getting access to the cable.

The concrete had to have a proportion of 1 : $1\frac{1}{2}$: 3 by weight. It also had to give a 28-day 6 in. cube strength of not less than

5000 p. s. i. Such a specification, no doubt, was not very scientific according to the concrete technology but what was intended to convey was that the specified mix must not give a strength of less than 5000 p. s. i.

It had been already explained that the stress variation under the live load at the bottom fibre was of the order of 900 p. s. i. under which guniting was likely to crack in course of time. In order, therefore, that moisture might not get access to the steel through these cracks, sheathing was provided with grouting. Grouting, sheathing and guniting were thus intended to obviate any possibility of the outside air, any time in the life of the bridge, coming in contact with the high tensile wires.

As the cables were released quite some time after the first stressing, there had taken place some loss in steel stress due to shrinkage and creep of concrete. In releasing the cable what was required was just a slight movement of the anchor cone by pulling out the cable just by an eighth of an inch which did not put any more stress on the wire than what was already put during the first stressing. By a special but very simple device the anchor cone could be held back in the withdrawn position and the cable released. One or two such operations enabled the cone to be completely removed at one end. Removal of the cone at the other end was then a simple operation of pulling out the cable from that end.

Replying to **Shri E. P. Nicolaides'** remark regarding the kink in the load-deflection diagram at the load when the first crack appeared, the Author stated that what was meant was the commencement of deviation from linearity of the diagrams, as the beam passed from an elastic stage to R. C. C. stage when cracking commenced. In the present load test they were particularly interested in finding out the load for zero stress at bottom fibre. The reason why the curve in Fig. 3 was not quite straight upto cracking had been explained on page 39 of the Paper. It was due to the overnight increase in deflection without corresponding increase in load having been distributed in the succeeding few readings of deflections under increased loads. However, no absolute accuracy in this respect was sought to be claimed.

The agreed design provided for a certain prestress at the bottom fibre under live load and they wanted to ascertain how much of it had actually been imparted. This was possible only when the structure was loaded (or rather overloaded even) to cracking. As the design provided an ample residual precompression or at least no tension in any case at the bottom fibre under the maximum live load moment there could be no question of making the structure weaker by cracking had the designed

prestress been actually imparted. Had the design prestress not been actually imparted, unambiguous plans for making up the deficit by strengthening the structure were already in hand. An agreed prestress formed the basis of agreement and it was necessary to take every precaution in construction procedure and details to ensure that the agreed prestress was actually realised. If it had not been so, then something was neglected somewhere and had to be remedied whatever its price. This was the view point, right or wrong, which then prevailed when the load-testing as had been done was decided upon.

He agreed with Shri Nicolaides on the necessity of early partial prestressing which should, however, make an allowance for the higher shrinkage losses due to early age of the concrete. The problem of loss of tensile strength of the concrete (at the bottom fibre of the beam) had also another aspect, i.e., of differential shrinkage, which was quite unavoidable. Concreting of the beams and slab of the structure of the present size took several days (anything from 10 to 15 days). The bottom flanges of the beams were cast first. Subsequent concreting of ribs and slab with a fair time interval caused differential shrinkage inducing considerable tensile stress in the bottom fibre of the beam. This loss was quite unavoidable. The present load tests had conclusively shown that residual tensile strength of concrete at the bottom fibre of beams was of the order of 180 p.s.i. only as against a figure exceeding 50 p.s.i. to be expected of a 5000 p.s.i. concrete.

Replying to Shri **N. S. Gupchup**, the Author agreed that the possibility of some mortar, i.e., slurry from concrete, finding its way into the sheathing was always there but what had actually happened in the present case was that the sheathing had been tightly built around the cable. A sample piece of a sheathed cable about a yard long was on the display on the work site and it was impossible to move by hand the cable in the sheathing.

It did not appear probable that the cables came to be stretched beyond their ultimate strength since the jack pressure was always a guide to this. It was possible that some of the wires in the cable, on account of getting anchored at some point, might have got overstressed beyond their ultimate strength but such an eventuality, as already stated before, was improbable.

The locked-up extension indicated a stressed state of the cable, after its release from end anchorages, on account of the reverse friction coming into play. However, once the cable was again stressed from ends, this reverse friction would disappear and the stress indicated by the jack would alone be the total

stress anywhere in the cable and no more. The stress in the cable, therefore, during restressing never exceeded 80 t s.i.

The increase or decrease in the deflection without a corresponding increase or decrease in the load taking place during periods of test must partly be as pointed out by Shri Gupchup, a phenomenon of deferred strain. Change in temperature too must have been playing some part in this as had been reported in the results of some other load tests also. The reason was obvious. During the noon time the whole of the deck slab got heated up while the girders below which were in shade were comparatively cooler. This would make the deck hog. The little friction at the bearings also played a part.

In the case of load testing of the slab referred to by Shri Gupchup it was perhaps the slab which was to be principally tested and it might not be too much if it were prescribed to be tested for a 50 per cent more live load than the designed load. If this was putting too great a strain on any of the girders the Author felt that the situation could perhaps have been remedied by supporting the girders suitably. If the testing of the slab was for an experimental purpose (as it appeared to be since in an established type of design testing of a slab was hardly ever done in a bridge at least), it would appear desirable that a full scale model of the slab with rigid supports replacing the beams should be tested instead.

Replying to **Shri Y. Guyon**, the Author stated that as had already been explained it was difficult to imagine why a few wires alone out of the cable should have got locally bonded. If a sheath got extensively damaged the whole cable should get bonded up, in which case the jack pressure would be a guide to the stress in the steel. If there was only, a local damage so that the concrete got in touch with a few wires only this bonding would reasonably be overcome by the great force acting on each wire. At a jack pressure of 80 t. s.i., the force on individual 0.2 inch dia. wire was 2.5 tons. This should overcome all possible bond. Supposing a wire got completely embeded in cement slurry for a length of, say, 2 ft, a force of 2.5 tons was enough to overcome a bond of 360 p.s.i.

In the present case the cables were moved to and fro so as to ensure that there was no local bonding. This was, however, done at the time of stressing and not immediately after concreting.

The considerations that led to the testing of the bridge as carried out had already been mentioned. In case of span No. 7 the visible crack during first loading appeared at a load of 101 tons only as against 123 ton load producing the design live load moment. Here, even with the tensile strength of the concrete, there was no safety against cracking.

Replying to **Shri C. G. Swaminathan,** the Author stated that the measurement of deflection was not such an important consideration in the present case. It was only a side issue and hence too much attention was not paid to the measuring device adopted. The figure of 1/336th of an inch was a printing error. It should have been 1/224th of an inch. The deflection was magnified seven-fold by the lever arrangement. At the registering end it was possible to read to an accuracy of 1/32nd of an inch. This meant that the accuracy in measurement of deflection was $1/32 \times 7 = 1/224$th of an inch.

Electrical strain gauges for the measurement of strains had been adopted in the present case but the results were so inconsistent that it had to be concluded that either the electrical strain gauges did not give accurate results on concrete surfaces or they were not suitable for field conditions. Measurements of deflection were also taken by a level but the results did not prove as consistent as the deflectometer reading. Further, it had already been stated that the absolute values of deflection did not form an important consideration in the present case.

Shri M. S. Bisht (Chairman) thanked the various speakers, notably Shri Guyon for his analysis of the subject and Miss Joshi for her valuable comments.

It was quite clear that the whole trouble could be traced to defective sheathing. In all other spans where sheathing was carefully done there was no trouble whatever, and the wires were fully stressed, the beams developing the required moment of resistance. A particularly disquieting feature of the trouble was the rupture of many wires in these two spans.

Prestressed concrete was coming more and more in use in our country and many important bridges were being built with this material. It seemed to him that prestressed concrete was being taken for granted. This could be harmful and the trouble that had developed in this particular bridge should serve to open our eyes to the great need for attention to details.

It had been established during discussion that rupture of wires was due to anchorage that had developed in certain stretches which could be due to many causes.

He only hoped that the methods adopted to strengthen the beams would prove successful in the long run, but essentially the need for adopting such measures should not arise.

Discussion on Paper No. 190*

"Study of a Clay Bank Failure on an Indian Railway."

By

U. G. K. RAO

Sunday, 12th May, 1957

Shri S. R. Mehra (Chairman) called upon Shri T. K. Natarajan to introduce the Paper on behalf of Shri U. G. K. Rao who was unavoidably absent.

In the absence of the Author, Shri T. K. Natarajan introducing the Paper said that on tracing the history of the embankment since its construction, one found that it had been a source of continual trouble ever since 1912. A superficial study of the problem might indicate that the failure was due to inadequate strength characteristics of the materials composing the embankment. But, the fact that slumps had occurred in 1941, 1942 and again in 1955 at different places, and the fact that the occurrence of these slumps mostly coincided with the time of withdrawal of the monsoon, were very significant and clearly suggested that improper drainage was probably the principal cause of failure.

Shri H. G. Verma said a careful study of soil characteristics before constructing an embankment was necessary not only in the case of railways but also in the case of roads. Several roads had failed because of defective soil and defective drainage. The number of such failures was on the increase on account of formation of impervious road surface which did not allow water in the base course to evaporate freely as was the case with the water-bound macadam.

In the Uttar Pradesh, observed Shri Verma, several cases were referred to the Research Institute in the recent past for suggesting a solution. Stretches of roads on G. T. Road in Bulandshahr district and miles 5 to 11 of Meerut-Baghpat road and miles 41 to 49 of Bareilly-Pillibhit-Tanakpur road gave satisfactory service till the surface consisted of water-bound macadam even in years of abnormal rainfall. But with improved wearing coats, the road surface became uneven with deep undulations in long stretches. It became impossible to drive on them after the last rainy season.

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The soil analysis of the base course showed that it was clayey and had high shrinkage and swelling characteristics. After a careful study of the problems, the Research Institute suggested that the formation level be raised by about 2 ft and suitable drains provided on both sides of the embankments. Also, it was proposed that subgrade soil should be mixed with coarse sand so that its gradation might fall within standard grading limits fixed by the Bureau of Public Roads, U.S.A. In addition, the thickness of the existing crust was found insufficient. According to the C.B.R. test it should have been 11 in. whereas it was 5 in. only in the portions which had been damaged.

The Author had not clarified in his Paper what action had actually been taken to remove the defects in the railway embankment and with what results. It appeared that action had not yet been taken on the recommendations made by him.

Shri Verma felt that the failure of the embankment had been primarily due to the presence of highly shrinkable soil in the top layers combined with defective drainage system As a general rule, such a poor soil should have been placed at the bottom, or at the most upto the centre of the embankment where the weight of the overlying materials tended to inhibit the high volume changes of the clayey soil. Recently, plastic films had been developed for waterproofing purposes. One such product was now available in India in sheet form with thickness ranging from .001 to .007 in. The introduction of this film was said to serve as a water barrier. If the film was introduced above the non-cohesive layer so as to envelop the portion of the bad soil, it would prevent the passage of water into this soil and thereby eliminate its swelling characteristics. He was not sure how far this method would be successful but it certainly needed a trial in waterlogged areas. It might not be possible to try this method in the case under discussion as the non-cohesive layer was about 3 to 4 ft below the ground level which could not be reached except at a prohibitive cost.

Referring to the analysis of soil in Plate I, he pointed out that the clay percentage of the soil was pretty low in most of the cases. Ordinarily, soils having such low percentage of clay should not be highly plastic. Hence, he failed to appreciate high plasticity of the soil in question. Along with other charactristics of this soil the Author should have included the volumetric shrinkage, concluded Shri Verma.

Shri A. K. Deb said that for a problem like the one described by the Author, one would anticipate some calculations on stability of slopes, but the Author was right in leaving out those calculations as the material comprising the embankment was not

at all homogeneous. He agreed with the Author on the cause of the failures also, namely, the development of excessive hydrostatic pressure in the sand pockets and granular water-bearing strata lying a few feet below the surface. The solution to the problem lay in the dissipation of this excess hydrostatic pressure by providing suitable drainage measures.

He considered that, on a study like this, some field measurements of the actual pore water pressure in the water-bearing strata by the installation of tensiometers would have been very interesting. He wanted to know if any attempts were made in this direction and, if so, with what results ?

Brig. S. K. Bose had examined the data given in the Paper from the stability point of view. Failures had occurred between Ch. 900 and Ch. 1050. But data given for embankment at Ch. 900 in Plate I was quite silent on the main characteristics of the soil, such as, values of cohesion, angle of internal friction, and the field density. These values were, however, given for the embankment at Ch. 1400. Taking that the same values applied to the soil at Ch. 900, too, it had been assumed that the slip circle passed over the ground as was evident from the cross sections given in Plate II. He found by the Taylor formula that the stability number was 0.135 and the factor of safety 2.45. He assumed the value of cohesion as 4.9 per sq. in. instead of 49 shown in Plate I because value of 49 lb per sq. in. for clayey soil was not possible. Even in black cotton soil the value was between 8 to 10.

He had taken 21 per cent as the moisture content for the value of cohesion of 4.9 lb per sq. inch and for the factor of safety of 2.45. But cohesion was intimately related to moisture content in respect of clayey soil. The Author had stated that the original embankment was clayey soil, akin to black cotton soil. In such soils if saturation conditions reached, failure would occur, as the value of cohesion got reduced considerably. Assuming that the value of cohesion was reduced by half, the stability factor would be 1.25.

The method adopted for determining the value of cohesion was not indicated—whether unconfined compression test at the site or whether direct shear stress in the laboratory and whether adequate precautions were taken against loss of moisture content. He did not, therefore, agree with the Author that the embankment failed entirely due to lack of drainage. The lack of drainage no doubt contributed to this failure which caused saturation in the fill material. But adequate drainage only could not remedy the defect. He felt that coarse material also mixed

with the fill material, the trouble was not likely to end. He, therefore, wanted this to be done at the time of taking the work in hand.

As the soil was mostly clayey, Brig. Bose failed to understand why riser-pits had been used. Free water could not be drained out from clayey soil. Therefore, any amount of riser-pits or rubble drains could not drain excess water in the embankment.

Shri S. A. Swami said that the study by the Author showed that the failure of the bank was essentially due to defective surface and subsoil drainage and, as such, great stress was laid on proper drainage. It was noticed that only the up-side slope of the embankment of the up main line had given way, and this had been the case in the previous years also. He felt that in addion to the provision of drainage, wooden sleepers driven vertically down the slopes at 6-8 ft depth from the formation would strengthen the slope of the embankment in the weakest portion. This coupled with a rubble toe well at the foot of the slope would make the slope free from sliding, when normal drainage had been effected by the drains provided. This improvement was not likely to be costly, as old sleepers might be available in plenty with the railways. The above-mentioned improvement would be particularly very effective in view of the Author's recommendation under para. 4.5 where replacement of the top 6 ft of the embankment by a different material was envisaged.

Since it was realised that the subsoil moisture flowed towards the up-slope of the main line where the hydraulic gradient was set up, good cross-drainage with pipes at convenient intervals below the expected gradient lines and connected to a main drain at the toe would reduce the undermining effect of the subsoil moisture.

In Plate I, the soil test results revealed that in most cases the liquid limit was very high, for example, in trial pits No. 1, 2 and 3, it was 54.5 per cent, 45.5 per cent, and 53 per cent respectively. Normally, a higher liquid limit was associated with a higher clay content in a soil. He presumed that the soil classification in this investigation was based on the M.I.T. classification in which particle size below .002 mm. was considered as the clay fraction. He wanted the Author to confirm this presumption.

Shri Swami remarked that a rational analysis based on the 'C' and 'ϕ' values of the clay explaining the clay bank failure would have enabled one to appreciate the problem better.

Shri E. A. Nadirshah remarked that the Paper appeared to him to be the first-ever investigation of the kind based on modern principles of soil mechanics in this country. It showed how a problem which had defied solution for almost half a century could be solved by careful work in a laboratory.

He wanted to know if any stability computations were carried out, or any detailed observations made of the various strata of the soil occurring in the bank, for example, determination of moisture-density relations of the soils as they occurred, the unconfined compression strength of clays, and the shear resistance of the different strata. Stability calculations based on such test results and observations of ground levels at different points would give satisfactory explanation of the movements that occurred and also help to determine measures which could be taken to prevent further failures.

He specially laid emphasis on compaction. In all earthen banks it was of the greatest importance that the material should be compacted to a high density and have the minimum of air voids. This was particularly true for materials of a clayey nature, for, when the voids became filled with water, there would be a tendency for the clay to soften. If the voids were appreciable, this softening effect might be very considerable. For all railway embankments, therefore, it was essential to specify the density of the placed material and to design the bank for the shear strength of the material in the fully softened condition corresponding to this density.

Regarding the remedial measures suggested, he felt that consideration could have been given to the construction of counterfort drains running at right angles to the length of the bank and extending beyond the slip plane. These drains were usually in the form of trenches filled with hard core or brick rubble. They also fulfil a subsidiary function of supporting the slope against further slip. Such drains were further assisted in their function by the provision of a herringbone system of surface water drains on the surface of the slope.

Shri C. G. Swaminathan felt that the bank might have slipped owing to the combined effect of both improper drainage and instability of the slope. In his opinion, the density given appeared to be low for an embankment of the type under investigation.

Continuing, Shri Swaminathan said that some more data should have been given regarding the soil in the embankment and at places where failures and cracks had occurred. He said that most of the trial pits were dug along the toes of the embankment.

as was evident from Plate II. Shri Swaminathan further added that the nature of the soil reported to have been employed for a portion of the embankment varied very widely. For example, trial pit No. 2 at chainage 900 showed that the soil was mainly silty while trial pit No. 1 showed that the soil was a very soft clay. The data given seemed to indicate that the soil was more or less like quicksand or loocss. Microscopic analysis of silt might indicate if the particles were porous or otherwise.

Referring to the longitudinal cracks at chainage 900, Shri Swaminathan felt that more particulars regarding characteristics of the soil near the crack should have been given. In his opinion, the latitudinal cracks might have been due to the use of different types of materials, i.e., silt and clay. The cracks, perhaps, represented the line of demarcation and developed as a result of differential movement of moisture.

As regards the recommendation made by the Author, he felt that the riser-pits were not very effective as the slip of the bank appeared to be due to built-up pressure. In his opinion, even toe walls might not be effective. To reduce the hydrostatic pressure within the embankment he suggested that a series of horizontal and vertical tile drains might be of some help.

Lastly, he was of the view that in addition to the pucca surface drains a bituminous blanket over the slope laid at a depth of 4 to 6 ft below the ground level at the toe portion might prevent the entry of water into the embankment flowing from south-west to north-east.

Shri R. N. Dogra felt that the information given in the Paper was, perhaps, not comprehensive and more data as pointed out by some previous speakers would have enabled one to get a more correct and scientific appreciation of the problem. The suggestion made by the Author that the failure was entirely due to lack of drainage did not appear to be quite true. It was probably a combined effect of bad drainage, incorrect choice of soils in the embankment and inadequate design.

Brig. Bose had already pointed out why he considered the embankment would fail even if the drainage was improved. Shri Dogra was inclined to agree with his views. Unless and until soil characteristics of the embankment were improved, merely improving its drainage would not help.

Drainage was, of course, a very important factor and must be taken into account while constructing all new embankments. While investigating some of the recent failures of road embankments in the Punjab it had been observed that they could be

invariably correlated to a rise in the water table. In most of these areas the water table was rising due to either bad drainage naturally or the drainage being obstructed due to cultivation or due to excessive irrigation of the areas, etc. But the fact that the soil contained very high percentage of moisture in it was the main contributing factor. In the design of our embankments, therefore, steps should be taken to ensure that there was no rise of moisture from the sub-base. In other words, the embankment had to be carefully drained and insulated to prevent subsequent moisture rise from the ground.

The other important thing was the load factor. The intensity of traffic on our roads and railways was steadily increasing. It was essential that the embankments should be designed for this load rather than for some arbitrary values. The embankments could be designed and should be designed like any road structure on scientific basis utilising the shear values or C.B.R. values of the materials, etc.

Further, after the embankments had been correctly designed it should be ensured that there was sufficiently rigid field control to see that the designed mix of the soils was used in the embankment and it was compacted to the designed density throughout the depth of the embankment. Unless soils with the correct characteristics were put into the embankment, the desired result would not be obtained. Field control was, therefore, of very great importance in the case of all large scale soil work.

Shri S. N. Gupta stated that two different soil structures were involved in the embankment. The first was soil in the subgrade on the basis of which the embankment was formed. The second was the soil in the embankment itself. The 35 ft high embankment had provided a vertical overload of, say, 35 cu. ft. per sq. ft. Probably, the subgrade which was predominantly clay was not strong enough to bear this pressure of nearly 2 tons per sq. ft. Therefore, gradual settlement occurred.

It was also not clear from the Paper whether the density of the embankment soil was checked. In all probability the soil was not adequately compacted during construction. This might have aggravated the inadequacy of the slope. Without minimising the importance of surface and sub-surface drainage, want of compaction, if not of stabilization of the subgrade as well as the embankment, was bound to prove critical. To remove the inadequacy of drainage, vertical sand drains might have proved a good remedial measure.

Shri J. S. Narasimham also observed that sufficient data regarding the characteristics of the foundation soils had not been

furnished in the Paper. If that data were supplied, perhaps a more critical examination could have been made. The Paper mentioned that the embankment consisted of clay as well as coal-cinders but coal-cinders had not been approved as an engineering material as yet. Railway embankments constructed with coal-cinders over poor foundation soils were not safe. A strata consisting of coal cinders could not be compacted well, because as it was compacted, the grading changed due to the disintegration of cinders. In one case he had investigated the bearing capacity of a coal-cinder strata of 30 ft depth as a foundation base for constructing a workshop shed. The bearing capacity of this material was found to be inadequate.

The Author had dealt with a problem of an old embankment and had attempted to strengthen it to avoid further slips. He felt that in a case like that it was necessary either to use vertical sand drains or to stabilise the strata by pumping cement slurry under pressure into the strata at various places. The drainage in the embankment and subsoil would pass off through the cinders as it was a pervious material. The cement slurry would give enough strength to the cinders in the embankment from being dislodged under the dynamic stresses developed by the movement of the rolling stock.

Shri Narasimham desired to consider strengthening of the embankment on the lines suggested above. It would not be correct to assume values of 'C' and 'ϕ' for such a material consisting of coal cinders. Therefore, the stability of such old embankments containing coal-cinders and soil mixed should be obtained by pumping under pressure cementitious material and giving flat slopes to the embankment.

Shri E. C. Chandrasekharan * referred to para. 3.4 wherein it had been stated that soil samples were taken from the slope of the up-embankment in the portion where no damage had taken place. It was not known whether the Author had analysed the stability of the slope of the embankment at the place of worst moisture condition and whether there would be adequate factor of safety, if the possible effects of the hydraulic gradient mentioned in para. 3.4 (iv) were neglected. He desired details of such studies, if any, to be furnished.

From para. 3.4 (iii) and (iv), it was seen that the embankments had been placed on a basin shaped formation and that the idge located beneath the down track formation caused the movement of the surface and subterranean water on either side and the effect of the flow of water towards the upside of the embank-

* This and subsequent comments were received in writing.

ment might have been instrumental in causing the failure that had occurred. The water levels during the monsoon season under the bank for the up main line and engine lines at Ch. 1400 had been connected in Plate I and the fall in gradient was apparent. This, in his opinion, was the most important of the findings in the investigation conducted and the remedial measures recommended were directly or indirectly based on it. While the water levels had been determined at and near the cross section taken at Ch. 1400, these observations had not been extended from Ch. 1000 to 0, except at the well near Ch. 400 at the toe of the up main line. In other words, confirmation of the existence of similar gradients in the water level all through the full length of the region in which failures had occurred repeatedly, would be necessary, especially when, as already mentioned, all the recommendations of remedial measures made centered round this most important finding.

He also desired to know the type of shear test adopted in determining the values of 'C'and 'ϕ' and also the natural moisture content and voids ratio of the soil collected from the up slope of the undisturbed portion of the embankment (trial pit No. 1), i.e., the material used for constructing the old embankment.

Shri N. Mohan Rao observed that it was very seldom that enough importance was given to the drainage aspect of it, which influenced to a very great degree the stability of foundations, particularly the slope stability. Sometimes this aspect was totally ignored and the investigations were directed only towards carrying out the stability analysis.

He felt that the Author in arriving at the conclusion that the subterranean moisture had a greater part to play in causing failure, must have been largely influenced by his finding that the three banks had all been put up in a basin shaped formation which had a small ridge beneath the down track formation sloping away towards the up track thus encouraging flow of both surface and subterranean moisture away from it in either direction. Probably because of this ridge formation and consequent flow of water away from it, it was only the left embankment that had slipped many times while the right ones were stable. Otherwise, there was no reason why these also should not have failed having the same type of soil. He wanted to know whether the Author had any other reason in view which might have influenced him to conclude that the main cause was the subterranean flow of water.

The Author had also pointed out that during the 1955 slide, a 2-in. wide crack 3 ft deep developed for a length of 100 ft on the up-cess of the embankment which went down at an angle of 60°

right down to toe. It was a general observation that tension cracks, the depth of which was determined by the cohesion of the soil, developed impending a slide though the development of 60° crack down to the toe was not very usual.

Incidentally, the Paper highlighted some of the usual wrong procedures inadvertently practised in trying to prevent failures. The Author had mentioned that the wide cracks which appeared in 1955 were made up by unloading coal ashes, presumably on the top, trying to close the cracks. This procedure instead of helping the situation might have only caused further deterioration by causing additional sliding movement.

Before replying to the comments, **Shri U.G.K. Rao** (Author) said that because of the expansion of the yard at Ajni it had not been possible to implement the remedial measures suggested in the Paper. The measures would be tried as soon as the conditions permitted.

The Author agreed with **Shri H.G. Verma's** contention that soil used for the construction of the embankment was very poor. As the whole quantity of soil required for the embankment could not be available from the borrow-pits nearby, it had to be transported from long distances. The Author remarked that it was also possible that the consolidation of the embankment was not very satisfactory. He felt that in a job like the one mentioned in the Paper where materials used were not homogeneous only soil properties could not give all the information. One had to depend also on the information obtained from local observations, from actual moisture movement as indicated in the accident reports, and from the trial-pits at the site. Due importance was given to the properties of the soil as found in nature. The samples obtained from the embankment were useful only to a limited extent.

The Author was doubtful about the success of plastic films referred to by Shri Verma. He maintained that lowering of the water-table by introducing a layer of non-cohesive soil below the ground level, by superimposing a layer of graded non-cohesive material on the top, and by preventing collection of water on either side of the embankment were the only practical solutions.

Referring to Shri Verma's criticism about high plasticity indices of soils with low clay-content, the Author said that the P. I. was determined for fractions passing B. S. S. No. 36. He addded that mineralogical clay also appeared to be of highly absorbing type of montmorillonite. As the soil contained a good percentage of coarse-grained material, determination of volumetric shrinkage would not have been of much help.

As regards the measurement of the pore water pressure mentioned by **Shri A. K. Deb**, the Author pointed out that as the embankment was of heterogeneous materials, even driving of pipes from the top or inserting of any equipment in the embankment would have been very difficult.

Replying to **Brig. S. K. Bose,** the Author mentioned that the stability calculations were not given because, as stated earlier, the embankment was a heterogeneous mass. In view of the fact that during many years in the past materials of varying properties had been used, it was not possible to depend either upon shear properties of the soil obtained from the slopes of the embankment or be sure that the same material existed even a few feet away from the spot from where the samples were collected. The Author was confident that the circumstantial evidence proved beyond doubt that the failure of the embankment was on account of movement of moisture. In such cases a permanent solution could be had only if the entry of the moisture into the embankment was sealed off. He agreed with Brig. Bose that there was no need to provide riser pits, as the poor quality of the soil would never have permitted trapped water to be drained into these pits.

Every year railway engineers adopted some accepted method of stabilising embankment.

The Author did not agree with **Shri S. A. Swami's** suggestion for driving wooden sleepers in the middle of the slope of the embankment. In his opinion such sleepers were likely to enable water getting into the interior of the embankment and thus be a cause for instability. He added that the method suggested by Shri Swamy was tried on another embankment by the railway engineers and was reported to have led to very serious results. The Author was not in favour of puncturing the embankment anywhere. On the contrary, he was of the opinion that the top of the embankment should be so good as to allow unobstructed and quick flow of the water rolling down it. Cross drainage was often tried when sub-surface drainage failed to lower the water-table.

For determining the clay content of the soil, hydrometer analysis using sodium chloride as a dispersing agent was adopted. The soil was classified as per P.R.A. classification.

With reference to **Shri E. A. Nadirshah's** comments, the Author stated that during the last 10 years the Indian Railways had been following modern methods of laying and compacting embankments and they had given good results. As regards the provision of counterfort drains, etc., he pointed out that the

material used for the construction of the embankment was not such as would have allowed proper drainage. If the counterfort drains had been provided these would have got choked as riser-pits did.

Shri C. G. Swaminathan's contention that the slope adopted for the construction of the embankment was unstable was not borne out by facts as found by investigations, remarked the Author. The normal practice on the Indian Railways was to allow a slope of 2 : 1 if the material was good, for example, moorum. For clayey soils the slope specified was $2\frac{1}{2}$: 1. Though factual data was not available, the Author had every reason to believe that the slope of the embankment under discussion was not steeper than $2\frac{1}{2}$: 1.

The Author agreed with **Shri S. R. Mehra** that the soil of the type used for the embankment was not susceptible to chemical or cement injections. Grouting was tried on the Indian railways in several cases as an experimental measure. In the past and also not long ago after full analysis of the soil was made by the Railway Research Department, these experiments proved that, unless the material of which the embankment was made was granular, cement grouting could not be successful.

Finally, the Author said that in the last four years the Railway Testing Research Centre had been analysing a number of problems connected with the failure of embankments, cuttings, hill-sides, etc., and the one referred to in the Paper was only one of them. The present day knowledge of soil mechanics used in conjunction with the knowledge obtained by a study of local conditions, accident reports, and other observations in the field had been of considerable help in such investigations.

The Author did not refer to the points raised by Sarvashri Dogra, Mohan Rao, Narasimham and Chandrasekharan as they had been covered in his replies to others.

Shri S. R. Mehra (Chairman), winding up the discussion remarked that so far as the Paper was concerned it seemed obvious that failure had been due to the combined effect of lack of proper drainage and unsuitability of the fill material for such a high embankment superimposed with heavy loads. That was alright in itself, but what the Paper, to his mind, brought out as a more important point, was the necessity of designing proper embankments and the materials that make them. It would, no doubt, be possible to find some remedial measures, but in this particular case, it was going to be extremely difficult to find very effective remedial measures for an over saturated clay strata which was very impermeable. No amount of drains or injections

of cement or chemicals was going to find a perfect remedy and it was difficult to say how far these remedies were going to be successful. So the moral was that in these days when so much about soils was known, high embankments should be designed and constructed scientifically and properly whether it be a road or a railway or any other structure.

Besides artificial embankments, Shri Mehra referred to natural slopes in which concentrated research was required. There were constructions in hill areas in all kinds of engineering projects and the hillside was cut and left to take its proper slope gradually, by removing slips as and when they occurred. But slips had a bad habit of upsetting traffic flow. It should be possible to find some reasonable and workable method by which a natural slope disturbed by construction could be treated so as to make it as little vulnerable to slips as possible. In the Central Road Research Institute an attempt was being made to do some research work on this problem, but the problem was so big on account of the variety of soils concerned and many other natural considerations involved that it was not within the scope of one institute to do justice to it. He suggested that the Indian Roads Congress might try and get as many laboratories as possible to do some work on the problem in order to find a practical solution.

Discussion on Paper No. 191*

"Resistance to Abrasion of Concrete Pavements"

By

P. J. JAGUS & M. R. Chatterji

Monday, 13th May 1957

Shri K. K. Nambiar (Chairman) called upon **Shri P. J. Jagus** (Joint Author) to introduce the Paper for discussion.

Shri P. J. Jagus, one of the co-Authors, introducing the Paper said that, since the iron-tyred bullock cart would continue to be for a long time to come the motive power for transport, abrasive resistance of concrete roads should be one of the most important considerations while selecting the coarse aggregate for cement concrete. He emphasised that the severe effects of narrow rims of bullock carts could be judged from the fact that the average intensity of contact pressures exerted by them on surfaces were as high as 500 to 900 lb per sq. in. compared to 200 to 300 lb per sq. in. developed by the steel treads of the heavy army tanks. Besides, the unevenness of the pavement in contact and that of the rim curvature could increase these intensities by another 200 to 300 per cent. Though all classes of pavements, rigid as well as flexible, were equally affected, special consideration was made for the rigid pavement, i.e., the cement concrete pavement, as it was treated as a permanent class of construction and no routine maintenance was supposed to be necessary.

Any damage to concrete surfaces due to heavy bullock cart traffic was likely to cause discomfort to the road user and shortened the life of the pavement. Non-rigid surfaces, on the other hand, needed regular yearly maintenance and periodic renewals when damages caused could be attended to.

Abrasive wear of concrete had been studied in foreign countries, but without the iron-tyred wheels. The effects of steel treads of army tanks studied by Dr. Glanville during war years in the U. K. and reported in the Journal of the Royal Engineers in 1945 could approximate to that of our bullock cart wheels. However, the overall severity of the tank traffic could be nowhere near that of the bullock cart traffic. He feared that the existing procedures to test wear did not reflect truly the abrasive qualities

* Published at pages 63 to 97 of the Journal of the Indian Roads Congress, Volume XXI-1, February 1957,

of road stones under the action of bullock cart traffic which was peculiar to our country only.

Shri Jagus pointed out that the photographs showing abrasive wear were meant merely to emphasise the damage caused to our roads. This damage was not necessarily because of poor quality of the aggregate, grading, or lack of curing discussed in the Paper.

Laboratory findings mentioned in the Paper were being co-related with the behaviour in the field on the C.R.R I. test tracks and when they were completed, they would be of considerable practical value and interest.

Shri H. G. Verma was of the opinion that, if the equipment described in the Paper could be made portable so that concrete, mortar, or even stone surfaces could be tested in-situ to determine their quality, it might prove to be more economical than other equipment like ultrasoniscope used at present for testing the quality of concrete in-situ by non-destructive method. Also, it was necessary to establish a relationship between the abrasion value and the compressive strength and other properties of concrete and mortar for different grades using various types of stones and sand. Unless this was done, the quality of work could not be checked by abrasion test alone.

He wanted to know whether the pneumatic tests mentioned in the Paper had been carried out on wet or dry mortars. He felt that wet and dry mortars were likely to give different results and hence it was important that compressive strength and abrasion should be determined under the same condition for co-relation of the two, as mentioned above.

Referring to the values obtained for Bundelkhand granite gneiss in Los Angeles abrasion test and aggregate value test as given in Table 1, Shri Verma said that they were rather low as compared to the results obtained by him in the laboratory. Against the figures of 12.5 for Los Angeles abrasion test and 18.1 for crushing value, his average figures were 28.5 and 21.8. The Los Angeles tests specified two gradings for aggregates, and he would like to know which grading had been adopted.

Again, for Muth quartzite the percentage of loss registered in the Los Angeles test was considerably less than that obtained by him, viz., 27.8 per cent (Table 1) compared to Authors' 44.8 per cent. It was possible that the sources of supply were different. He wanted the Authors to confirm this.

Shri Verma did not agree with the statement made in para. 4.2, that the overall performance of the wearing course could be

improved by designing the mortar of high resistance to abrasion and by so laying the concrete that the exposed surface presented a greater area of mortar than the coarse aggregate. In his opinion, the use of softer aggregate was not desirable in structures where abrasion was expected to be considerable. Even the British Standard Specifications suggested lower aggregate crushing value for concrete wearing surfaces. The use of richer mortar or subjection of greater area of mortar to abrasion was likely to make the concrete costlier. It might be cheaper to use better aggregate than to increase the quantity of mortar or improve its quality, concluded Shri Verma.

Shri E. A. Nadirshah commented that the Paper constituted possibly the first piece of fundamental research on concrete pavements done in India. In a way, it was also the first investigation of a problem of particular significance to Indian traffic conditions. According to his experience about the construction of concrete roads in the country for the last 35 years, several things had been taken for granted, viz., (1) that cement concrete roads constructed in any way provided an answer to bullock cart traffic; (2) that cement concrete could be used for wearing surface only over water-bound macadam surfaces; and (3) the thickness of the cement concrete slab could be 3 to 4 in., depending upon the thickness of the water-bound macadam over which it was laid, even for heavy traffic. These notions had taken root, as upto the last war the traffic was not very significant and as most of the deficiencies which were causing concern since then had started appearing during the last 10 to 12 years only. Complacency on the part of some engineers to details of concrete road construction was due also to the fact that several defects did not show up for a considerable time after construction. He felt that where wearing was conspicuous and extended up to an inch, measures should soon be taken to repair rather than allow the pavement to crack.

Referring to para. 2.2, Shri Nadirshah said that, since no specific test had been evolved to measure the concrete making properties of the aggregates till the evolution of aggregate crushing test and impact test, engineers judged the relative qualities of stones by the attrition and rattler tests. He was not in favour of continuing these tests any more. Further, he commented that the aggregate crushing test and the pneumatic test described in the Paper should be jointly used to evaluate aggregates for concrete work.

The information given in Fig. 2, para. 4.1, was very useful and he wished it could be made available in a more comprehensive form with characteristics of cement mortars using sands

from various regions in the country so that a concrete mix of the highest wearing resistance for a given set of aggregates could be used for wearing surfaces where there was fear of the surfaces rutting under bullock cart traffic. He pointed out that many of the test results which he had come across showed compression strengths of less than 4,000 lb per sq. in. The low strength of concrete might have been one of the causes responsible for the failures illustrated in the Paper.

Referring to the last para. on page 72, Shri Nadirshah said that if a practical method by which economical concrete mixes could be worked out and laid where inferior aggregates could be deeply embedded in concrete to be kept away from the wearing action, the aggregate problem might not be so bad.

While concluding his remarks, Shri Nadirshah suggested that the properties of surkhi (para. 7) should be standardized; otherwise, the use of this material in the field would encourage malpractices. Also, it was desirable that some long term effects of admixtures should be studied before final conclusions were arrived at.

Shri N. S. Bawa had some apprehensions about the modified abrasion testing apparatus shown on page 94. Firstly, in his opinion, the test would give the weighted average of the aggregate and mortar loss depending on their area proportions. Secondly, the results would differ very much for the same concrete because different specimens would have different area proportions.

On the other hand, he felt that the aim should be to know which of the two, the mortar matrix or the coarse aggregate, was the weakest and what its abrasion resistance was. The test could not give individual characteristics of either, which were very important. Also, for a 2.78 in. cube test specimen, the percentage of loss was likely to be very low. Hence, use of smaller specimens might be considered. Further, the size of the bigger specimens referred to at page 96 of the Paper should have been mentioned.

Shri C. L. N. Iyengar said that certain general conclusions were unwarranted because failure or deterioration of a cement concrete pavement could not always be attributed to abrasion. It could also be due to fatigue, as in the case of thin slabs 3 to 4 in. thick. Abrasion might be responsible for the failure of slabs on some busy approaches to towns or of lanes which were so narrow that bullock carts were forced to keep to one de finite path only along the road.

He agreed with the Authors that the tolerances presented by the B.S.I. or the A.S.T.M. were unsuitable and that we should evolve more rigid standards.

As regards using coarse sand for concrete mixes, Shri Iyengar remarked that this was subject to certain limitations, unless, as suggested by the Authors themselves, crushed stone was mixed in place of sand.

Since the relationship between the wear resistance and compressive strength was direct for various practical ranges of the concrete employed, properly designed concrete mixes could have adequate resistance to abrasion as well. Many of the investigations included in the Paper confirmed this.

Shri P. L. De pointed out that the apparatus had the following limitations:

(i) As the actual amount of loss due to abrasion was very small, even little inaccuracy in weighing or slight irregularity or nonhomogeneity of the material just at the point where the charge struck the surface might lead to serious errors. In other standard methods, the loss due to abrasion was quite appreciable. He suggested that this drawback could be rectified by increasing the amount of charge or velocity of draft or by repeating several cycles preferably at different points of the surface.

(ii) The apparatus might not be suitable for stone surfaces, etc., for which other standard methods would be better and simpler.

In reply to **Shri H. G. Verma's** comments, **Shri P. J. Jagus** said that recommendations had already been made in the interim report on "Standardization of Method of Measurement of Abrasive Resistance of Concrete by Pneumatic Sand Blasting," issued by the Central Road Research Institute, for adapting the apparatus for in-situ tests. The modification might comprise the same nozzle with the sand cone mounted on a tripod at a fixed angle such that the tip of the nozzle was at a fixed distance of 2 in. and at an angle of 80° to the concrete pavement surface to be tested. For obtaining an overall idea of the abrasive quality of the concrete pavement in the field, a number of tests would have to be made, say, 50 to 100 tests.

He agreed that testing of as many road stones as possible was necessary, and this work was being done in the C.R.R.I. However, without the help of the regional or State laboratories, testing of aggregates on a large scale would be unwieldy and it might not be possible at all to collect the data in a reasonable time. He wished the State laboratories could lend a helping hand by carrying out similar tests on aggregates which were mainly used by them.

The abrasion test on the mortar cubes was done in a dry state. The specimens were first dried at constant temperature of 100°C. for two hours after removal from the curing tank. The surface laitance was removed by sand papering in order to expose the actual matrix of the cement mortar for getting true results. The Authors, however, did not agree to conducting both the compressive and abrasion tests under similar conditions (i.e., wet or dry). The standard procedures for compressive tests and other strength definitely laid down that the concrete specimen should be saturated and surface dry. Drying out of the specimen in compression tests would result in higher strength values and also the consistency of results could not be maintained.

With regard to the quality of Muth quartzite, the first sample which was sent to the laboratory by the Chief Engineer, Uttar Pradesh, was so flaky in nature that it broke into flaky pieces merely on handling. Another sample was, therefore, called for and the values given in Table 1 were for the second sample.

Mention in the Paper regarding the use of softer aggregates in concrete pavements subjected to heavy traffic did not imply that the quality of the concrete could invariably be the same as that obtained by using good quality aggregate. It was merely to show that special processes such as those adopted for manufacturing vacuum concrete, shock concrete, etc., were resorted to when using softer aggregates. Adequate abrasive resistance could be ensured provided the area of mortar mix exposed was as great as possible.

In reply to **Shri E. A. Nadirshah's** comments, Shri Jagus stated that it would be inadvisable to postpone adopting remedial measures till the ruts in the cement concrete pavements were 1 in. deep. For a pavement which was used by mixed traffic, these could be not only very uncomfortable but also hazardous. The study conducted so far indicated that it was possible to use the aggregate crushing value in conjunction with the abrasive value as suggested by Shri Nadirshah. Nothing definite could, however, be said at this stage.

With regard to preparation of more number of curves using different types of sand, Shri Jagus stated that the ultimate idea was to carry out further study with sands from different sources and prepare a number of curves similar to those shown in Fig. 2,

He agreed with Shri Nadirshah that standardization of the properties of surkhi was very important as that material was being advocated widely as an admixture for effecting economy in the use of cement. Wherever surkhi was desired to be used for replacing cement, its quality should be properly evaluated by means of lime reactivity and such other tests.

Replying to the points raised by **Shri N. S. Bawa**, Shri Jagus said that the modified cabinet would definitely give losses which would be weighted averages of the exposed surfaces of the aggregate and the mortar matrices of the concrete tested. Whereas greater accuracy was needed in ascertaining the individual abrasive qualities of the mortars and the aggregates, it would be sufficient to obtain an accurate idea of the overall abrasive quality of the concrete as a finished product. The reliability of the results would depend on the number of specimens tested. The error due to varying exposure of the aggregates on the surface, from specimen to specimen, would be minimised to a considerable degree by testing adequate number of samples.

Using the $2\frac{7}{8}$ in. cubes in the standard test, the value of losses as indicated in the figure was $\frac{1}{4}$th of the actual total losses as measured on the four surfaces of the cube. The measurability of this loss was no doubt limited, but using accurate balances reading up to .02 of a gram, very good accuracy could be obtained. The coefficient of variation as obtained in the standardized test was found to be as low as 5 to 6 per cent, and this in itself proved the point stressed.

The modified cabinet could carry specimens of any size depending upon the outside dimensions of the cabinet which could be easily handled. In addition, the travel of the carrier on which the specimen was mounted could be increased to cover the larger surface area to be tested in the bigger specimen.

In reply to **Shri C. L. N. Iyengar's** comment with regard to the selection of coarser sands for improving the abrasive resistance, Shri Jagus suggested that, wherever sand of requisite coarseness was not obtainable, crushed stone screenings could be blended to improve the grading. Although, in general, a properly designed concrete mix would have adequate abrasive resistance, it might not be so in all cases. The Authors drew attention to Figs. 4 and 5 in the Paper where even for very small variations in compressive strengths and density of the mortars, abrasive resistance varied substantially with variations in the grading of sands.

The points raised by **Shri P. L. De** with regard to the limitations of the apparatus and the small percentage of losses had been replied to while answering Shri Bawa's criticism.

A larger number of test values would help to overcome the factor of variability of aggregates and would give a near-true picture of abrasive quality of the aggregate. The pertinent drawbacks of the existing abrasion tests had already been stated in para. 2.3 of the Paper. In the case of Los Angeles abrasion and Deval's attrition tests, in addition to the factors of shape, size and surface texture of the aggregate affecting the degree of loss, the presence of the abraded material from the aggregates tested would affect the test condition differently from one stone to another. The severity of the test would be reduced more in the case of softer aggregates, where the larger quantity of the worn out material would give rise to greater cushioning effect than that in the case of harder rocks where the quantity of the abraded material would be less.

While winding up the discussion, the Chairman, **Shri K. K. Nambiar** said that, as pointed out by Shri C. L. N. Iyengar, the problem of abrasion was not very serious generally speaking on concrete roads. But it was of importance only in the case of roads under certain peculiar conditions such as in the vicinity of docks, harbours, etc., where the bullock carts queued one behind the other. If the traffic was fairly dispersed on more than half the width of the road, the slab could not fail by abrasion. It would fail only by repetition of load. Shri Jagus had shown some photographs of the G. W. Trunk road where deep ruts had been formed on the concrete slab by abrasion. It was due to the fact that the concrete strip was only 8 ft wide with two tracks on either side and bullock carts had to queue one behind the other with the result that the steel tyres of the carts had caused abrasion.

Similarly, in an area near the Madras harbour due to the flow of bullock cart traffic abrasion had been caused in the road. The remedy was to have two layers of concrete slabs so that the top layer could be removed when damaged. It was true that many attempts had been made to use various chemicals to improve the concrete mix but no successful method had been evolved.

In conclusion, Shri Nambiar thanked the Authors for their interesting Paper and the various speakers for their comments.

Discussion on Paper No. 192*

"Design and Construction of a Prestressed Concrete Bridge across River Coleroon"

By

K. K. NAMBIAR & P. G. NAMBIAR

Tuesday, 14th May 1957.

Shri R. C. Roy (Chairman) requested Shri K. K. Nambiar, the Senior Author, to introduce the Paper.

Shri K. K. Nambiar (Senior Author) stated that Coleroon bridge was the first major bridge work in India undertaken in the Freyssinet system.

The decision to adopt prestressed concrete for the superstructure of Coleroon bridge was dictated by the pattern of economy presented by the tenders. Although, at that time they were successfully tackling the first prestressed concrete road bridge in India, viz., the Palar bridge in the Magnel Blaton system, Coleroon bridge involved altogether new problems of great magnitude, such as launching by specially designed machinery, production of consistently high grade concrete to yield a minimum strength of 7000 p.s.i. at 28 days for prestressed concrete beams, some of which were as long as 191 ft. The contractor was new to the field, but, for that reason, they could not reject a tender which appeared to bring in a new and bright and promising era in bridge engineering in India.

In the execution of Coleroon bridge they had suffered all the troubles and tribulations of pioneering. But this trouble was compensated by the experience gained.

As regards the rather abrupt ending of the Paper without saying anything about the prestressed concrete decking, he stated that at the time the Paper was finalised they had not commenced work on the decking, and they felt this had no place in the Paper which was dealing with the realities of execution. The decking work had since been completed and their experience thereon with its many interesting features could well form the subject of another Paper.

The bridge had since been completed in all respects and was to be opened to traffic on the 11th June 1957. In this connection Shri Nambiar acknowledged the services rendered by STUP of Paris and Krupps of Germany in successfully completing this bridge.

* Published at pages 149 to 263 of Volume XXI-1 of the Journal of the Indian Roads Congress.

The contractor to whom the work was entrusted being only a layman with no technical knowledge or experience, the responsibility for organisation and execution devolved entirely on the departmental staff, particularly Shri P. G. Nambiar, the co-Author, without whom it would have been almost impossible to carry out this pioneering work involving altogether new problems in bridge construction.

Before inviting members to speak on the Paper he invited their attention to a few typographical and printing errors which had crept into the Paper.

List of Corrections

Page	*Para.*	*Line*	*Corrections*
193	13.2.2	7	For **ream**—Read **seam.**
196	13.4.5	9	Omit **of** after projecting.
198	14.2.6	3	**Before rotating the bolt is removed,** must be shifted to end of para. to form the last sentence of para.
207	—	4	For **207**–Read **297.**
209	—	—	Photo 9 to be inverted.
215	15.4	—	In formula for **T**, for **1 d**–Read **1+d.**
220	Table	1	For **354**–Read **353.**
220	Table	—	In column 5 for $\frac{\text{elongation at 2000}}{3}$ Read $\frac{\text{elongation at 200}}{3}$
220	2nd para. after table	2	For **little**–Read **less.**
224	last para.	2	For **sq. cm**–Read **sq. mm.**
224	last para.	5	For **sq. cm**–Read **sq. mm.**
227	Table 6	—	Column 5 last line, for **61.5**–Read **60.50**
227	—		Last line, for **70.4**–Read **60.50**
236	17.7.1	11	For **chain**–Read **Chair**
237	17.8	—	For **girders**–Read **girder.**
240	17.9.3	1	For **1 and 3**–Read **1 and 2.**
246	17.13.1	last line	For **32(c)**–Read **32(e).**
253	(d)	7	Insert **2** under number column.
253	(d)	17	Delete.

Shri M. P. Apte stated that many new aspects of design and construction were introduced on the Coleroon bridge and the foundations were designed by resort to modern methods of soil mechanics. It was, therefore, necessary to study the limitations of the new methods adopted so that they could be used on other works after fully understanding them.

It was not understood what considerations weighed with the designers to adopt a linear waterway of 2,100 feet, i. e., about 50 per cent more than would appear necessary on hydraulic considerations. The railway bridge was 2,100 feet long. But it was an old bridge and might have been designed when the upper reservoirs and anicuts controlling the discharge of the river did not exist.

The linear waterway of a bridge was usually $K\sqrt{Q}$ where Q was the discharge and K a constant between 2.5 and 3.5 and had a usual value of 2.67. He asked why in the case of Coleroon bridge this constant worked out to 4. There were many instances in India (for example, bridges on Godavari river) where road engineers decided the waterway more rationally and provided smaller waterways than the old railway bridges.

Shri Apte felt that an expenditure of a few thousand rupees on investigating the correct linear waterway for such a tidal river, in a hydrodynamic research station, would have made a saving of about Rs 5 to 6 lakhs by reducing the length of the bridge.

The scour depth calculated by the Authors for the design of the foundations was 50.11 feet. Shri Apte felt this to be on the lower side. Assuming silt factor to be unity, maximum depth of scour at the noses of piers taken at twice the normal scour depth worked out to $2 \times 0.473 \times (270{,}000)^{\frac{1}{3}} = 61.5$ feet as per I.R.C. Code. Allowing for grip, the foundations should have been taken about eight feet deeper. It was not clear what method was used to find out the scour depth as 50.11 feet. As the river bed was not of such a coarse material as to warrant a higher silt factor in the above equation, Shri Apte remarked that all calculations regarding bearing power of the foundation soil, settlement, etc., would be valid only if the foundations were sufficiently below the maximum scour level. The saving of Rs one lakh made in keeping the foundations at higher level after testing the bearing power of the soil was, therefore, not very desirable. In the case of Coleroon bridge, a reduction in the linear waterway and an increase in the depth of foundations were warranted by the hydraulic characteristics of the river and would have resulted in a considerable saving also.

Shri Apte further stated that the equations on page 177 of the Paper for determining the settlement of clay had their own

limitations. Some clays were extra sensitive and their field consolidation curves were not straight. The actual slope of the upper part of the line might be several times higher. The approximate method of computation, based on Terzaghi and Beck's equations used by the Authors, merely furnished a lower limiting value for the compression of clays. The real compression of sensitive clays might be several times higher.

He pointed out that in the Paper on foundation problems of the piers of the Little Belt Bridge, published in Volume IV of the Second International Conference on Soil Mechanics and Foundation Engineering, it was stated that by using the theory of Terzaghi, a settlement of pier 3 was found to be only 1.5 cm. in ten years, while the actual settlement of pier 3 during that time was about 43 cm.

Shri Apte felt that the clay strata at Coleroon bridge would in all probability belong to the above type of extra sensitive clays, which usually included marine clays, highly organic clays and clays of volcanic origin. Mention was made in the Paper that fossils and poisonous gases were met with during well sinking which indicate organic nature of the clay. The bridge site was within 7-8 miles from the sea and, therefore, Terzaghi's equations for settlement could not be fully applicable to the Coleroon bridge.

He did not agree with the differential settlement calculated on page 175. If calculated settlement of pier 10 was 10.2 inches and of pier 11 was 8.7 inches, the differential settlement was taken as 1.5 inches. This could not be accepted, as the calculated settlement might not occur at all in one pier or might occur fully in another pier because of any local changes in the type of clay, local effects due to scour, uneven loading, etc. In such a case, the maximum differential settlement between two piers could be as much as 10.2 inches.

Shri Apte did not like the idea of using unbalanced cantilever type of superstructure for this bridge as there was every chance of the scour level being more than assumed in the design and actual settlement being much more than calculated. In this type of structure, if one pier was washed away, all other spans of the bridge would be affected immediately without giving any time for the operation of jacks which were designed for lifting the girders by only $4\frac{1}{2}$ inches. He wondered why something like abutment piers and abutment spans were not provided in this bridge, as was the common practice in the design of arch bridges. This would have restricted the damage to only a few spans, in case of emergency.

He also referred to the method used for testing the wells and said that many improvements were necessary to get more reliable

test results. He also suggested that loading experiment should have been done on two different plates having different ratio of area to perimeter, so that the shear factor could be eliminated from the observed readings while calculating the bearing capacity of the strata.

Shri S. A. Swami stated that the details of the foundation design showed that the foundations which were to be taken into hard compact clay were later rested on a sand layer 4 ft to 8 ft above the clay strata. This was a scientific step as a foundation on sand would distribute the load better than on clay which was bound to yield to a greater extent under a direct load.

It was mentioned in Table 2 that maximum settlement under various piers varied from 5.7 in. to 10.2 in. and the maximum differential settlement worked out to 4.4 in. in two cases. This was quite understandable as there was a clay strata beneath the sand layer and that clay would undergo consolidation under the pressure due to the loads, leading to gradual settlement. The phenomenon of consolidation and subsequent settlement of a clay had been explained by Terzaghi through his famous equations :

$$P = u/v\,(p_1 H_2 - \int_0^H u dZ). \qquad \ldots 1$$

$$\frac{du}{dt} = Cv\,\frac{du}{dZ^2} \qquad \ldots 2$$

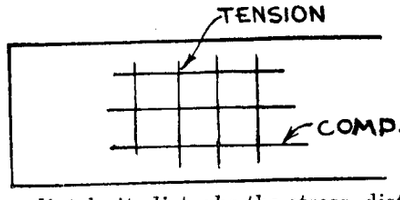
From equation No. 1, it was quite clear that consolidation would occur till the pore water pressure died down and then final settlement would have occurred. But it would take years for this process to be completed depending on the type of clay and the load.

Hence the rate of settlement was an important factor. The Authors' statement on page 173 under para. 10.6.1 that "the rate of settlement was not a primary concern" was not quite clear to him. While agreeing with the Authors that it was the differential settlement that mattered, he thought that a load-settlement curve based on Terzaghi's consolidation tests on the clays would have been an asset, since that would indicate what would be the settlement of the structure in any anticipated time and when final settlement could be expected.

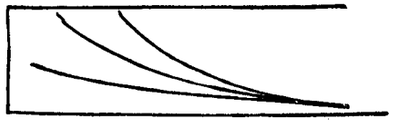
This would have been of particular importance, considering picking arrangements had been provided to lift up the deck in case of differential settlements.

Miss Shakuntala Joshi stated that from Fig. 9 of the Paper it was clear that some cables were anchored intermediately in the top chord.

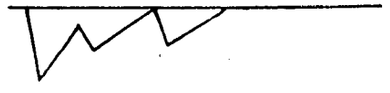
According to expert opinion, intermediate anchorages should be avoided as far as possible as they had the following disadvantages :

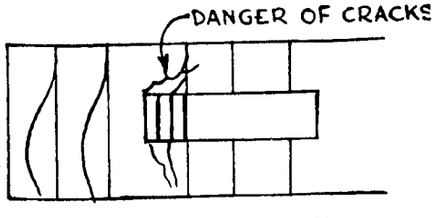


(1) In a prestressed concrete beam, stress trajectories result only if all cables are taken up to the support. But if some cables are anchored intermediately it disturbs the stress distributions and gives rise to diagonal tensile stresses.

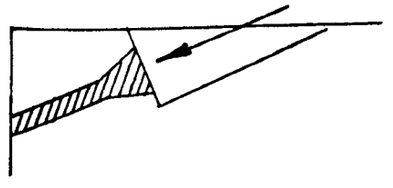


(2) According to Mons. Y. Guyon, intermediate anchorages give rise to saw-toothed shearing force diagram, which means high shear and greater possibility of principal tensile stresses.





(3) The steeply increased compressive stress behind the anchorage lead to deformations which give rise to tensile cracks at the back and on the sides of the anchorage. Although one can prevent such cracks becoming visible by providing reinforcement, intermediate anchorages should be avoided especially in case of works exposed to weather conditions.



Regarding the longest span of prestressed bridge, as the Coleroon bridge was the longest prestressed concrete bridge in India, Miss Joshi referred to a continuous bridge of three spans 101.65 m + 114.2 m + 104.2m constructed in 1952 across the river Rhine at Worms in Germany.

Shri T. K. Natarajan said that it was not quite clear to him why no consolidation test had been performed on any of the samples when a detailed settlement analysis had been attempted.

The statistical relationship $C_c = .009\ (L_w - 10)$ had been made use of to determine the compressive index of the soils. This relationship was known to be applicable only to clays which were normally loaded and which were fairly insensitive. The water content for the samples analysed had been found to be closer to the liquid limit than to the plastic limit. While this might bear testimony to the fact that the clay was normally loaded, it was not by any means indicative of the sensitivity of the clay. He asked for clarification on this point as to whether this aspect was taken into consideration at all. In view of this, he could not help feeling that at least one or two consolidation tests could have been performed to justify the implicit reliance that had been reposed in the statistical relationship and to check if any modification in the value of the coefficient in the relationship was necessary.

In the set of typical computations for settlement analysis of clay on page 177 of the Paper, the settlements of the clay layers of different thicknesses had been determined and added up together such as S_1, S_2, S_3, S_4, etc. The compressive index and the initial void ratio of all such layers, had been shown to be the same and as such it was not clear why there was any need to divide the 16 ft of clay layer into layers of 2, 5, 5 and 4 ft respectively.

Finally, he pointed out that this was a case of a pier foundation located on a relatively stiff layer above a soft deposit. The sand layer being situated below the scour depth was a dense layer overlying a softer clay deposit below. Therefore, this sand layer would act somewhat like a natural raft that distributed the entire weight of the structure over the surface of clay beneath. The flexural rigidity of this natural raft would prevent the surface of clay below from heaving beyond the loaded area. Since it was clear that the probable seat of settlement was the clay layer below and not the dense sand layer above, he felt that the compressibility of the sand layer could have been altogether ignored in the settlement analysis made. In other words, he was of the opinion that if and when the settlement occurred, the pier and the sand layer would settle together.

Shri A. Banerjee said that the bridge had been designed for a discharge of 270,000 cusecs, i.e., for the same figure as the railways had adopted. Calculations by Lacey's formula showed the required waterway necessary to be only 1,400 rft. The total clear waterway provided was 2,100 rft, i.e., the same as that of the railway bridge. He requested the Authors to explain what were the

factors that necessitated this excessive provision. It was found that the main channel of the river was hugging the south bank. It might be possible that some spans on the north were not giving any real service.

Again, by Lacey's formula for depth of scour even if 'f,' the silt factor, was taken as 1.0 (it may not be in any way greater than this figure), the normal scour depth came to 30 ft, and the corresponding calculated depth of foundation from H.F.L. to 80 ft. But on page 152, the Authors had stated that the depth of scour from M.H.F.L. was 50.11 ft. He requested the Authors to indicate which empirical formula was used and what value of 'f' was adopted in calculating the depth of scour.

On page 153, it was given that the foundation consisted of three rectangular wells, 11 ft-0 in. × 12 ft-6 in. of 1 : 3 : 6 mass concrete having a steining thickness of only 2 ft for the upper 40 ft. The Authors had stated on page 154, "where external loading was of no avail the water level inside was depressed by pumping, etc.", i.e., dewatering was resorted to. He asked the Authors if any cracks were observed in the steining during dewatering and what was the maximum difference of head at any time between the inside and outside of the well? A small calculation showed that dewatering more than 10 ft would induce tension in the steining, even if each well was externally loaded by kentledge of 75.00 tons.

Light steining generally increased the cost of sinking and entailed risk of "running of the well" when dewatering. If the idea was to reduce foundation pressure, R.C. steining of lesser thickness could as well have been used.

It would be of interest if the Authors could give the figures of maximum tilts and shifts of the wells.

On page 152, the Authors had stated that the estimated cost of bow string girder bridge came to Rs 24.22 lakhs, but on page 248 the cost details showed that the cost was Rs 34.5 lakhs. The two figures were confusing and required clarification. It would be of benefit to know the actual cost of the bridge.

Scour meters had been installed in pier No. 12. This was a very good idea of finding out the actual scour during flood. It would be very helpful if the Authors would give more details and explain how the 4 in. diameter pipes were fixed to the well steining during sinking, and how they were subsequently cleaned and how they would actually work during scour.

On page 170, the Authors had said that "allowing for a scour depth of 30 ft, the soil below the scour level was counted

for a fraction of the skin friction actually observed during sinking." It was desirable to know what was the value of skin friction actually observed during sinking and what friction of it was actually considered for relief of previously calculated base pressure.

While calculating stability under horizontal forces (ref. page 190), the Authors had found out the tractive effort or braking force by the formula $5+0.12\ L$, where 'L', the loaded length, was taken as 127 ft. It appeared that 'L' should have been taken for the full span, i.e., 159 ft.—0 in.

Shri Banerjee wanted to know if the rubber plate bearings had proved to be sufficiently durable under exposed weather conditions in tropical climates and how the mechanical properties had been tested. He also wanted to know (i) if the specifications and formulae for calculations had been incorporated in the bridge code of any leading country, (ii) the cost of these bearings, and (iii) whether the materials were imported or locally manufactured. It appeared that for the same brick piers sliding plate bearings could have been used with advantage if these rubber bearings failed to function. Cracks might develop in the pier due to huge temperature force.

The prestressed superstructure had been designed for a compressive stress of concrete of 2,500 lb per sq. in., for $f_c=7{,}000$ lb per sq. in. (cube strength). This value seemed to be very high in comparison with the specified strength in different countries. In Britain, the draft code gave an allowable stress of 2,000 lb per sq. in. for $f_c=6{,}000$ lb per sq. in. and on the Continent the value of f_c usually specified was 450 kg/cm^2 or 6,300 lb per sq. in. with a factor of safety of 3.0. In this case, a factor of safety of 2.80 had been kept against the ordinary value of 3.0. Adopting such a high value of concrete strength involved most careful design, care in mixing, curing and placing of concrete which could not be easily achieved in the field, and it appeared that an allowable stress of 2,000 lb per sq. in. with $f_c=6{,}000$ lb per sq. in. would not have increased the cost of the bridge by more than 1 per cent.

Finally, he requested the Author to clarify whether the prestressed sections were designed against ultimate strength of concrete and steel. In that case, what were the factors of safety considered separately for concrete and steel?

Shri H. G. Verma made observations on the following points.

In para. 4 of the Paper, it had been stated that 150 ft spans were decided upon to prevent formation of eddies and consequent scour. In this connection he wished to point out that if the old bridge which had 42 spans of 50 ft and was situated only 135 ft below the proposed site, did not affect the railway bridge, how the proposed road bridge situated at 1,115 ft from the railway, could affect the latter. In Uttar Pradesh, the proposed road bridge at Garhmukteshwar was being located 600 ft below the railway bridge with 160 ft spans as against 200 ft spans of the railway bridge. Model studies done at Poona Research Station clearly showed that neither the road nor the rail bridge would be affected by this proximity and the variation in spans.

With regard to para. 6.2, he felt that twin wells would have been better than three independent rectangular wells which had been sunk. Being so near to each other they might have caused considerable difficulties in sinking and appreciable tilts had taken place.

Regarding scour meter in para. 7, he desired to know the difficulties in sinking the pipes. The maximum scour must have taken place at the nose but this had evidently not been measured.

In para. 9.2, it had been mentioned that full load tests on the wells were not carried out because in that case it would have been necessary to plug the wells. In fact, plugging of wells was not necessary before testing and such a test would have given erroneous results. It was well known that under worst conditions, in floods, only skin friction on the unscoured depth of a well resists the load whereas in such a test the entire depth would have been effective.

Regarding the bearing test dealt in para. 9.9, he desired to know if the well was dewatered before the bearing pressure test was carried out. He also wanted to know whether the water worked up during the test and whether any allowance had been made for such water in the test and the formula $\frac{B}{D}=\frac{b}{d}$.

In para. 11.1.3, it had been stated that the cost of the superstructure worked out to Rs 13.18 lakhs. Assuming 50 per cent of the total cost for the substructure, the cost of the whole bridge would be about Rs27 lakhs against Rs 24.22 lakhs for the bow string girder as mentioned in para. 4. Making allowance of Rs 1 lakh for the lesser foundations as mentioned on page 178, the total cost for the bow string structure should be in the neighbourhood of Rs 23.22 lakhs. These figures show that the prestressed structure cost more than the bow string girder type. He, therefore, wanted to know why it was adopted. As a matter of fact, the

prestressed structure should have cost much less than the bow string girder type.

In para. 12.1, it had been stated that the use of 1 : 1.26 : 2.38 concrete had been made against the normal mix of 1 : 1.5 : 3 due to sand having a fineness modulus of 2.09. Would it not have been more economical to mix powdered stone obtained from crushers with sand to increase its fineness modulus rather than improve the mix proportions.

In para. 11.8, it had been stated that rubber plate bearings were used in the articulation and over the north abutment. As these types of bearings were absolutely new to the country, he desired to have more information regarding the life of these bearings and their behaviour so far observed.

Shri S. R. Joshi stated that the Authors had mentioned in the Paper that the collapse of the old bridge appeared to be due to blocking of one span by a tree. This might have been one of the reasons for collapse. But it could not convince one to be the only reason. Hence, a complete study of collapse of the old birdge would have been very helpful in the design and construction of the new bridge.

The site of the new bridge was selected 135 ft upstream of the old one and 1,150 ft upstream of the railway bridge. It appeared that downstream of the old bridge would have been a better site, as in that case advantage could be taken of the existing flood embankment. It might be that the debris of the collapsed bridge led to the decision taken but it was not a sufficient reason to do so.

It would have been safer to found the wells on hard clay which was just 15 ft below the designed level. The danger of settlement of foundations and of unforeseen factors could have been thus minimised. This would have also given certainty to the foundation design. It might have then been economical to increase the span due to increase in depth of wells.

The Authors had described the various reasons for the particular design which had been adopted. It would have been more instructive if they had mentioned why three wells were used. If settlement was still expected in the wells after construction, he felt that it was rather risky to have three wells in these types of foundations, as little cavities formed by differential settlement of wells would affect the bearing capacity to a great extent. He asked the Authors to indicate what secondary stresses, which would be effective in the well caps due to unequal settlement, had been accounted for in the design.

The external fluid pressure of sand at level - 40 after dewatering might have endangered the steining. He asked whether the steining was designed for the bending moment and shear in the horizontal direction and whether shear reinforcement was provided, which he felt was necessary if dewatering was used while sinking. He also wished to know the stress allowed in the steining for 1 : 3 : 6 concrete and whether any tension was also allowed ; if so, how much.

The kentledge used was upto 70 tons which was much on the low side. He felt 200 tons would have been right.

Dewatering, in his opinion, was rather risky where sand blowing at 25 ft took place. This might affect the tilt and shift in the wells. He appreciated the accurate sinking of the wells. But, at the same time, he wished to point out that it was dangerous to design the distance between the two wells as only 2 ft-6 in. where a little shift of 1 ft-3 in. in two adjacent wells at a depth of 50 ft would endanger the steining.

The grab used while sinking was probably 3 sq. yds. instead of 3 cu. ft. which seemed to be only a misprint. The use of bigger grabs facilitated sinking of wells more than smaller ones.

He considered that the introduction of water pipes in steining and water jetting might have been cheaper in sinking. The pipe would also serve as reinforcement.

The settlement at the plate while testing was measured by a sensitive meter reading to .005 in. The Authors seemed to have missed to mention the axial compression of the stanchion due to the applied load.

The bearing capacity of the soil could have also been tested by loading the well without plugging. The load could be calculated in certain proportion to the area of steining and the area of full well. This would have been a much cheaper way of testing.

Shri K. S. Rao said that bearing test for finding the bearing capacity of soil should not be taken as a test which could give direct results as compression test of concrete, etc. It was of utmost importance that bearing test should be viewed with laboratory tests on one hand and probable behaviour of prototype structure under loads, on the other hand. The two problems connected with foundation design, viz., strain problem connected with settlement and the stress problem connected with rupture or shear failure of soil, should be studied together. Location of foundations of Coleroon bridge was decided taking these into consideration.

As regards laboratory tests and the field bearing tests, laboratory test results were taken to be confirmatory tests on the field observations and more emphasis was laid on the number of plate bearing tests conducted.

It was true that consolidation test was not conducted. But for the computation of settlement it was not very important that consolidation test should be carried out, as Skempton's formula was quite reliable from practical considerations. The clay met with was normally loaded and there was no doubt that the sensitivity of clay was low. Peck, Hanson and Thernburn had advocated the use of this formula and this was what they said in this connection.

"The equation is of great practical importance because it permits one to compute the approximate settlement of structure above a deposit of fairly insensitive normally loaded clay if only liquid limit is known and even if consolidation test is not performed."

Shri Rao stated that there was room for improvement in these bearings tests. In fact they had effected improvements in the method of loading and measurements over similar tests conducted on other bridges. They had set up a Highway Research Station which was being equipped for taking up all tests connected with foundation problem.

Taken as a whole, it would be seen that the conclusions drawn from this plate bearing test were quite on the conservative side. From the point of view of safety and economy the bearing test proved quite useful in locating the foundations.

If the advantage of prestressed concrete structures was to be fully realised it is imperative that the materials should be stressed as high as possible. There generally seemed to be doubt at what permanent stress a structure should be designed. In Coleroon bridge a permanent prestress of 125,000 lb per sq.in. had been adopted and this was one of the reasons of the great economy obtained.

The restriction of permanent stress in the steel reinforcements, as stated in certain specifications, seemed to be generally due to fear of an increased fragility of high tensile wire under fatigue.

Research conducted in France had shown that higher the permanent stress higher is the fatigue ultimate strength. This point was elucidated by M. Guyon the previous day.

In a series of tests conducted in France by STUP, the tests showed that ultimate strength under fatigue measured on three series of beams with same static ultimate strength, increased with permanent stress in reinforcement.

He wished to mention that a stage had come where specifications might be laid down in this country for the permanent stress in steel. Every restriction of the permanent stress in steel was prejudicial both for strength and for the cost of prestressed concrete. In this context, Coleroon bridge design and construction might be considered as a major test.

Shri E. P. Nicolaides stated that attempts made to use the science of soil mechanics in order to solve foundation problem of Coleroon bridge had not been very fruitful as the information regarding the soil lacked in its effective value for a verdict on the foundation problem. There was hardly a soil investigation report at the end of which the soil experts had concluded and determined in a responsible manner the type of foundation to be adopted, together with the safe depth and bearing capacity of the soil. It seemed to him that the science of soil engineering would require two or three more Terzaghis and possibly at least another score of years of research before it could attain the standard of accuracy of the methods used for the design of bridge superstructures.

Without wishing to belittle the effort made for a scientific approach to the foundation problem, he ventured to suggest that Shri Nambiar, in deciding on his foundation depth and safe bearing pressure, had finally by-passed all the results of his soil investigations and relied more on his engineering feeling and experience.

For the shape of the wells, he would have preferred a round one as the mechanical grabbing at the corners of a rectangular well at great depths was a difficult procedure. In this country, very often skilled divers were used for sinking wells and they did their job extremely well using only divers' helmet without the complete suit. This practice would hardly be found common in other parts of the world where divers' work was invariably very expensive and acceptable only on few special occasions. It was admirable how the Indian diver could work so efficiently under up to 60 feet of water with only a helmet on.

Referring to the rectangular shape of the wells and calculating the stresses in the cross-section taken as a closed rectangular frame, Shri Nicolaides stated that under 40 feet of uniform water pressure all round acting on the outside, he obtained a maximum tension of 267 lb per sq. in. which normally would be considered as unsafe for 1 : 3 : 6 concrete.

On the subject of testing the soil at the bottom of the wells, he very much doubted the reliability of the results, when the bearing plate of the loading device described by the Authors was laid at such great depths completely in the dark; obviously, a uniform contact could hardly be expected between the plate and the soil at the bottom of the well and even if that were possible, the low slenderness of the column transmitting the load would certainly introduce considerable overturning effects which might easily alter the result fully by hundred per cent from the assumed uniform distribution.

The Authors might perhaps give more details of the maximum tilts and shifts of these wells during sinking, on the way they were controlled and, where permissible limits were exceeded, how they managed to correct these tilts and shifts. With these rather slender wells, he would have anticipated appreciable tilts and shifts, particularly so with the variable strata met with at greater depths and the heavy blowing reported.

For the plugging of the wells, he would like to bring to notice the great advantages of using grouted concrete when laying under water; the colcrete process was invariably being used in such cases and comparative full scale results, carried out side by side with ordinary concrete, had proved conclusively that colcrete gave a very dense and practically watertight mass, which might be difficult to attain with any of the other processes for laying concrete under water.

Another interesting point to consider was the method of dimensioning the well caps; large masses of concrete were laid with a very high percentage of reinforcement, using design assumptions and methods of dimensioning which were obviously irrational, applying, for instance, the theory of design for slender structural members—valid only for depth to span ratios not much above 0.10 to these capping slabs of wells, usually having a depth to span ratio of 1/3 or thereabouts; furthermore, the solid piers above the well caps were treated as being perfectly plastic, devoid of any shear strength or even the least cohesion. This resulted in heavy wastage of both concrete and steel, which could be reduced substantially and safely by certain simple design considerations submitted recently to the Roads Wing of the Ministry of Transport for scrutiny.

The design of the decking of the Coleroon bridge was certainly a novel one and from the details given it appeared also to be a very economical one; he was not quite satisfied, however, with its stability against damage to one span, as it appeared that on such an accident, the whole length of the bridge would crumble following the local collapse, as a result of the unbalanced

reactions acting on the successive spans; from the Military point of view he was sure that such a consideration, if substantiated, would heavily offset all advantages of economy.

The Authors had also made use of cross prestressing in the decking and while he did not dispute the technical advantages of this procedure, he was still doubtful about its economy. The cross-prestressing cables were normally in length, a fraction only of the longitudinal cables; yet the anchorages and other end devices remained as expensive in both cases; the result obviously was a much heavier increase in the cost per ton of cross-prestressing cables to cover end anchorages, etc., as compared to that of the much longer longitudinal cables. Calculation showed that a cross prestressing slab could hardly compete economically with the ordinary R.C.C. slab where cables were to be spaced closer than 4 feet apart. Mon. Guyon might consider that a reinforced concrete slab over prestressed concrete girders was now outdated but it could be pointed out that there were already many prestressed concrete bridges in use in India, and he believed elsewhere also, with a reinforced concrete deck slab, behaving perfectly satisfactorily; and so this type of design must not be discarded before the economy of the new one, using a cross prestressed deck slab, could be estabilished.

Shri Nambiar had focussed their attention to the 'Neoprene' bearings used for the Coleroon bridge superstructure. While adequate testimonials regarding the durability and efficiency of these bearings should certainly be called for, he considered that the almost exclusive use of cast steel bearings for road bridges stipulated by the Consulting Engineer to the Govt. of India was unjustified and uneconomical. Cast steel bearings were very expensive indeed and they were also in very short supply.

Apart from the 'Neoprene' bearings, the R.C.C. rocking and the Freyssinet bearings were perfectly well proved types which for some indefinite reasons were still looked upon with unwarranted suspicion both by the P.W.D. and the Consulting Engineer to the Government of India. Yet there was not a single failure reported on the many bridges fully tested with R.C.C. bearings. There was a perfectly reasonable safe method of designing the same and above all there were easy and economical ways of testing such bearings fully before use. Instead of spending six to eight times more money on cast steel bearings, it was high time now for removing the ban placed on R.C.C. bearings and allowing their use, on satisfactory safeguards being adopted for their proper design and, if necessary, selective full scale testing. In the same way, the use of 'Neoprene' bearings should be given due consideration as they appeared to offer marked advantages over both cast steel and R.C.C. bearings.

In paragraph 12.1.2 of the Paper, the Authors had mentioned a water-cement ratio of 0.35 as required for their concrete to achieve the strength requirements. Even with an efficient vibration, he would strongly doubt whether an adequate workability and proper placing of such a dry concrete would be possible under the working conditions of the high Indian temperatures. Perhaps fairly wet coarse aggregates and sand were used and their water content was ignored in assessing the above figure of the water-cement ratio.

He would also point out that the straight line stress-strain diagram for concrete given in Fig. 14 of the Paper was certainly unrealistic ; no concrete could reach so near its ultimate compressive stress (in this case around 8,000 lb per sq. in.) retaining up to that limit a strict proportionality between stress and strain as indicated by the Authors.

Similarly, in Figure 15, the stress-strain curve of the steel appeared also to be a diagrammatic one and not drawn out of actual test results ; in the latter, strict proportionality would be revealed to end at much lower values than 175,000 lbs per sq. in. (78 tons per sq. in.) stress even for a steel with the maximum limit of110 tons per sq. in. breaking stress as used on the bridge.

In paragraph 15.3 of the Paper, the loss of stress due to creep was calculated by the formula $\triangle T' = \frac{Es}{Ec} \frac{F}{S}$, with the meanings of the symbols given therein ; consequently, in Appendix 1 of the Paper, the actual loss due to creep was worked out by the same formula as 6 kg/mm^2 which was only 5 per cent of the initial tension of about 120 kg/mm^2 adopted. Similarly, the allowance for loss due to shrinkage given in the same para. as 3 kg/mm^2 was only 2.5 per cent of the initial tension.

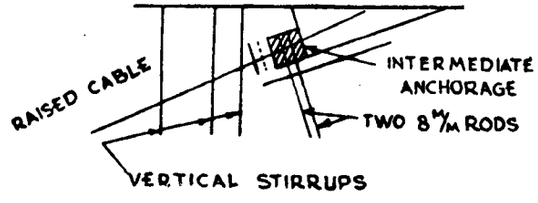
He would point out that the provision for both these losses (creep and shrinkage) was about half the normal one adopted in their designs of prestressed concrete bridges in India.

In the end, Shri Nicolaides stated that very much higher permissible working and initial stresses had been adopted in this bridge compared to the normally permitted ones in India by the Consulting Engineers' Office and the Design Offices of State P.W.D's. He was convinced that such higher stresses were necessary if it was desired to claim economy in prestressed concrete designs ; and in spite of the many vague apprehensions expressed against their adoption, he suggested that more emphasis should be laid on the safeguards of accuracy in design and quality control of execution rather than irrationally retaining too low working stresses,

Mon. Y. Guyon stated that the questions raised by Shri M. P. Apte and Shri Swami did not call for any further comments.

He further stated that Miss Joshi had expressed the opinion that intermediate anchorages should be avoided on account of shear stresses developed at each of these anchorages. This point of view was not confirmed by experience ; a considerable number of bridges with such raised cables and intermediate anchorages had been built, without any trouble. The usual reinforcements in Freyssinet system were 2 rods of 8 mm. diameter around an anchorage of 40 tons, connecting it to the bottom of the beam.

It should be noted that these cables were tensioned after those which run over the whole length of the beam ; therefore, the stresses due to such intermediate anchorages and which are a particular case of the effect of localised stresses, studied in his Paper published by the International Association of Bridge and Structural Engineering, are generated in an already prestressed member.



This prestress took care of the tensile stresses which could occur on account of the fact that the anchorage compresses the concrete in front of it, and tensions the concrete behind it (i.e. between the bearing and the anchorage). These tensile stresses were in fact small, because they had obviously for maximum the tangential reaction which could occur, at the bearing, when the beam was subjected only to its weight ; this maximum was equal approximately to half of the weight, multiplied by the coefficient of friction. That meant, for a beam weighing 100 tons, a maximum force of some 15 tons, much smaller than the forces exerted by the 8 cables tensioned at first (320 tons).

The inconvenience feared by Miss Joshi might, therefore, be ignored, and, on the other hand, such cables afforded great advantages. They allowed to follow more closely the requirements of resistance, to vary when necessary or advantageous, the amount and eccentricity of the prestressing forces, and to reduce the number of anchorages to be placed at the end.

On the question of general stability, raised in particular by Shri Joshi, it could be said that the precautions taken by Shri Nambiar prevented the foundations from the risk of settlement. He would say that, in this respect, the Coleroon solution was convenient for the particular site. In other sites where the risks of scour would have to be considered, a solution with a double cantilever, as he had suggested in his Paper, would be preferable.

If it was a question of Military risk, in case of a span being bombed, the case was the same as for almost all continuous structures: Coleroon was not continuous, but it should not be forgotten that a connection had been provided between the successive spans, by means of vertical cables passing through the cantilever and assembling the two beams hinged at this point. This ensured a certain ultimate resisting moment of the hinge, which was of an order of magnitude of 600 tons × meters for the total width of the beam. A certain amount of re-distribution, due to this resistance of the hinge, was then possible. However, it would be seen that in case of a span bombed and broken, the next span would be subjected, by the play of these re-distributions, to a positive moment above its support and would break also but that the second span should hold.

Shri Rao had raised the question of the high stresses allowed for the high tensile steel of 125,000 lb per sq. in. for an ultimate resistance of 210,000lb per sq. in. Such stresses were of common practice in France.

To obtain these stresses in the middle after all losses, it was necessary to tension the anchorages to some 175,000 lb per sq. in., i.e., about 85 per cent of the ultimate, and everybody knew that this figure was much higher than the stresses allowed in the regulations of certain countries. But it could be said that these initial tensions had been used by them in France, for a considerable number of works, without any incident.

The coefficient of safety in any prestressed structure had to be taken against failure, and this required a certain area of high tensile steel, and against cracking, and this required a certain prestressing force. Knowing this force and the area of steel, the tension to be exerted was known.

This tension must be obtained at mid-span after all losses; hence the value of initial tension at the anchorages could be worked out taking into account losses on the length of the tendon and the losses due to creeping and relaxation. There does not appear to be any inconvenience to go up to 85 per cent or 90 per cent of ultimate at the anchorages, and the reason of a

third coefficient of safety to be applied on the magnitude of the **tension** and which had nothing to do with the safety of the prestressed member was not understood. Of course, it could be said that such a coefficient was intended to avoid risks of rupture of wires during the operation of prestressing itself, and also on account of risks of stress corrosion. On the first point—risks of rupture of wires at prestressing—experience showed that with initial tensions reaching 90 per cent of ultimate, this risk was negligible. This experience resulted from the French practice, and Coleroon showed that it extended to Indian conditions. And this was obvious on account of the shape of the stress-strain diagram of the steel. The coefficient of safety should be taken on the ultimate elongation and not on the ultimate stress, and this was not at all the same.

As to the second point—risks of stress corrosion—he would say again that it was not a matter of tension. The important things were:

(i) to use a suitable steel,

(ii) to protect the cables after tensioning by a good grouting.

(i) On the question of suitable steel, it could be said that certain errors which could have been made at a time, in order to 'improve' the characteristics of the stress-strain diagram, had been mended, and that, actually, the products elaborated by the **specialists** of prestressing steel fulfilled the required conditons.

As to the risk of stress corrosion, if it would be present—and it should never be accepted—it was entirely dependent on the **nature** of the steel and not on the amount of tension applied; a reduction of tension could never improve a bad steel.

(ii) Assuming the steel as being of the required quality, i.e., free from brittleness, it must be protected as soon as possible. This was quite evident and held good for any structural steel, which should never be left without painting, much more so when it was subjected to high stresses; however good its quality, no steel could be left in open air under tension, no matter how small, without breaking after some time; this was not dependent on the quality of the steel, but was simply a consequence of the penetration of corrosive agents through unavoidable surface defects or microscopic cracks.

A good protection called for grouting with a suitable mix by a pump, and under pressure (60 to 70 lb per sq. in).

Apart from the risks of rupture when tensioning and the risks of corrosion, a third argument he heard once was that the elongations imposed on the steel should not be too great and beyond the capacity of the concrete to follow them, considering that the strain of the concrete at rupture would be around 4 per thousand. This was a very surprising argument because, when the section broke, the elongation of steel did not occur at the same level where shortening of the concrete took place. The initial tension had nothing to do with such an argument either. The only valid remark in this respect was that where, out of the total ultimate elongation of the steel, too large a proportion was absorbed during the initial tensioning, the reserve of elongation left available, for the stage beyond the initial tensioning and up to failure, might become too small and insufficient to allow the curvature of the beam to develop up to the limit necessary for the concrete to reach its ultimate strain.

This appeared a necessary safeguard and was the main reason for fixing a minimum to the ultimate elongation of the steel. It should be borne in mind that by high stresses were meant only those stresses which occurred before losses and at the anchorages; the need for a margin of elongation to remain available for failure conditions did not arise there but only at midspan where failure through bending took place; and at midspan the stress in the steel was invariably very much lower than at the anchorages due to the effects of friction and the subsequent losses due to creep, so that by fixing a minimum ultimate elongation requirement to the steel in the specifications, they were able to regulate for failure requirements also.

In other words, it would be unreasonable to make an attempt to raise the steel-stress up to 90 per cent of ultimate at midspan; there a practical design limit was 2/3 of ultimate, for the steel stress, and having fixed such a limit, care was taken of the losses both along the tendon (by friction) and in time (creep and relaxation) by providing a suitable supplement of tension at anchorages, whatever that might be. A practical maximum of 85 to 90 per cent of ultimate leaves a good enough margin of elongation against the risk of rupture at tensioning, being the only consideration at these terminal sections.

The aim in using the strength of steel to its practical maximum was not only economy; the quality of the structures was also important as it had been established experimentally that, for different beams prestressed with the same area of steel, but with varying degrees of tension, those with the higher tension resisted better the fatigue tests and this seemed also obvious.

All that he had said above showed that a great importance is attached to the specifications for steel. This subject was being discussed in France at the very moment, after several years of study and tests, and he would send to the Congress a Draft of their specifications as soon as they were finalised.

He considered it of very great importance for India to adopt the high values of tension used and proved as safe as possible in France; this meant a reduction of the consumption of steel, and for the time being, a very necessary saving of foreign exchange.

He also added that he hoped it would soon be possible to produce high tensile steel in India; for India this appeared to be an efficient way of increasing the general potential in steel production; it must be remembered that one ton of high tensile steel could replace five tons of mild steel; though the rates per ton were not the same, a very appreciable saving still remained and furthermore there was the advantage of using national labour.

Shri Nicolaides had raised the question of wells for foundation and preferred the circular wells from a resistance point of view. He must say that he was more particularly interested in the comparison of costs, because, it had a decisive influence on the choice of a type of bridge, as stated in his Paper.

Though he had been unable to form a definite opinion on the subject, it would appear from the various brief enquiries he had been able to make, that it might be more a case of depth of foundations.

He had a more definite opinion on bearings. The cost of steel bearings and the delays in the deliveries seemed to be prohibitive. He had read in the Proceedings of the Seventeenth Session of the Indian Roads Congress that the cost of steel bearings for the Pennar bridge, with some 70 ft spans, amounted to 20 per cent of the cost of superstructure (there were examples of the same order of magnitude in France), and when visiting the Ghagger bridge he had been told that the time for delivery was nearly one year.

They had used successfully concrete bearings, on almost all their bridges up to some five years back; more and more rubber bearings which had proved still simpler and more economical were now used by them.

Concrete bearings had been used for the first time by Mr. Freyssinet in 1923 on the Candilier bridge. They have never had any incident on the bridges where they had been applied. Experience had shown that they could support, without visible

cracks, rotations of 1/100 of the radian, this rather large rotation having been reached accidentally during the erection of the Esbly bridge.

More conclusive laboratory tests had been carried out on the occasion of the construction of the Tancarville bridge; hair cracks in the reduced section of the concrete bearing appeared at a rotation of 1/200 radian, under an average pressure of 300 kg/cm^2. Under an average pressure of 400 kg/cm^2, no crack was observed up to a rotation of 1/100 radian.

The Neoprene bearings which had been used on the Coleroon bridge were still simpler. They had been used successfully on over one hundred bridges.

References on the durability of such bearings had been called for :

Tests of accelerated ageing had been carried out by Dupont de Nemours, and had led to proving results; this firm had published a number of booklets describing these tests. It might be added that the French Railways had used these rubber bearings since 1932.

Shri Nambiar had given in his Paper different data on the qualities required, and these must be followed.

Shri N. Mohan Rao* greatly appreciated the detailed work carried out to find soil bearing pressure.

However, he did not agree with the Authors in the assumption for surcharge equivalent between the well and the test plate which was given by the relation $\frac{D}{d} = \frac{B}{b}$. This might hold good for clays and not for sands.

The test results obtained with 2 ft diamater plate were not interpreted for the larger size of the well and hence the assumed bearing capacity was a little conservative. The Authors could have theoretically evaluated the skin friction from the data on the strength characteristics of the layers below the erosion depth.

Shri K. K. Nambiar (Senior Author) then replied to the comments of the various speakers. Replying to **Shri M. P. Apte**, he assured him that the conditions which obtained at the site of the bridge warranted a linear waterway of 2,100 ft and any construction by means of guide bunds would have been prohibitively

* This comment was received in writing.

costly as rough stone had to be brought from 80 miles by rail. Further, the formula $K\sqrt{Q}$ generally applied to large natural streams in alluvial beds and having undefined banks. The River Coleroon had protective flood banks on either side and the bed could not be classified as alluvial. Hence, Lacey's formula could not strictly be applied to this case.

The scour depth had been calculated by an empirical formula $2.1r\frac{V_2}{V_1}$ where r is the hydraulic mean depth, V_2 is the velocity through vents and V_1 is the normal velocity of the river. This formula was in vogue in the Madras Public Works Department and also the Military Engineering Services. However, even granting that the scour depth was 61.5 ft, the foundations had to be taken at least 6 ft below the scour line, viz., 19.72 – 61.50 or – 41.78 according to Shri Apte. The foundations had actually been taken on an average to 59.00 depth and hence were quite safe.

Shri Apte was not in favour of unbalanced cantilever type of superstructure. The river Coleroon was a controlled river and the discharge was mainly from the surplus from the Mettur Reservoir. Further, the adjacent spans were inter-connected by means of high tensile cables and there was no fear of the entire bridge collapsing due to settlement of one pier. If at all, one or two adjacent spans only would be affected. He also invited Shri Apte's attention to the comments of Mon. Y. Guyon in this respect. Thus there did not appear to be any case for fear that the bridge would collapse if one pier were to settle.

Miss Shakuntala Joshi had raised some technical points which had been answered by Mon. Y. Guyon.

However, he liked to add that it was the general practice to adopt intermediate anchorages for long spans and probably these had been adopted in the bridge across Rhine in Germany referred to by her.

Replying to **Shri A. Banerjee**, the Author stated that dewatering of wells was resorted to only in a few cases and no untoward incident was met with, neither were there cracks in the steining. The wells were generally sunk plumb and only in a very few cases there were tilts and even these were within 1/80.

Regarding the discrepancy in cost, the actual cost of the completed prestressed concrete bridge including protective works, construction of quarters, purchase of tools and plant, etc., was Rs 34.5 lakhs. The figure of Rs 24.22 lakhs referred to the cost worked out roughly to compare the cost of 14 spans of 150 ft each with 30 spans of 70 ft each.

Shri Nambiar then gave the details of the scour meter. Three Nos. C.I. pipes, 4 in. diameter, were sunk along with the wells attached to the steining by clamps. The pipes were sunk to different levels and the bottoms were covered with slender concrete blocks to prevent sand, etc., getting inside. Just after completion of the bridge, the scour measuring assembly consisting of a drum with a definite number of turns of thin wire rope with a 1¼ in. diameter probe rod attached at the end was mounted at the top of each pipe and the probe rods lowered down breaking the concrete blocks. When scour took place the length by which the probe rods went down was measured by the number of turns loosened at the top. This would give the scour depth.

Mon. Y. Guyon in his remarks had given further particulars regarding the neoprane rubber pads. The approximate cost of one pad measuring 12 in. × 20 in. was Rs 15. Generally, not less than 6 numbers of pads were used for each bearing.

Regarding the high stresses adopted for this bridge work, with the advances made in concrete technology and with the experience gained by the field staff in the production and control of concrete, such high stresses would have to be permitted for the sake of economy.

He had already discussed the points raised by **Shri H. G. Verma** in his replies to the other speakers. The figure of Rs 24.22 lakhs as already stated referred to the approximate cost worked out for purposes of comparison ; it should not be taken to arrive at the cost of the scheme.

The question of mixing powdered stone with sand to improve the fineness modulus was not an economical proposition as granite metal dust had to be brought from a distance of 80 miles by rail.

He assured Shri Nicolaides that the decision on the foundation question was taken on the basis of the data obtained from the test results which had not been by-passed. Experience in well foundations had also helped to take decision in this matter. Regarding the question of the shape of wells, the performance of wells in Coleroon was quite satisfactory and the question seemed to be more a matter of opinion. However, in recent times circular shapes had been standardised for the sake of convenience and uniformity. As M. Guyon had mentioned it would be better to examine this question from considerations of cost also.

Shri E. P. Nicolaides had mentioned that his calculations showed a tension of 267 lb per sq. in. in the steining treating the cross-section of the well as a closed rectangular frame. Shri Nambiar mentioned that the wells were deliberately rounded off

at the corners and he presumed that Shri Nicolaides had not considered this fact in his calculations.

Colcreting for well plugging had not yet been tried in Madras State and he was thankful for the suggestion.

Regarding the design of well cap, he agreed that there was a case for a re-examination of the whole design on a rational basis. On the question of cross prestressing the deck, he did not agree that R.C. slabs would in all cases be cheaper especially when considering the increase in the cost of mild steel and cement.

Shri Nambiar informed that the workability of the mix with a water-cement ratio of 0.35 was found to be quite satisfactory for the type of powerful form vibrators used at Coleroon. Of course, an additive was used to improve the workability, viz., Lissapol *N*.

The values of loss due to creep, shrinkage, etc., provided for in the design had been arrived at by STUP after mature experience and study.

In conclusion, the Author stated that he had noted the suggestions made by various speakers and thanked them for the same. He specially thanked Mon. Y. Guyon for his valuable comments and suggestions.

Shri P. G. Nambiar (Junior Author) also offerred some clarifications. In reply to **Shri M. P. Apte**, he stated that in spite of all mathematical refinements in working out problems, the solutions offered by soil mechanics in regard to the question of settlement were very approximate and gave no more than broad indications of the approach which the engineer must use intelligently to make decisions.

He further stated that if the calculated values should be considered as the minimum, one would like to know what would be the maximum. An assumption like this would lead to unresolvable difficulties if the differential settlements were to be worked out as suggested by Shri Apte by assuming the settlement in one pier to be nil and in the other to be the maximum as calculated.

Actually the soil conditions did not warrant such an over-conservative approach. Systematic records of levels had been maintained and the observed settlements were quite negligible and only tended to show that the estimate of settlement was very much on the safe side.

Shri S. A. Swami had raised the question of the rate of settlement. The rate of settlement would have been very im-

portant indeed if the clays differed drastically in significant characteristics from pier to pier. Then one pier might have attained almost all of its ultimate settlement within a relatively short peroid, while an adjoining pier might have taken a very long time. In the interval between these two periods, it was possible that the structure might have passed through a stage of differential settlement in excess of the ultimate differential settlement. In such circumstances the emphasis laid by Shri Swami on the rate of settlement was fully justified, but with reference to the conditions at Coleroon these arguments had no validity. All the same, there was no hesitation in agreeing with Shri Swami that a consolidation test would have been a great asset.

For calculating the stability under horizontal forces, as stated by Shri Banerjee, perhaps it was more correct to take the full span. However, even by doing this, the safty aspect was not altered at all.

Referring to **Shri H. G. Verma's** remarks, the Author stated that model tests had not been performed in the case of Coleroon.

The old road bridge existed before the railway bridge was built and therefore the presumption that one did not affect the other might not be correct.

If the well was load tested without the plugging, only the bearing capacity of the well ring would be tested against that of the entire well which was required. Because the bearing area was annular, all sorts of uncertain factors would crop up and affect the result. The kentledge required would be very considerable. As against this, the plate test offered a more straightforward and economical solution.

With reference to **Shri S. R. Joshi's** remarks, he stated that no authentic facts were available about the collapse of the old bridge which occurred more than half a century ago.

He felt that the error due to neglect of axial compression in the stanchion used in the load test was only on the safe side, and its share in the total deflection would be very insignificant.

Shri E. P. Nicolaides had doubted the reliability of the soil test results. To this the Author replied, that the divers who went down the well shafts were first class divers and they had ensured proper bearing of the base plate. The load transmitting stanchion was also designed for the load it was expected to carry and so there was no question of the adverse consequences imagined by Shri Nicolaides.

The stress-strain diagrams were taken from actual tests and they were not as straight as they appeared in the reduced scale of reproduction in the Paper.

Shri R. C. Roy, (Chairman), in winding up the discussion, thanked the Joint Authors for bringing out this Paper in which they had enumerated in detail both the design and construction aspects of a prestressed concrete bridge. He also thanked the various speakers for their comments. Prestressed concrete had so many outstanding advantages over reinforced concrete that he was sure in future all major bridges in India would be constructed in prestressed concrete. Hence what was required now was a sound design criteria and also a detailed specification. He was glad to note that the I. R. C. had taken up the first item and hoped that they would take up the second one also. Arrangements for the production of high tensile wires and bars were also necessary.

Discussion on Paper No. 193*

"Influence Fields for Finite Concrete Slabs Supported Freely along Two Opposite Edges and Free at the other Two"

By

K. C. RAY, R. SUBRAMONIAM, AND S. BADARUDDIN

Wednesday, 15th May, 1957

Shri B. Chaudhury (Chairman) called upon Shri A. Bannerjee to introduce the Paper in the unavoidable absence of the Authors.

Shri A. Bannerjee regretted that none of the Authors was present to introduce the Paper. He then read out the following introductory remarks received from one of the Authors.

"In the wake of countrywide road development programmes the number of small crossings to be negotiated would be numerous and the amount to be spent would be of the order of several crores. Hence a rational method for evaluation of stresses in slabs, which were mostly adopted in such cases, would be very desirable.

On going through the current standard methods, it was observed that the following methods had so far been evolved:

(1) Westergaard's solutions for distributed and concentrated loads on plates with boundaries—(a) infinitely supported and (b) finite and supported on four sides.

(2) Ketchum's load distribution (very approximate method).

(3) Pigeaud's solution for plates with partly or wholly distributed load with boundaries at infinity in unsupported direction.

(4) Marcus' solution with Gheler's approximations for concentrated loads for finite plates supported along four boundaries.

(5) Pucher's influence fields for concentrated loads, which may be applied for distributed loads also, for all cases of boundaries conceivable.

* Published at pages 265 to 281 of the Journal of the Indian Roads Congress, Vol. XXI-2, March 1957.

The case of the culvert slab constitutes a finite plate with two edges supported and the other two free. Truly, such a case had been worked out only by Pucher which might be directly applicable to our problems. But Pucher's tables provided only for a single span/breadth ratio.

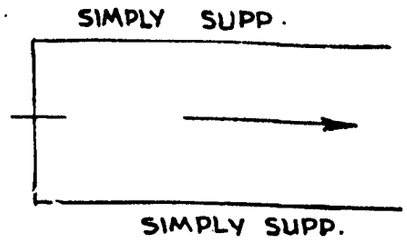
So it was realised that influence fields for all practical span/breadth ratios should be found out so that a completely rational method of design for culvert slabs might be available for design offices. Methods now followed in different design offices were one of the five mentioned above with the designer's discretionary approximations. However, in most cases the slabs were over-designed and uneconomical. The Authors had undertaken the present work with an idea of at least finding out a rational method of design. As a structural designer's problem, this was a new one and the tables worked out with breadth/length ratio ranging from 1 to 6 were expected to cover most cases.

An example worked out in detail had established that the apprehension expressed by the Authors was true, viz., that with the heaviest I.R.C. loading, slab thickness worked out to be considerably less as compared to that adopted at present.

The solution offered in the Paper was a theoretically correct one with Poisson's ratio value of R. C. taken as zero and might be confidently adopted in the design of R. C. culvert slabs in our design offices."

Miss Shakuntala Joshi stated that the Paper presented the B. M. influence curves for flat, isotropic, rectangular concrete slabs simply supported at two opposite edges and free at the other two. The ratios of breadth/span considered were 1, 1.2, 1.5, 2,3 and 6. As pointed out by the Authors, such influence curves were already prepared by Adolf Pucher for almost all support conditions and breadth/span ratios. For slabs simply supported at two edges he had considered the breadth/span ratios of 0.5 and 0.75. It was stated in his introduction that for values exceeding 0.75, one could use the table for a breadth/span ratio = ∞ for finding out the B. M. at the centre of the slab and the table of the half strip for finding out the B. M. at the centre of the free edge. The results were fairly correct if allowance was made for the fact that in the Authors' slabs, the two free edges did not have any fixity as a part of the strip of slab might have.

The Authors had, however, calculated exact values for which they must be complimented. B. M. influence curves given by the Authors would be useful for design of slabs for culverts although such breadth/span ratios would be rare in girder and slab bridges.



There were two points in the Paper which were debatable:

Firstly, these curves could be applied for R. C. C. slabs only after making adjustment for the Poisson's ratio. Poisson's ratio had greater significance in determining My for the breadth/span ratios considered by the Authors. In Germany, Rusch had prepared ready-made tables for all ratios of R. C. C. slabs for their loading after making due allowances for the Poisson's ratio.

The correction to be made to $My = (Mx - My)$ Poisson's ratio – for $ly/lx \geqslant 2$.

where Mx and My are found assuming Poisson's ratio = 0.

This correction reduces parabolically from $ly/lx = 2$, until it becomes 0 for $ly/lx = 0$.

Secondly, the B. M. influence co-ordinate for the load acting at a point was found and given by the Author. This was theoretically incorrect. A perspective view of influence curve for B. M. is drawn and given in Fig. 1.

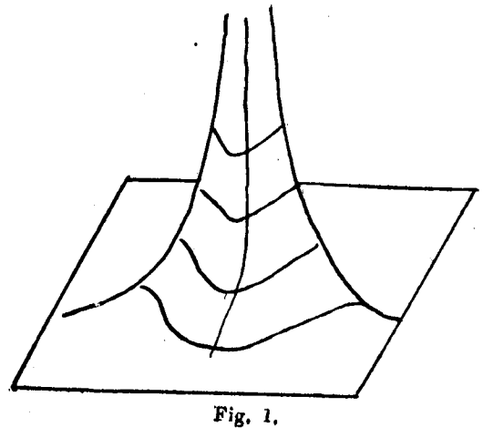


Fig. 1.

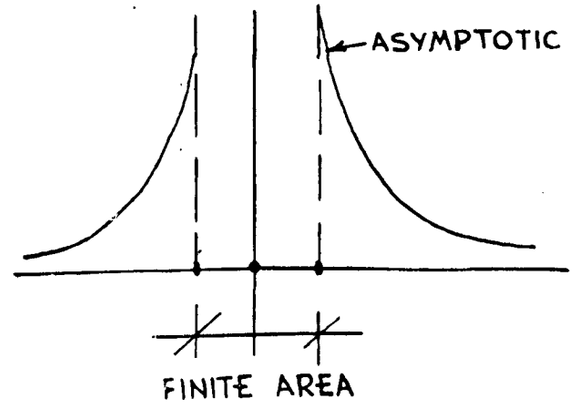


Fig. 2.

The sectional view, Fig. 2, shows a curve which is asymptotic to the vertical drawn through the loaded point. The result was that the B. M. influence co-ordinate for the point was theoretically ∞. If there was a load distributed on a finite area, the total B. M. would be equal to the volume of figure shown.

This volume was finite and could be correctly calculated. But if finite loaded area was reduced to a point, the B.M. would become infinity.

Taking, for example, the case dealt with by the Authors for breadth/span ratio = 1, the value for influence ordinate at the centre is given as 0.43. A section through the Authors' curve would be as in Fig. 3

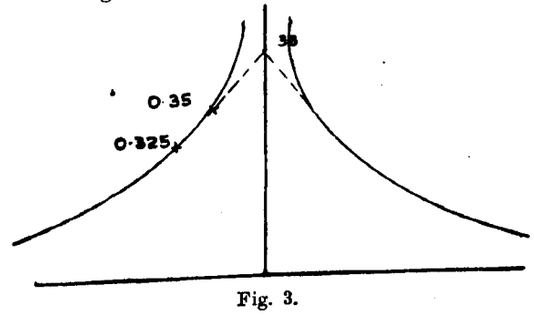


Fig. 3.

The Authors had extended the lines joining the points corresponding to the influence curves for 0.325 and 0.35 to meet the vertical through the centre at 0.38,

If one tried to draw still more influence curves, the lines would tend to become vertical. So the value of 0.38 might change from person to person depending upon how many influence curves he drew.

This was, of course, a theoretical point and might not have much significance in practice, though it may be said that the influence ordinate of B. M. under the load should not have been mentioned.

In the numerical example for class AA loading, the Authors had considered the 70-ton load as distributed on an area of 12 ft × 10 ft. Really it was distributed on two strips 12 ft × 2 ft 9 in. each. Also, class AA wheeled vehicle had not been considered. It would have to be seen whether that could give a higher B. M. value.

Shri S. H. Mahadevan said that among the assumptions made in the derivation of the formulae in the Paper, there were two which seemed to be somewhat contradictory. It was assumed that concrete was elastic but the Poisson's ratio for the concrete had been assumed to be zero. For an elastic material it might not be quite correct to assume the Poisson's ratio as zero and it was not known whether the usual value of 0.15, if assumed, would alter the formulae derived considerably. He requested the Authors to clarify if this check was made.

Secondly, he felt that the whole Paper seemed to be an analytical one and no experimental work appeared to have been done. In the concluding paragraph of the Paper, it had been mentioned that when subjected to test loading, many culvert slabs had developed cracks along the span due to moments at right angles to the span. It was not known whether those tests were conducted to verify the analytical results derived in the Paper. If so, the results could have been furnished in the Paper for establishing conclusively that the cracks were only due to the transverse moments and the correctness of these formulae could also be checked.

Shri C. V. Padmanabhan requsted the Authors to explain the need for the extrapolation curve referred to at the foot of page 270. In practice, kerb beams were provided in the road slabs and the stiffness of these beams influenced the moment distribution pattern to a marked extent. It would have been more helpful if this practical aspect had been examined. Comparison of the thickness and economy in steel, etc., based on Pigeaud's method or other alternative methods, could then be made.

At the foot of page 275 and continued on page 276, the Authors had stated that steel might be gradually reduced. He feared that minimising the effects at corners in skew slabs might not be advisable. In this connection he referred to the findings in the Research Bulletion No. 332 of the University of Illinois and requested the Authors to re-examine if there was adequate basis for reducing the steel at the corners, particularly in slabs with ratio of a to b varying from 1.00 to 2.00 that were mostly used in highway structures.

Lastly, he commended the suggestion of the Authors for the standardisation of the design of slabs for culverts with the addition that kerb beams might be specifically stipulated.

Shri C. G. Swaminathan stated that the Authors had not only made a more rigorous approach to the problem but had also given a set of influence field diagrams which were perhaps much simpler than those normally used in Pigeaud's charts.

As the Authors themselves had pointed out, there was a distinct advantage in this method, namely, that the bending moments at right angles to the span could be obtained directly. He wished that the values of the bending moments obtained by the usual methods had also been incorporated for purposes of comparison. Further, it was assumed that the loads in class A loading were concentrated ones while normally the wheel contact areas were also considered. Perhaps the difference in the values so obtained did not differ appreciably.

Also, on page 272, to obtain the position of the loading for maximum bending moment, a trial and error procedure was suggested. Taking Figure 2, since the distance such as AB, AE and BC were usually fixed, the problem actually amounted to fixing the position of load A so as to give an overall maximum bending moment. Taking equations 30 and 31 on page 270, and assuming the coordinates for A as Xo and Yo with respect to the centre of the slab, the value of Xo and Yo for the maximum values of Mx and My for the system of loads could have been obtained. This might eschew the trial and error procedure.

In this connection, he was not sure as to whether the values of Mx and My would both be maximum for the same position of the loading. Perhaps not, but he supposed for purposes of safety both the positions should be considered.

Finally, he requested the Authors to enlighten him as to whether they had considered the extension of their approach for the design of slabs for different degrees of fixity at the ends.

Shri E. A. Nadirshah said that the analytical approach in the Paper possibly marked a big departure from the empirical

methods of designing most of the reinforced concrete members on Indian bridges. Though at this stage it would be difficult to assess the scope of utilising the results of calculations as indicated in this Paper in a practical way, i. e., either for assessing more exactly the quantities of steel or of their placement in the reinforced concrete slab, he was sure that it would bring a greater appreciation of the actual behaviour of the slab under the loading conditions. It would have been very desirable if the Authors had made some comments on either the degree of conservatism or of deficiencies in the design of culvert slabs that were now being designed by the I.R.C. Code for road bridges.

He felt the assumption that the slab was a thin plate might not be absolutely correct. Particularly in case of slabs of 20 to 30 ft span where dead load bending moments were likely to be considerable since relative to the span, the slab thickness would be considerable.

The correct layout of reinforcement according to the calculations indicated in this Paper might add to its satisfactory behaviour under working loads, but it was felt that they would not add to its ultimate load carrying capacity as it was sometimes expressed that even reinforcement in one direction would be adequate to develop ultimate load carrying capacity with the failure starting with concrete.

The effects of dead loads (uniformly distributed) were also likely to result in transverse bending moment ; he wanted to know whether they would be of the same order as that of the concentrated wheel loads or much less.

He also enquired whether the Authors recommended the distribution of reinforcement to be varied over different widths of the span by determining actual moments from the influence fields, or critical width reinforcement adopted over the entire width of the bridge.

Brig. S. K. Bose said that this was an excellent Paper giving the influence lines for various positions of loading for a slab supported at two ends giving the maximum bending moment at the centre as shown in Plates I and II. These calculations were based on treating the slab as a thin plate. Assumptions made by Westergaard were idealised for the purpose of simplification of calculations. Now that the mathematical calcultaions have been made to determine the influence fields, it was desirable to know how far the results tally with the actual distribution of the bending stress ; because as the previous speaker had

said the analysis had been based on the assumption that the plate had no weight. He, therefore, suggested that when means of measuring strains and bending stresses with the help of strain gauges were available, a test slab be laid with strain gauges at various points in order to determine the distribution of bending stresses, say, under unit load at the various points on the slab and from that compare the results with the mathematical analysis. Determination of a correlation would help in formulating actual design procedures.

Monsieur Y. Guyon said that he had the opportunity of discussing this Paper, when passing through Calcutta, with one of the Authors, Shri K. C. Ray. Having studied the same question himself [1, 2] though from another approach, he was happy to find that their results were concordant. In the course of unpublished developments connected with these studies, he had incidentally found an expression in finite terms for the moments Mx (on sections perpendicular to the span) and in the case of a slab of an infinite width.

In fact, this finding was that the expression of Mx on the centre line (parallel to the supports), deduced from an analysis of the arching phenomena taking place at the end of the elastic phase, led rigorously to the same numerical values as the expression of Mx deduced from the elastic analysis by Fourier series.

Calling $2a$ the span of the slab, $2v$ the transversal width of the load measured in a direction parallel to the supports, and y the distance to the centre of the central transversal axis (parallel to the supports), he found that Mx was proportional to the expression :

$$\frac{Q}{2\pi v}\left[va\,\frac{a^2+v^2-y^2}{(a^2+v^2-y^2)+4a^2y^2}+arc\ tg\frac{2va}{a^2-v^2+y^2}\right]$$

Q being a certain force (which was the thrust of the compression members).

He had not been able, so far, to demonstrate mathematically the reason for this identity, which could easily be checked numerically. He thought, however, that this might be done, by introducing certain functions dealt with by him in a Paper published by the International Association for Bridge and Structural Engineering[3].

Anyhow, the maximum value of Mx, for $y=0$ (centre of the slab, i.e., under the load) would be:

$$\frac{Q}{2\pi a}\left[\frac{1}{1+\frac{v^2}{a^2}}+2\,\frac{arc\ tg\ \frac{v}{a}}{\frac{v}{a}}\right]$$

It might be seen that when v is very small, by developing *arc tg* in series ($arc\ tg\ \frac{v}{a}=\frac{v}{a}-\frac{1}{3}\frac{v^3}{a^3}+\ldots$), this expression would become:

$$\frac{Q}{2\pi a}\left(3-\frac{2}{3}\frac{v^2}{a^2}\right)$$

which has a finite limit for $v=0$, this limit being $\frac{3}{2}\frac{Q}{\pi a}$.

He did not find time to develop these considerations but he thought that it would be of certain interest to bring this contribution to the Paper, hoping that, if there was something to be found along this line, the Authors of the Paper, and also Miss Joshi, could find it.

For his part, he was more and more convinced that the elastic phase was only the first part of the usable life of a slab, and that such a slab was able to carry much more than one could find by the elastic theory alone.

However, a distinction should be made between simply supported slabs like those dealt with in the Paper and continuous slabs; it was more specially in the latter type that he concentrated his research, in view of their special importance in bridge decks.

From the tests he had made[4] on this subject, it was established that the carrying capacity of a continuous prestressed slab depends, when the load increases, on the resistance of different resisting systems; the elastic one is only the first, the second one being a three hinged arch due to the incipient cracking, finally developing into a stiff triangular strutted skeleton substituting itself progressively to the flexural system, as fast as the resistance of the latter becomes exhausted. This substitution takes place without any discontinuity, precisely on account of the identity he had mentioned above, between the expression of Mx, deduced either by the elastic theory or by the arch theory. A stationary phenomenon thus occurs, the cracks being prevented

from developing, the arching effect closing them as soon as they try to extend.

A third and possibly a fourth carrying system follow this second system but he would not deal with these here. He would only add that these were not theoretical views, but the interpretation of results of his tests.

The cracking load derived by the elastic theory would have been, under the conditions of those tests, 800 kg. with the tensile resistance of concrete ignored; it would rise to 2,700 kg. with the actual tensile resistance of the concrete taken into account; the actual full cracking load, however, had been on an average 4,500 kg. determined in the shape of a microscopic hair crack absolutely invisible to the naked eye. Beyond this stage, the load had been pushed up to 8,000 kg. without any opening of the crack—which remained invisible to the naked eye, with only its length along the axis of the slab increasing. Failure occurred finally under 23 tons minimum, i.e., 30 times the load deduced on the basis of the elastic theory ignoring tensile resistance of the concrete.

These very large co-efficients of safety indicate the need of revising the whole subject of slab design. He had proposed a method of calculation where the values of the moments were retained, the resistance to them being ensured by the three hinged arches formed inside the slab. He had made a contribution to the subject at the Lisbon Congress in 1956, and it would be found in the Proceedings of this Congress. His method was very conservative, since it was using only the beginning of the second carrying system; in fact, the loads safely carried could be doubled; anyway, he could definitely state that the method permitted to design without an excessive reserve of strength. All the decks in France were now designed by this method. Some Indian bridges had also been designed by the same method and tests were being carried out on the decks of these bridges. And in view of the fact that the values of the moments were not altered (owing to the identity between the values of Mx as he had mentioned above) the usefulness of theories like those dealt with in this Paper remained complete.

Furthermore, and he might stress on this point, the method of calculation proposed by him, applies to continuous decks, and more so generally to slabs in which the arches could form themselves, i.e., slabs, the supports of which could resist horizontal thrusts. The Authors had actually dealt with only freely supported slabs, but as mentioned in the course of the discussion, it had been stated that their results could be used for any type of slab.

He thought it interesting to call to attention the fact that the conditions of resistance could be completely different, and that was in fact the case in almost all the bridge deck slabs.

REFERENCES

1. Calcul des Points-dalles-Annales des Point et Chaussess-Novembre-December 1949.
2. A load distribution theory for bridge slabs-by R.E. Rowe, Magazine of Concrete Research-July 1955.
3. Stresses at the ends of prismatic bodies. International Assotiation for Bridge and Structural Engineering, Eleventh Volume-1951.
4. Essai sur des dalles continuous precontraintes-Institut Technique du Batiment et des Travaux Publics-Novembre 1955

Shri K. C. Ray (Joint Author) who was not present at the discussion sent the following replies to the various comments on his Paper.

In the introduction to the Paper it had been pointed out that this was an exact solution on plate theory with value of Poisson's ratio as zero and considering the plate to be an isotropic and homogeneous one. The approximate solutions as indicated by Pucher with reference to his curves might be checked with his solution.

Secondly, an R. C. plate was not a homogenous, isotropic one owing to the presence of steel in varying quantities at different sections and also owing to the existence of cracked tensile zones in concrete. In the truest sense, rigid application of the plate theory in R. C. slabs was impossible. Hence, whatever corrections were made with regard to Poisson's ratio, they might not finally be of interest from practical design point of view. Regarding **Miss Joshi's** third observation about infinite value of B. M. under a point load, she was perfectly correct. Actually, values of B. M. had been calculated very near the point, so very near as to come within one inch of the point of application for any reasonable practical slab dimensions. These values were then connected by a curve of parabolic order to obtain the nearest approximate figure. For similar procedure reference might be made to the method adopted by Westergaard in presenting his values under load.

In reply to **Shri S. H. Mahadevan**, attention was invited to numerous experimental works on slabs by Bach and Marcus where it had been proved beyond doubt that an R.C. slab under small deflections followed the elastic theory. The Authors would be in a position also to publish some results of their tests in future.

Regarding **Shri C. V. Padmanabhan's** comments, it was clear from the statement at the foot of page 270 of the Paper that the necessity for a value for the field under the load was obvious.

The problem with stiffened edges as suggested by Shri Padmanabhan was a separate one and might be worked as an anisotropic plate on similar lines by any future worker.

Regarding disposition of steel, this could be left for consideration of the designers. The Authors had only given their suggestions.

Shri C. G. Swaminathan's observations were corrrect. Regarding other edge conditions, reference was indicated to Adolf Pucher's work on plates.

Shri E. A. Nadirshah's doubt as to the behaviour of slab as a thin plate might be dispelled on the grounds that all the theories in vogue work on the same assumption.

Regarding failure of slabs in practical cases, probably the slabs in almost all cases were over-reinforced and, on account of their ultimate strength with due regard to plasticity, the phenomenon as described by Shri Nadirshah was not improbable.

Whether in case of dead or live loads, concentrated or distributed, the results would be the same.

Brig. S. K. Bose's queries had been covered in reply to previous comments.

Lastly, one of the Authors (Shri K.C. Ray) had an opportunity of discussing with **Mons. Guyon** in detail the problems of plates. His suggestion for making a forward stride in the subject of plasticity was bold enough at least to justify the necessity for such a Paper on elastic theory. In India, although they were conservative at present, it was hoped that the outlook would change in the light of the new theory proposed by M. Guyon.

Discussion on Paper No. 194*

"A New Method of Supplying India's Requirements of Bitumen for Black-Topped Roads"

By

W.A. GRIFFITHS

Monday, 13th May, 1957

Shri C.M. Bennett (Chairman) called upon the Author to introduce his Paper.

Shri W.A. Griffiths, the Author, said that the Paper was intended to focus the attention of Highway Engineers to the fact that there was scope for bulk supply of bitumen which was now being manufactured in the oil refineries in the country.

The Railway Board were making special efforts to reduce the railway freights and he hoped this would facilitate the introduction of new machinery and equipment in this country. At this stage it was necessary to adopt more modern equipment and mechanisation to suit the bulk supply method of bitumen. He stressed the usefulness of this method for India, specially for large scale pragramme of black topping and maintenance in the near future.

Shri S.A. Swami said that engineers being interested in combining stability and economy in construction should favour the elimination of the cost of packing drums which was avoidable and which formed 40 per cent of the total cost. This was particularly important as the drums had poor salvage value. The substantial savings could be utilized to build more milage of roads.

He also stressed the advantage of saving time, labour and energy, when bitumen was ready at short notice for the day's work. Daily progress of work would also be considerable. Lastly, Shri Swami mentioned that mutual co-operation between Govt. departments and the oil companies for a successful implementation of this new method was essential.

Shri Swami wanted to know whether the cost of bitumen would be increased due to re-heating the same when there was fall in temperature.

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Shri K. K. Nambiar commended that the Paper on bulk supply of bitumen was very timely, particularly when the problem of containers had indeed become important and serious in these days of steel shortage. This was more so when there was a large programme of work to be done under the current plans. He remarked that the Author was partial to Delhi and Calcutta for supplying bulk bitumen as an experimental measure, leaving Madras out of the picture. If it was the view that bulk supply will not help the work being done with premixed chippings, popular in Madras on a large scale, he would like to mention that they had 5,000 miles of asphalted roads which needed sealcoating every year. He, therefore, felt that Madras might also be included for bulk supply with advantage.

He was of the opinion that the outturn of 1100 squares per day, equal to 9 furlongs of 18 ft wide road, was too much unless the Author had authority for that data.

Shri Nambiar sought clarification whether the saving of Rs 200 per day in working cost referred to actual observed data or was worked out by way of illustration. This was, however, not so important compared to the savings in the cost of bitumen. Actually one mile and one furlong of road of 18 ft width would require 22 tons of bitumen. But before savings could be effected, surface dressing methods would have to be mechanised completely. As pointed out by the Author himself, this would presuppose cleaning of the road surface in advance for the entire length. That could surely require complete mechanical equipment, e.g., mechanical brushes, spreaders, etc., and a number of trucks to feed these spreaders. In that way only it would be possible to figure out the savings correctly. Shri Nambiar stressed the need for such mechanisation in order to implement large programmes.

Lastly, he mentioned that even used drums could fetch a price of as much as Rs 4 to Rs 5 per drum, as they were in great demand for making trunks and other equipment.

Shri C. G. Swaminathan stated that bulk supply prevented over-heating of bitumen and assured uniform and right temperature. Secondly, the new method would facilitate the use of high viscosity binder resulting in a stronger and stabler surface.

He desired to know if hard grade bitumen like 50-60, 60-70 penetration could be supplied in bulk. He preferred the indirect heating of bitumen instead of direct heating mentioned by the Author.

He pointed out the discrepancies in the temperatures of the present supply of 170° C. for straight run bitumen and 110° C.

for cut-backs ; these were on the low side in one case and high in the other case, viz., cut-back.

He sought clarification of figures about the actual savings in bulk supply as compared to drum packing.

He emphasised the great advantages of executing the work of surface-dressing with pressure distributors to ensure strength, durability and longer life ; these factors were now adversely affected by lack of uniformity in spraying. That was a great point in favour of mechanical sprayers.

Lastly, he advocated the use of a constant rate spreading machine in preference to a constant pressure type. Such a machine could deliver a constant volume of binder per unit area of road surface irrespective of variation of speed, etc.

Shri K. F. Antia said that the depreciation cost appeared to be on the low side. He desired to know the cost of the bulk supply lorry and if the idle time and the life of the vehicle had been taken into account as those were quite significant factors.

The second point was how premix work would be managed.

The third point was about the pipe getting blocked and how to open it out.

Fourthly, he desired to know if the cost of heating had been taken into consideration in arriving at the figures.

Shri N. Das Gupta stated that it was easily possible to supply any grade of bitumen if the necessary storage tanks were built at selected places. As regards the distribution, he suggested the alternative of runners and trailers instead of lorries.

Shri C. J. Fielder was of the opinion that it was high time that the old practice of hand spraying and hand mixing were changed to mechanical methods in the interest of efficiency and reduction in cost of construction. He said it was possible to have bulk storage at selected places fed by special railway tankers. From the storage depot the binders could be distributed either by ordinary drums or in road vehicles for ready use. He raised a point whether bulk supply would be economical as the special rail cars would return empty from the depot to the refinery covering some times more than thousand miles. The question of comparative economy had, therefore, to be studied. He mentioned that the bulk distribution from the depot to the work site could be operated economically within a limited radius and that for the area beyond the usual drum supply would have to be resorted to till more depots were established.

Shri W. A. Griffiths (Author) replying to the points raised by Shri **Shri S. A. Swami**, stated that the value of bitumen containers was not a complete loss for, as stated by **Shri K. K. Nambiar**, a price of Rs 4 to 5 per drum was obtained in Madras. Moreover, they were extensively used for making corners round curves, as gabions round trees, etc.

As regards reheating, this would naturally add to the cost but this was likely to be a very small amount.

Replying to Shri K. K. Nambiar, Shri Griffiths stated that he had mentioned Delhi and Calcutta as examples of suitable places for introducing bulk supply, but Madras and other places could easily be included also. He, however, stressed that this could only be done gradually as and when suitable railway wagons, which had to be manufactured, became available.

As regards the figures of cost, he stated that those had been given as a result of observations and would naturally vary under different conditions and methods of working.

In reply to **Shri C. G. Swaminathan**, the Author said that any grade of bitumen could be supplied by bulk supply method to conform to the consumers' demand and naturally the temperature at which supply was made was adjusted to suit the particular grade. The other points were matters of detail.

Replying to **Shri K. F. Antia's** points, Shri Griffiths stated that the figures given in the Paper were illustrative and would have to be worked out in detail to suit the circumstances under which the plant was used. Premix work would be facilitated by transferring the hot bitumen from the bulk supply lorry to the mixer.

If a pipe was blocked that could easily be rectified by using a blow-lamp.

The Author did not consider necessary to reply to the comments raised by **Shri N. Das Gupta** as his suggestions referred to matters of detail.

He agreed with **Shri C. J. Fielder** that the cost of returning the empty rail cars had to be considered but it had been estimated that this would be more than offset by saving in the cost of containers.

The method of bulk distribution could only be built up gradually and extended by constructing storage depots. It could not replace, at least for many years, distribution by drums but

would be introduced initially in the larger centres where there was considerable volume of work within a small radius from the railhead.

Shri C. M. Bennett (Chairman) in his concluding remarks said that they all agreed that, generally, in this country the methods adopted for black topping roads were antiquated and Shri Griffiths had given an indication how improvements could be effected. He had very rightly said that introduction of new processes of this magnitude would take a little time and it must be done step by step. He thanked Shri Griffiths for his interesting Paper.

Discussion on Paper No. 195*

"Earth Moving Machinery in West Bengal"

By

D. N. GHOSH

Tuesday, 14th May, 1957

Shri W. X. Mascarenhas (Chairman) in his introductory remarks stated that the Paper on earth moving machinery in West Bengal was an objective presentation of the main facts relating to a road work executed through the agency of earth moving machinery.

The conditions vary so much from work to work that it seemed almost impossible to come to any except broad conclusions in regard to the significance of the costs involved by the use of machinery. The Author himself had nothing to suggest beyond stating the facts of his specific job. He had pointed out, for instance, that borrow pits in West Bengal could not be more than 3 ft deep. He had also pointed out that labour was extremely scarce and consequently the use of machinery was justified.

Shri Mascarenhas was of the view that the capital investment of Rs 12 lakh on machinery was not justified to execute earthwork of the volume of 175 lakh cu. ft. except for work carried out departmentally or under government auspices. It was true the Author had assumed that only 1/10th of the useful life of the machinery had been used on the work thus making available the remaining 9/10ths for other works. This was all right for work executed departmentally. However, it was doubtful whether a contractor would be ready to work under those conditions.

Coming to the assumed life of the asset, namely, 10,000 working hours as given in the Paper, Shri Mascarenhas could say from his experience that 6,000 working hours was nearly the maximum, depending upon the quality of maintenance. The working life could also be assumed as 10,000 hours but in that case the expenses on maintenance would be considerably higher than those given in the Paper.

Another point was that the interest charges on the sum invested on the machinery had not been reflected into the

*Published at pages 335 to 354 of the Journal of the Indian Roads Congress, Vol. XXI-3, April 1957.

accounts given in the Paper. These and other factors needed a very careful examination and the Author would no doubt reply to these points.

Shri D. N. Ghosh (Author) in introducing his Paper said that it dealt with the performance of earth moving machinery for construction of road embankments in West Bengal. Earthwork, if done with manual labour, took a very long time. There was also the question of bank settlement for which one or more working seasons were wasted.

In West Bengal, subsoil water level was generally high, and therefore, the maximum depth of borrow pit was usually limited to 2 to 3 ft. The lead of earth for high banks was fairly long. All these factors favoured the introduction of earth moving machinery in West Bengal.

To start with, 3 units of machine were purchased and employed in building a road where the bank was high and the lead was long, i.e., where the work was very difficult. These units were moved from one construction division to another as per programme previously chalked out. The Executive Engineer, Construction Division was the administrative head and he was responsible to keep accounts and to see that maximum work was obtained from the unit during the working season. The Executive Engineer, Mechanical Division, on the other hand, gave advice regarding maintenance and repair, and supplied fuel, spare parts, etc., as and when required by the Assistant Engineer, Machinery, who was in charge of the unit.

In earthwork with machinery, control of operation cycle was one of the vital points which must be constantly kept in view. There were several patterns of operation cycle but when earth for road works was available on the road side, straight loading was the easiest and the best. The loading and the unloading points of scrapers and the position of pusher for filling up scraper bowl should be fixed prior to starting work so that each cycle could be completed in the shortest possible time. The crawler tractors which were slow moving were not allowed to turn very frequently.

The details of operations and costing were given in the Paper. With the use of machinery, huge volume of work could be handled in a very short time and also the banks compacted as they were being built up. Hence subsequent work such as laying of soling, consolidation of metal, etc., could be taken up simultaneously; that could not be expected with manual labour. Machinery also helped in clearance of jungles economically and expeditiously.

However, there were certain disadvantages also. One was dependence on foreign countries for import of these machines, their spare parts, fuel, lubricating oils, etc. The second was that these machines remained idle for five to six and a half months in a year. It was very difficult to transport the machines during rainy season over paddy fields and because of their long length and weight they could not be transported by rail unless they were dismantled. Another important factor against the use of machinery was that landless labour was deprived of means of their livelihood. The Author also pointed out that in West Bengal the drivers and mechanics were mostly illiterate and hence sense of responsibility in them was very rare.

Shri L. R. Patel observed that the Chairman had summed up the situation very well, he would like to lay emphasis on one point, viz., that the Paper should not be taken up as a general summing up of the machinery situation. Firstly, machinery had been used under conditions which did not permit its use for many months in the year. Similar conditions did not prevail everywhere else. Secondly, their experience had been that these machines could be used up to eight months in a year. So he suggested that the Author's remarks should be taken with this factor in mind that they applied to a part of the country which had very wet ground conditions for many months in the year.

Regarding life of the machines, Shri Patel felt 10,000 hours of work was not an over estimate. However, 8,000 hours might be taken as a conservative estimate. Machines had been seen working for more than 15,000 hours but even then they were economical provided they were well maintained; this was very important. Proper lubrication was also required.

About mobility of the plant he felt that if they were required to cross rivers it would be difficult, but if there were any roads, it would not be difficult for scrapers. In Bengal, it had been decided to group machines into units. A unit consisted of three scrapers, a pusher tractor, one small tractor and a truck. To do work by such a small unit or grouping in that fashion was uneconomical; this was apparent from the number of staff employed to run each unit. About 30 persons were employed to run each unit. If proper plant was selected, he felt that many of these difficulties would not be experienced.

Shri C. R. Keshwamurthy did not agree with the conclusions given in the Paper. Having discussed advantages and disadvantages of the use of earth moving machinery, the Author should have normally concluded that it was always advantageous to adopt heavy machinery for earthwork embankments in road making. But it was not understood how he came to the

conclusion that in order to get better progress, the pay that was offered to mechanical staff should be reduced and only bonus for good work paid.

Instead of reducing the pay, he thought, it was better to increase it even three or four times in order to make them feel responsible and look after proper maintenance of the machinery. It did not matter even if specialist mechanical engineers were appointed as drivers of heavy machinery. Experience of road construction had shown that generally even four or five road rollers in a sub-division could not be maintained in good condition throughout the year. At least two of them would get out of order and remain idle for 4 to 5 months. It was, therefore, suggested that mechanical engineers be made responsible for the upkeep of heavy machinery. The entire three units of machinery of West Bengal could have been managed by one qualified mechanical engineer.

The Chairman had already referred to hire charges of 10 per cent assumed in the data. During the first 1,000 hours very good service was given by the machinery and the assumption of 10 per cent of hire charges was, therefore, not correct.

Shri S. N. Gupta said that the basic question was whether mechanised labour or manual labour should be employed for doing earthwork embankment. It was not only the question of rate or cost but other factors were also involved. Time and speed were important. The construction of an embankment by manual labour had taken three years to settle properly to final stage. In West Bengal, machinery could be employed on embankments with economy in some places. Shri Patel had mentioned that this type of machinery was not suitable for West Bengal. But heavy machinery was purchased there only after making a comparative study of different types of scrapers with their operation cost, etc., and after finding out that this type was the most economical. As regards the type of tractors, pneumatic tyred or crawler, one had to be acquainted with the soil conditions in West Bengal. Shri Patel would bear him out that it was difficult to move the pneumatic tyred tractors. Once the soil got moist after a small shower, the wheels would run in one place and not move forward. For that reason precautions were taken to purchase crawler type tractors.

Regarding the transport question for moving the heavy type scrapers, they could be moved by inland water-route.

The scrapers and other equipment were divided in three units. Each unit could handle 80 lakhs to 1 crore cu. ft. of earth per year. If all the three units could be put in one place saving

could have been obtained in operation cost; however, there was no road project where 3 crore cu. ft. of earthwork was concentrated in one place. This seldom happens in construction of old embankments. The scrapers were, therefore, distributed to different works in different locations.

Shri D. N. Ghosh, the Author, replied to the various comments of speakers. He said that the first point raised by the Chairman and **Shri L. R. Patel** was regarding the life of machinery. In their State the machines were about 6 years old. They had worked for 6,000 to 7,000 hours. The condition of the machines was still good and he was sure they would run at least for 10,000 hours. And so the calculation of 10 per cent as depreciation per year on work basis was not unjustified.

Regarding the use of heavy machinery as pointed out by Shri Patel, Shri Gupta had already replied to that point.

As regards use of all the units together and number of men employed per unit referred to by Shri Patel, he would say that actually in West Bengal the conditions were very difficult and the transport problem was the most serious one. When two units were employed on N. H. No. 34 those had to be transported through river Bhagirathi on departmental river transport. The river Bhagirathi remains open hardly for two months. If all the three units were employed together, possibly some of the machines would have remained on the old site and, on account of transport difficulties, it might not have been possible to take them to the new site. In fact, at Malda in the year 1950–51 all the machines could not be taken to one side of the river and consequently some of the machines remained idle for the whole year. That was why the machinery was distributed in one or two units.

Replying to **Shri Keshwamurthy**, in regard to the mode of payment to mechanical staff, he could say from his personal experience that regular monthly payments made them neglect their work. The payment of full wages during idle period also encouraged the tendency to keep the machines idle as far as possible. He, therefore, felt that the mode of payments should be changed to get the maximum return. He was, however, not against giving sufficient wages to the staff.

To another objection regarding the placing of civil engineer in charge of machines, he could say that if one had only some knowledge of machine parts and their performance and took some interest he could easily control machinery even if he were to be a civil engineer.

Regarding the objection in costing, which was very important, he would say that they had not taken into consideration

interest on the capital outlay. Actually, for their purpose they had made calculations only on the basis of actual expenses incurred for running the machines both during working and idle periods and depreciation of the machines taking them on the hour basis. They should have also taken the interest into account provided they had worked out figures on commercial basis. Actually that was not done.

Answering the point raised by the Chairman for not employing machines on two shifts, the Author said that they had no trained hands and training up one or two of their foremen took a long time. They took particular interest in the maintenance of machines at periodical intervals and as such did not mind for the loss in not using the machines for two shifts.

Shri W. X. Mascarenhas (Chairman) in his concluding remarks said that, as mentioned earlier in his opening remarks, the Paper made no provision whatsoever for providing a general guide to the use of earth moving machinery for the construction of road embankments. It had evidently very limited value. It described conditions and gave the cost of a work executed in West Bengal under the peculiar conditions described in the Paper. One could form no general opinion or draw any general conclusion from the data supplied. The use of earthmoving machinery was not economical except when, firstly, there was very large volume of embankment to be made up, secondly, speed or time was an important element in the job and, thirdly, work executed by manual labour would be generally speaking either too slow or too expensive. In this connection it had been suggested that one of the advantages of machinery was the securing of compaction of the embankment during the process of construction. That was true. It had been his own experience that the compaction secured under the crawler type of tractor was so good that earth did not settle even an inch. But that did not mean that they could not combine compaction with construction by manual labour. In these days when dams were being built up in his State with manual labour, work was done by the gangs. Compaction was done simultaneously by using ordinary road or sheeps-foot rollers. In this way advantages of both the types of construction could be obtained.

As regards maintenance, Shri Mascarenhas quoted an instance from his personal experience. He had purchased some tractors from the Army Disposal and then called a representative of the makers to make them workable. Only to strip down each machine and discover what was wanted, Rs 2000 were quoted excluding cost of spares which in one case cost as much as Rs 6,000. Then an Army Officer was asked if he could do

something and he repaired every one of those machines for Rs 1800 only which was less than the stripping cost quoted by the agents of the firm. That instance could give some idea of how some makers regard maintenance to be wholesale replacement. In drawing out proformas, due allowance would, therefore, have to be made for proper maintenance—not wholesale replacement of parts. Interest charges would also have to be taken into account. Sickness rate in maintenance should also be allowed for.

Lastly, as regards the question of incentive of wages he entirely agreed with the Author that some such inducement should be held out. Bonus might be paid to the workers and they could be relied upon to take care of machines in the way the big contractors or organisations do. From his own experience he could say that this kind of incentive produced miraculous results.

Discussion on Paper No. 196*

"An Investigation for Mass Production of Pozzolanic Portland Cements from Overburnt or Fused Jhama and WellBurnt Bricks by Utilizing Brick Kilns"

By

A. K. DATTA

Monday, 13th May, 1957

Shri E. A. Nadirshah (Chairman) called upon Shri A. K. Datta (Author) to introduce the Paper.

Shri A. K. Datta in his introductory remarks stated that bricks were the most common building material throughout India. Numerous brick kilns were found everywhere in India. It was, therefore, desirable to find out whether it was possible to utilise the overburnt bricks by turning them into a cementing material.

The first Paper on this very subject had been read by him before the Indian Roads Congress in 1939, the second in 1943, and this was the third one. It took some time to conduct research and produce some conclusive results. Even men like Dr. Michaelis of Germany who tried to introduce pozzolanic cement along with portland cement could not succeed. Gradually every part of Europe, Japan, etc., started adopting pozzolanic cement. In 1937, when he was constructing the cement factory at Karachi, pozzolanic silica cement of Osaka, Japan, at Rs 27 per ton was used in the construction of this factory. In England, the *trass* cement was a pozzolanic cement. In America also, pozzolanic cement had been used extensively. Here in India, pozzolanic cement was not much used with burnt shale as pozzolana (20 per cent) until now. It had been used extensively only at Bhakra-Nangal recently and this was the first case of its kind. Bricks did possess pozzolanic property which was better compared to other pozzolanic materials found in India. Shri Datta showed a briquette composed of 50 parts of cement, 50 parts of overburnt brick dust and 300 parts of standard sand mixed with 3 per cent water. Side by side he had made briquettes of 100 per cent cement and 300 per cent standard sand with about 8 per cent water. Both these briquetttes were made under similar conditions and at similar temperatures. They were tested at 3 days, 7 days, 14 days, 28 days, 90 days and 180 days. The tensile strength at six

* Published at pages 381 to 394 of the Journal of the Indian Roads Congress, Volume XXI-3, April 1957.

months was found to be 825 lb per sq. in. against 758 lb per sq. in. for portland cement mortar (1 : 3). That increase in strength was due to pozzolanic action of brick jhama dust.

Further, the Author stated that elaborate experiments had been carried out on this subject in the Swai Madhopur and Dalmia-Dadri cement factories. Of the six tests mentioned by him, the first was with 100 per cent cement, the second was with 70 parts cement and 30 parts brick jhama, the third was with 50 parts cement and 50 parts brick jhama, the fourth was with 40 parts cement and 60 parts brick jhama, the fifth was with 20 parts cement, 20 parts lime and 60 parts brick jhama, and the sixth was with 20 parts lime and 80 parts brick jhama. Compressive strengths were as follows :

Proportions	Strength in lb per sq. in at. 1 day	180 days
100 per cent cement	375	758
Cement and Jhama		
7 : 3	342	850
1 : 1	250	825

Thus, it would be observed that there was gradual reduction in the quality of portland cement—from 100 to 0—with improvement in the 180-day strength.

There were something like 132 factories producing cement in India and those could help in producing the portland pozzolanic cements in India.

By mixing 70 parts cement and 30 parts brick jhama, the production of cement had been increased by about 50 per cent. Such cement had actually been manufactured at Dalmia-Dadri only about 3 months back. Seventy parts of cement clinker and 30 parts of brick jhama with 4 parts of gypsum were ground in a cement mill. After manufacturing 350 tons, the cement produced was tested. It was found that all the physical properties and tensile strength compared favourably with those of the ordinary portland cement. They were even better. This cement was used for constructing the extension of the cement factory there.

Shri Datta expressed the view that by the method suggested in the Paper it was possible to reduce the cost of cement as well. The weight of 1,000 jhama bricks was 3½ tons and cost about Rs 30. So the cost of one ton of jhama brick would be about

Rs 9. Breaking bricks into ballast and grinding the same to cement fineness, say with the help of a crusher and a ball mill, would cost Rs 11 or so per ton. So the cost of brick jhama, ground to cement fineness, could be taken as Rs 20 per ton. The overall cost for 2 tons of a mix of 50 parts cement and 50 parts brick jhama would be Rs 120 + 20 = Rs 140 or about Rs 70 per ton plus Rs 30 or so for the cost of mixing, operational expenses, overhead charges, cost of bags, profit and taxes. So the overall cost would come to Rs 100 per ton compared to Rs 120 for cement. Moreover, production would be doubled. With a fall in the price of cement and brick jhama, the cost would be much lower.

Shri Datta felt that out of 20 tons of portland cement it was possible to produce 100 tons of portland pozzolana brick jhama cement quite good for all practical purposes.

Brig. S. K. Bose pointed out that it had been claimed that when cement having 60 to 64 per cent of lime sets, free lime was liberated and that soluble and active silica present in pozzolana reacted with free lime. It had also been stated that pozzolana with high lime content gave better result. For instance, Rajasthan jhama having 6.5 per cent of lime gave better strength than Calcutta jhama which had 2.8 per cent only. Similarly, Italian pozzolanic material containing 10 per cent lime gave higher strength. As far as was known, it was silica and not lime as stated by the Author which really increased the strength. He, therefore, wanted to know whether the chemical reaction of pozzolanic material on cement had been fully investigated. So far as he knew, this reaction was still not fully understood. Until this was correctly known, it would be rather premature and might be inadvisable to jump to conclusions. There were many instances in the history of cement industry where various firms had put forward in the market cement which gave initial high strengths but failed completely after 3 years. He, therefore, considered that, before considering adoption of jhama as pozzolana, observations in the field for at least three years were necessary.

Shri N. S. Bawa stated that it was not quite clear from the Paper whether the use of pozzolanas or hydraulic lime or a new type of cement was under consideration. Ordinary portland cement was essentially made by burning clay and lime together at high temperatures so that fusion took place. The Author had suggested addition of lime to brick clay and burning of both at high temperature, to almost fusion, to get some sort of cement. This material could not be called pozzolanic according to the definition of Dr. Lea, as the same would have cementitious properties in itself.

In the synopsis on page 381, it had been stated that addition to cement of jhama, containing high percentage of lime, gave tensile strength comparable to that when cement alone was used. This meant that the material was to be used as an admixture in cement.

Table 3 on page 390, sample No. II, had no parallel sample for lime clay. Jhama sample No. II in which no lime had been added had no doubt given good results but in the absence of a sample in which lime was added, the above statement was not justified.

Addition of lime to brick soil had been recommended by the Author. It is an established fact that the function of surkhi is to combine with the free lime in concrete liberated by cement hydration. By addition of lime to the clay, some sort of cement and not pozzolana would be manufactured. Free lime in the concrete would remain free which was very undesirable.

The studies in the C.R.R.I. had shown that there was optimum temperature for each type of clay depending on its mineral composition (for example, illitic clay required higher temperature of burning than montmorillonite clay), whereas the Paper seemed to suggest the same temperature for all soils.

Making of surkhi from bricks, in his opinion, was not a desirable practice because it was only the clay fraction which contributed towards pozzolanic characteristics. In the manufacture of bricks, a high proportion of clay might not be in the soil. The sand fraction was absolutely useless for pozzolanic properties. Therefore, addition of brick surkhi to concrete would mean only addition of mostly inert material. Table 4 on page 391 showed SiO_2 content of brick jhama (No. 1) as 82.58 per cent, which was only possible with 70—80 per cent of sand content.

Shri Bawa hoped the Author was familiar with the new methods of testing pozzolana which had been developed recently. One such test was reduction in alkalinity and dissolved silica test which showed whether pozzolanas were siliceous or otherwise.

In the chemical equation on page 383, it should be $4C_a(OH)_2$ instead of $C_a(OH)_2$ to balance it. Also, he was not sure whether the hydration of cement could be represented by such exact figures as 5 molecules of water of hydration.

Shri Bawa felt it was high time that the manufacture of pozzolanic cements was given serious consideration, but it was not possible with brick surkhi. Instead, the vast clay deposits should be exploited without adulterating them with sand or lime.

Shri S. C. Dikshit commented as follows :

Para. 2.2. The strengths obtained for various mixes of surkhi-lime mortar should have been given.

Paras. 2.2 and 5.1. Comparison of relative costs of both types of cements should take into account the extra expenditure involved in curing.

Para. 3.1. The effect of higher percentage of lime on strength of bricks needed consideration.

Para. 3.2. When lime was set free on setting of portland cement, it needed investigation why jhama with higher percentage of lime gave better results.

Shri C. C. Bagchi said that it would really be a great advantage if some alternative material in place of cement could be found. To achieve this, complete details about cost, availability of the material in bulk and its standardization were first necessary. Also, some trials as suggested by the Author were desirable.

Normally, the cost was the main factor. The public would use burnt clay, if the price was low, rather than use good kankar lime.

Further, he drew the Author's attention to the fact that poor quality of surkhi, if mixed with cement in different proportions, sometimes could not stand even one rain as the action of saltpetre had a very deleterious effect on this kind of mortar.

Shri K. F. Antia felt that there were certain fundamental misconceptions which he felt were necessary to be clarified. Time and again, speakers had mentioned that the proposals put forward by Shri Datta would produce more cement. What Shri Datta was actually doing was to replace certain raw materials with burnt bricks or surkhi. By following this procedure, production would not be increased by a single ton because the machinery required would be the same whether ordinary cement or pozzolanic cement was produced. This misconception appeared to be due to confusion between pozzolana and pozzolanic cement. One was a mechanical mixture in which pozzolana of right characteristics and proportion was added to cement. The other was a type of cement and that was what Shri Datta advocated.

As everybody knew, cement was manufactured from raw materials such as limestone, clay, etc. Burnt bricks or jhama could not be cheaper than limestone and clay. Further, the cost of a material which required duplicate processing was bound to be higher than one with single processing. It might be possible to obtain a small quantity of jhama as waste product at low cost. But when there was the question of manufacturing tons of cement, say, 50 to 100 lakh tons of cement, even the 250 kilns near Calcutta might prove inadequate.

The next point was that uniformity of quality would be very difficult to achieve in a product from numerous kilns.

Finally, he would say that he did not for a moment wish to belittle the efforts of Shri Datta. They were very praiseworthy. Pozzolanic cement was a material which had been manufactured and used in other countries, but the problem was that of producing larger quantities of cement and using all available raw materials.

Shri D. C. Chaturvedi* referred to the strengths of lime-surkhi mortar in para. 2.2 and said that the results obtained in the Uttar Pradesh P.W.D. Research Institute with lime-surkhi mortars were different. They found that third class brick surkhi (from Lucknow and Kanpur) gave higher strength than 1st and 2nd class brick surkhi in some cases. Taking 1st and 2nd class bricks as well burnt bricks and 3rd class bricks as not so well burnt bricks, the results showed that different clays from which bricks were made gave different types of surkhi. From some clays, 3rd class brick surkhi might give better results whereas from others 1st class or overburnt brick surkhi might give better results. This was due to different chemical and mineralogical composition of the clays found in different localities. It was, therefore, necessary to test the clays and surkhi before deciding which type of surkhi was to be used. Third class bricks were not accepted for construction work and so these bricks could be used for manufacturing surkhi. These would be cheaper and perhaps easier to grind. The surkhi obtained could be used with lime to make lime surkhi mortar or in pozzolanic cement as stated by the Author.

Shri P. J. Jagus stated that the subject matter of the Paper was extremely important. The employment of a local material for the manufacture of pozzolanas or pozzolanic cements necessitated that the research work on this problem should be carried out extensively at as many places in the country as possible, because any conclusions drawn from the use of materials from one or more specified sources would not be applicable to materials from other sources.

In para. 1.2, the Author had referred to cheap quality cement for road construction. This should by no means give an impression that a highway pavement could be treated as a secondary

* This and subsequent comments were received in writing.

type of structure as compared to a bridge or a building. It must be realised that it would be far more dangerous to use an inferior type of cement in road construction than it would be in any other structure. A highway pavement, as compared to other structures, was subjected to more severe and more frequent stresses including those due to temperature and moisture variation and subgrade restraint. He, therefore, assumed that the word " cheap cement " did not imply any cement inferior in quality to normal portland cement.

Para. 2.1. The strength imparting reaction between the jhama and the free lime liberated during cement hydration was not only restricted to lime silica combinations but also extended to the formation of calcium aluminates, calcium ferrites which might be cementitious and would in turn contribute towards strength.

Para. 2.2. The Author had referred to overburnt, underburnt and well-burnt surkhis or jhama. The statement did not give any idea about the exact temperatures of burning, which were very important from the point of view of manufacture of surkhi of maximum reactivity. Every clay had an optimum temperature of burning for maximum lime reactivity. A temperature of burning above or below that value would lower the reactivity and hence it was important to find out in every case what this optimum temperature should be. This would give a uniformly high quality of product and in certain cases (where higher temperatures were otherwise adopted) lead to saving in fuel.

Para. 3.1. Shri Jagus agreed with Shri Bawa that the surkhi mentioned could not be classed as pozzolana because it had cementing value.

Para. 3.2. The basis of judging the pozzolanic quality of the jhama used by the Author was the tensile briquette test only which was neither correct nor the basis of the test adequate at all to prove whether a pozzolana was of a good or poor quality. It was wondered why established tests of lime reactivity, chemical tests of reduction in alkalinity and dissolved silica were not adopted for adjudging the pozzolanic qualities of the surkhis.

In Table 1 of the Paper, the Author had stated the chemical composition of an Italian pozzolana. The lime content of this pozzolana was nearly 10.5 per cent. It appeared that this lime must be in the form of carbonate as the loss on ignition was also equally high, which perhaps accounted for the loss due to calcination of $CaCo_3$. Under the tentative draft specification of pozzolana being issued by the A.S.T.M., the requirement of the chemical composition called for a mineralogic composition so that the combined percentages of silica, alumina and iron oxide in a pozzolana together should constitute at least 70 per cent by weight of the pozzolana. Based on this standard, the material under reference could not be classed as an effective pozzolana. In the same Table, the Author had mentioned the silica content as a combined percentage for soluble and unsoluble silica. The insoluble silica content was of little value in pozzolanic reactivity.

Para. 4.1. The Author had suggested the use of rubbish from lime kilns, industrial waste from sugar factories, etc., for making surkhi. He felt that this was too dangerous a recommendation to make. Portland cement clinker was a chemically pure material and so also had to be a commercially made pozzolana. Extreme care was necessary in the manufacture of pozzolanas so that no deleterious matter could be present in it which might react with cement or aggregates or give rise to a reduction in strength or deterioration of concrete.

In Table 2, Fig. 1, the Author seemed to have adopted certain *ad hoc* combinations of slaked lime, overburnt bricks, dust, cement clinker and gypsum for studying the tensile strengths of briquettes made with these combinations. It could be seen from the Figure that the strengths attained even in best lime-surkhi cement combinations were less than those of pure cement up to ages of 80 to 100 days. He, therefore, wondered if the Author wanted such mortars to be used for road construction.

Para. 6.1. The Author had mentioned that the ground clay was dried and fused using coke as fuel under forced draft. It was stated that a lot of heat was required for fusion. This again was a vague statement on the degree of burning. Apparently, since fusion took place, the temperature must be in the vicinity of 1,100 degrees to 1,200 degrees Centigrade, which could be considered as rather high for cheap and efficient manufacture of a pozzolana. Clays of appropriate qualities, generally the montmorillonite and kaolin type, could give pozzolanas with very high reactivity at temperatures as low as 600 degrees to 800 degrees Centigrade.

Shri Jagus was also sceptical of several statements made by the Author in paras. 6.2, 6.3 and 7.1. They needed careful consideration on the part of any one who might be seriously interested in the manufacture of industrial pozzolanas or pozzolanic cements on a commercial scale.

In reply to **Brig. S. K. Bose, Shri A. K. Datta** (Author) said that higher percentage of lime in brick jhama had been

recommended by him for brick jhama pozzolanic cements made by blending hydrated lime with brick jhama pozzolana and not for portland brick jhama pozzolanic cement made by blending cement with brick jhama pozzolana.

The matter had been investigated by actual experiments and the reaction was fully understood. The results of the experiments clearly showed that higher the percentage of lime in the brick jhama or pozzolana, the more the strength attained.

Referring to the next point regarding increase of strength in relation to time, Shri Datta said that experimental results actually showed that the strength of portland pozzolana cements went on increasing with time. So there was no question of retrogression as feared by Brig. Bose.

Replying to **Shri N. S. Bawa**, he stated that the Banjari cement factory where experiments were made was within a few hundred feet from Sone river which had a sandy bed and, therefore, the soil around was very sandy. So the presence of a high percentage of silica (SiO_2) in the brick jhama was possible.

Other points raised by him had been covered in his replies to Brig. Bose.

Referring to the points raised by **Shri S. C. Dikshit**, the Author explained that the strength obtained from various mixes of surkhi-lime mortar had been included in his earlier Paper presented in 1943.

He agreed with Shri Dikshit that for comparison of costs of both types of cement, the expenditure involved in extra curing should be taken into account. He, however, considered that this extra cost was insignificant.

As regards the comments of **Shri C. C. Bagchi**, the Author pointed out that brick jhama pozzolana was not intended to replace portland cement fully but it was to replace only a part of it. He had advocated three mixtures for the present:

(i) 70 parts of portland cement clinker, 30 parts of brick jhama, 5 parts of gypsum—increase in production, 50 per cent.

(ii) Clinker 50 parts, brick jhama 50 parts, gypsum 4 parts—increase in production, nearly 100 per cent.

(iii) Portland cement 20 parts, brick jhama 80 parts, fresh slaked lime 20 parts, gypsum 4 parts—increase in production, 500 per cent.

A crusher and a grinding ball mill could be easily set up in a city to produce cement from brick jhama and picked jhama available from the brick kilns in the neighbourhood.

The cement clinker could be bought from the nearest cement factory. If larger quantities were required, more kilns could be started and the burning of bricks could be continued throughout the year instead of only for 6 months. That would, of course, require covered kilns.

Shri Datta agreed that it was necessary to have a standard specification for the manufacture of the portland brick jhama cement.

He did not share Shri Bagchi's fears regarding the action of rainwater or attack by saltpetre. Roman pozzolana concrete had stood admirably well in sea water for over 2,000 years. In buildings, the stones at the sides encasing the pozzolana concrete had been destroyed by saltpetre action but the pozzolana concrete inside stood intact. That had also been noticed in many old structures in Italy and Britain.

The Author appreciated **Shri K. F. Antia's** view that so long as the same quantity of portland cement was manufactured in the same factory there would be no increase in production. But, when the extra production of portland brick jhama cement was required, the position was quite different. The overburnt bricks and jhama could be available from the brick field; so no raw mill and kiln would be necessary to produce the same. The brick jhama could be taken from the brick kiln and broken in the crusher of the factory which, he believed, could be available usually for the purpose. Only a cement mill with the feed table and hopper and some extra space for collection of ground cement was required. A drier might be required to get the jhama bricks dried during rainy season. A 500-ton cement mill with feed table hopper and other accessories might cost about Rs 20 lakh, whereas a new 500-ton cement plant was likely to cost Rs 150 lakh. Similarly, the cost of a small crushing ball mill and a small crusher would not be much.

The Author differed from Shri Antia's criticism that burnt brick could not be cheaper than limestone and clay from which cement was manufactured, as in portland brick jhama cement there were 70 parts of cement and 30 parts or more of brick jhama cement. Brick jhama was mixed as a substitute for cement and not for limestone and clay as understood by Shri Antia.

Since brick jhama in the same locality had more or less the same property, there should be no difficulty about achieving uniformity in quality.

Referring to the comments by **Shri P. J. Jagus**, he stated that he agreed that research should be conducted all over the country. Actually he had already done a lot of work on the subject and the results of the tests carried out were published in Papers printed in the Journals of the Indian Roads Congress and the Institution of Engineers (India).

While introducing the Paper, he had mentioned how it was possible to reduce the cost of cement without deteriorating the final strength of cement. Therefore, there was no question of using inferior quality of cement for road construction. Portland cement developed somewhat early strength as compared to portland brick jhama cement, but the latter also developed sufficient strength in one month's time and was cheaper than portland cement. In this connection, he invited attention to Table 2, page 386 of the Paper.

He did not agree with Shri Jagus that the very definition of a pozzolana could not permit it to contain any lime except in the form of traces. Table 1 on page 384 of the Paper would show that all Italian pozzolanas contained 10.48, 10.0, 9.83, 12.09 per cent of *CaO*.

Shri Jagus's remark that the tensile briquette test was used as the only basis for judging the pozzolanic quality of the jhama was not correct. Compression tests and also tests for ascertaining the physical properties had been carried out side by side.

With reference to comments on Table 2, he pointed out that by using 1/5th cement it was possible in due course of time to get the same strength as portland cement. That was no doubt a great achievement. A strength of about 600 lb per sq. in. was attained in 28 days and that was quite good for road construction.

Replying to comments on para. 6.1, the Author said that it was true that clay which contained high percentage of lime required high temperature for fusion. The conclusion was based on the work done at the Banjari cement factory.

Commenting on Shri Jagus's remarks on para. 6.2, 6.7 and 7.1, the Author stated that results of elaborate experiments done on the subject could be made available for reference, if required.

In reply to **Shri D. C. Chaturvedi**, he pointed out that the strength of lime mortar depended greatly on the fineness of surkhi, degree of burning of surkhi, mortar consistency, composition of lime used in the mortars and grinding of lime-surkhi mortar. It was not stated by Shri Chaturvedi under what conditions the lime mortar tests were made by him. Neither the type of surkhi nor its gauge, etc., had been mentioned. The surkhi from well-burnt and overburnt bricks, unless finely ground and mixed thoroughly with lime, could not give good results.

Surkhi from well-burnt and overburnt bricks, when ground to cement fineness and mixed with lime and some coarse ingredient such as sand or surkhi, could give mortars having strength better than that of surkhi obtained from third class bricks. He drew Shri Chaturvedi's attention to elaborate experiments that had been carried out at the Government Test House, Alipore, on this very subject and printed in Indian Industrial Research Bulletin No. 24.

In conclusion, the Author stated that a very large quantity of overburnt brick pozzolana was produced throughout India. An ordinary brick kiln on an average produced 30 lakh of burnt bricks and it usually contained:

20 per cent 2nd and 3rd class bricks, i.e.,	6 lakh
30 per cent 1st class bricks, i.e.,	9 lakh
40 per cent overburnt picked jhama, i.e.,	12 lakh
10 per cent brick jhama, i.e.,	3 lakh

That would give a rough idea of the availability of pozzolanic material. If overburnt picked jhama and brick jhama were taken for production of pozzolana brick jhama cement, 15 lakh of bricks per kiln could be obtained, their weight being $15 \times 350 = 5{,}250$ tons. Two hundred and fifty kilns of Calcutta alone would produce $250 \times 5{,}250 = 13{,}12{,}500$ tons and out of this only 75,000 tons were required for a 500-ton portland brick jhama cement factory.

Shri E. A. Nadirshah (Chairman) in his concluding remarks said that all the criticisms of the Paper were for the good only.

Shri Datta had mentioned about brick kilns in India. Perhaps he was referring to northern India because in other places there was a considerable shortage of bricks. He had stated that cement was very scarce. Shri Nadirshah entirely agreed with him because if per capita consumption of cement

was considered, it was hardly about 28 to 29 lb per head per year, whereas in the other more developed countries the figure was as high as 400 to 700 lb per head per year. These figures showed that in India there was shortage of this material and great effort was needed to come anywhere near to the production in foreign countries.

At present, about 5 million tons of cement was manufactured in the country. By 1961, this figure would be stepped up to over 10 million tons per year. Even to attain the figure of 100 lb per head per year, about 18 million tons per year were needed to be produced.

The Author had remarked that the price of cement was high but as compared to other building materials, the price of cement could be said to be very reasonable. The price of other materials had gone up by 300 to 600 per cent, whereas the cost of cement had stepped up only by about 200 per cent.

Brig. Bose had brought out a very important point in connection with the reaction of free lime with the pozzolana. Probably, the Author had not understood the physical and chemical reactions by which pozzolana affected the properties of concrete.

It was a generally accepted theory that the siliceous compounds in finely divided pozzolanas reacted with the hydrated lime to form a highly stable cementing substance of uncertain composition involving water, calcium and silica, possibly monocalcium silicate. Most pozzolanas contain appreciable amount of other materials also and it was probable that other complex compounds were formed including alkalies, iron and alumina.

In using pozzolanic cement for construction, it should not be forgotten that the initial drying shrinkage tended to be higher and it might require a longer period of curing.

A clear picture of the economy to be derived by using pozzolanic cement was not given. One had to take into consideration the operational and overhead charges and also the likely upward spurt in the cost of raw materials such as jhama on account of its commercial exploitation. He, therefore, wanted the Author to work out the cost after taking into consideration all the relevant factors.

He did not agree with the Author's contention that more cement could be produced if the present units took up the manufacture of pozzolanic cements. The rated capacities of the present cement factories were based on the individual capacities

of units in different processes during the manufacture. If, however, pozzolanic cements were to be manufactured, apart from plant modification, the fine mill capacity as well as the kiln capacities would have to be adequately increased if extra production was desired over the present rated capacities for ordinary cements.

The Author in his Paper had conveyed an idea that burnt clay and volcanic pozzolanas were similar to chemical composition and that reaction with lime was the same. As a matter of fact, that was not so. Burnt clay pozzolanas were quite different in composition from volcanic materials. The former consisted of anhydrous alumino-silicates in contrast to the hydrated zeolitic alkali alumina silicates.

In the end, the Chairman thanked Shri Datta for presenting the Paper. He also thanked the various speakers for making the discussion interesting.

Discussion on Papers No. 197 *

"Study of Soft Aggregates from Different Parts of India with a View to Their Use in Low Cost Road Construction I—Rajasthan"

By

H. L. Uppal & Bhupinder Singh

Tuesday, 14th May, 1957

Shri H. R. Gupta (Chairman) called upon Dr. H. L. Uppal (Joint Author)to introduce the Paper.

Dr. H. L. Uppal (Joint Author) in his introductory remarks stated that this Paper was the first part of a study on soft aggregates such as kankar, laterite, moorum, etc., which exist in different parts of India. The study of these aggregates had been necessitated on account of the fact that these materials had so for been considered as unsuitable for road construction, even when available at site. The result had been that where hard stone was not available the cost of road construction had gone up considerably. Moorum, which was one of the soft aggregates included in this study, had been tried for road construction in some States but no attempt had been made so far on a large scale for its use in permanent road construction.

The object of the present study, therefore, was to find out some broad classification of such materials in different States, as far as possible, and see how these materials of different groups could play their legitimate role in various stages of road construction as such or after minor treatment. A study of this type could not be very comprehensive, specially when 1 to 2 samples only had been received from each quarry.

These samples (about 200 in number) were obtained by the Indian Roads Congress from various States in India. The present study comprises 55 samples from the various quarries of Bikaner, Jodhpur, Jaipur, Dholpur, etc., in the State of Rajasthan.

The word soft aggregate generally conveyed the idea that it was a neat material with low crushing strength, but the materials received from Rajasthan, in addition to being weak, were invariably mixed with large percentage of fine material of plastic nature.

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The first step in a study of this kind would be to screen the material and find out how strong was the aggregate. Since the economics of its use would depend upon the percentage of coarse material in the mixture, the entire samples were subjected to mechanical analysis and it was found that the fraction coarser than 10 mesh varied from 10-90 per cent and had an aggregate impact value between 17-40 per cent which was fairly high. (Lower the values higher the strength.) Kankar was the strongest of the lot. Analysis of the fine material revealed that it was fairly plastic in nature (plasticity index varied from 5-25). This had a special advantage in a place like Rajasthan where sand was available at site and the blending of clayey soils could, therefore, be carried out most economically.

On the basis of plasticity index, the entire samples could be divided into two main groups –(1) plasticity index 5-10 (ii) plasticity index 11-25. Each one of these groups could further be subdivided depending upon whether the percentage of coarse fraction was small or large, thereby resulting in four groups in all.

Though there were other tests which were also essential for selection of stone for use in road construction, yet crushing strength determined to a large extent the suitability of the material.

Looking to the analysis of the aggregates from Rajasthan, it appeared that kankar from certain quarries was as strong as some of the good road stones and, therefore, fit for use in water-bound macadam, provided the coarse fraction was economical to sieve. The other class of aggregates had an impact value between 30-40 and were, therefore, suited both for mechanical as well as Mehra's method of soil stabilization, (i.e. suspending coarse aggregate in soil).

Referring to the use of quarried material, the Author stated that Group R1 had very good grading, the plasticity index varied grom 5-10 and should therefore form excellent soil gravel mixture. R3 was similar to R1 except that it had less of coarse fraction and could be used by adding more aggregate to conform either to soil gravel or Mehra's specification.

R2 had proper grading of coarse fraction but the plasticity index of the soil mortar was high, which could be brought down with the addition of sand which was available at site. The mixture could be used the same way as R1. R4 had very little of coarse fraction and high plasticity index. This could be reduced with the addition of sand and be used successfully after addition of 35 per cent soft aggregate after Mehra's method.

It would, therefore, appear that almost all the quarried material of Rajasthan could be successfully used for road construction and it was not necessary for the State to depend upon imported stone.

Shri G. C. Sharma said that in view of the demand for greater milage of roads in the country, and owing to the paucity of funds, it was necessary that intensive research should be carried out to find out the suitability of using local materials.

It appeared to him that the Authors had not investigated the matter from all angles so as to come to a definite conclusion or to frame a standard to be rationally followed. They had done experiment on samples to determine the physical properties and not studied the physical constants such as unit weight and absorption tests, compressive strength tests, specific gravity and so on which were also necessary in estimating the quantities of materials required on a given job and for other job control purposes. He, therefore, suggested that the necessary tests should be made and results furnished in the following manner by making further experiments and tests on samples, besides those furnished in Table 1 :

(1) Crushing strength ;

(2) Unit weight in lb per cu. ft. ;

(3) Absorption percentage ;

(4) Percentage of wear ;

(5) Toughness or impact tests.

In general practice, it had been established that for macadam base course, the percentage of wear should not be more than 8 and toughness value not less than 6. The Authors had made only the quantity tests and not the control tests of materials.

From Table 1, it appeared that the Authors had not taken into consideration other important aspects of samples such as :

(1) The ability of the aggregates to resist disintegration due to changes of climate and temperature.

(2) The shape of individual stone particle (as flaked and elongated stone particles are a source of weakness for constructional purposes).

(3) Affinity of the aggregates whether hydrophilic or hydrophobic nature.

The hardness of aggregates was mainly essential for construction of dry-bound and water-bound macadam roads where voids

were not completely filled up. But when aggregates were required to be used in soil stabilization process, other tests were also equally important.

It was also not known whether the aggregate impact tests were made in the specimen specially prepared for the purpose or supplied directly from the quarry or pit as there were great influences in the tests on account of the shape and sizes of aggregates as well.

From the report given it appeared that samples were collected from 55 quarries and perhaps only one sample from each quarry. So the results of test values for a single sample from each quarry could not be advocated to fix up the standard limit and gradation specifications on the basis of which the Authors had made Groups R1, R2, R3, R4, and so on.

The Authors had evaluated the base course materials in groups by hardness of aggregates by grading of materials and the plasticity index of soil fines but not considered the density of the compaction. Of course, the Proctor density tests could not be made due to large percentage of coarse aggregates but the compacted densities could be ascertained in the field for all types of materials. It was experimented in other countries that densities of 140–150 lb of dry aggregates per cubic foot were likely to result in stable construction.

From Table 1, it appeared that the plasticity index in almost all samples grouped under R1 was more than 6 which was almost experimented as a standard limit to have practically stable sand clay or gravel sand clay roads with the liquid limits not exceeding 25. Again from Table 2, the mechanical analysis of samples, it appeared that the percentage of fines passing through sieve No. 200 in aggregates grouped under R1 by the Authors ranged between 1 to 34.26. But to have a stable road of the required type, the percentage of fines should be between 5 to 15 or not more than half of the percentage passing through sieve No. 40 as experiments had established in other countries.

He suggested that the following points should be considered in selection of groups like R1, R2, R3, & R4 made by the Authors after summarising the effects of gradations of more than one sample from each quarry :

(1) There should be enough material between sieve No. 10 & sieve No. 200 to provide interlocking of the soil grains and increase the shear strength.

(2) There should be enough silt and sand in the mixtures to act as a filler to provide capillary bond necessary for stability if the binder clay loses cohesion in wet weather.

(3) There should be enough clay to retain adhesion after capillary moisture has been evaporated during dry weather.

The following could be classified as the main processes of road construction under various low grade aggregates and soils:

(1) Mechanical stability such as without clay binder, dry-bound and water-bound, clay with chemical, clay with deliquescent.

(2) Special stabilising agents such as (i) bituminous binders, (ii) cement, lime and some industrial products.

(3) Heat treatment of soils.

Low grade aggregates and soils could also be used by improving the constructional methods. Uniform gradation in stability between the wearing course and the subgrade was essential for the design of a pavement as the stresses imposed by traffic, though penetrating to subgrade and base course, yet diminished rapidly with the increase of thickness. So it was uneconomical to use high quality materials in the lower sections of the base course. Or the subgrade could be improved (the base being considered as medium for spreading loads) as the road failed due to failure of subgrade on account of repeated loads.

It was the usual practice in the U. S. A. to improve the top 8 in. or so of the subgrade by compacting it thoroughly to about 95 per cent of optimum compaction or the subgrade was improved by incorporating materials with the process of ploughing and scarifying with agricultural machinery.

Shri N. S. Bawa observed that from the description of samples, one found that the samples were either moorum or kankar. Though both moorum and kankar could be considered as soft aggregates, yet they were two entirely different geological groups. Moorums were semi-weathered rocks and kankar was not a product of weathering but was formed from the soil due to leaching and deposition of calcium salts. Again, kankar soils would always be alkaline while moorums would not be so. He, therefore, suggested that the two materials should be studied and classified separately, if possible.

No study on soft aggregates could be considered complete, unless the weathering properties had been studied. Rather, the study should start from the weathering test. Three important tests were: (i) Wetting and Drying Test, (ii) Sodium Sulphate Soundness Test, and (iii) Freezing and Thawing Test. The last test could be eliminated if considered too severe. But the other two tests must be performed before any recommendation

was made for the use of soft aggregates. He felt that moorum samples might fail under those tests. Those tests were considered important even in the case of cement soil stabilization, but it was strange the same were not done in this study.

On page 444, para. 5.3, it was mentioned that in Mehra's method of soil stabilization, coarse aggregate content was about 40 per cent, while in Appendix 1, page 457, it was mentioned that soil shall consist of two parts of soil and one part of brick ballast. He, therefore, requested this anomaly to be clarified.

Assuming that two parts of soil and one part of coarse aggregate was correct proportion, it would be seen that coarse aggregate was 33 per cent of the mass. This would not give edge to edge contact of the coarse aggregate particles and edge to edge contact was not required in Mehra's method because soft aggregates were used in this method. This was very important because due to cushioning effect of the soil matrix, the impact test lost its value as a proper test for judging the performance of soft aggregates. It was strange that impact test value had been given importance in the study.

Shri Bawa then stated that on page 438, para. 3.2.3, it was mentioned that for all practical purposes there was not much difference in values obtained by the aggregate impact test and by aggregate crushing test. He pointed out that the Authors had ignored the other findings by the same Road Research Laboratory, i.e., aggregate crushing test had a very low coefficient of variation as compared to impact test and it was specifically recommended that, in the laboratory, aggregate crushing test should be preferred while, in the field, impact test only could be used. Another advantage in aggregate crushing test was, that it could be used for finer fractions of the coarse aggregate. He, therefore, hoped that the Authors would take note of it and adopt aggregate crushing test in the laboratory.

Brig S. K. Bose stated that in the body of the Paper, where the detailed description of R-1, R-2, R-3 and R-4 was given, the Authors had clearly stated that R-1 was good for base course, R-2 good for sub-base, R-3 good for sub-base and R-4 not even good for sub-base. His comments were, therefore, based on use of the soft aggregates as a base course material.

The Authors had chosen an arbitarary figure of plasticity index of 5 to 10 for R-1 aggregate. Normally, material of the plasticity value of more than 6 was not accepted for base course. So he did not know on what basis 5 to 10 had been selected. The evaluation of aggregates on basis of their grading and the plasticity index was dealt with by Glossop and Skemption in 1942 in

a Paper presented before the Institution of Civil Engineers. Thereafter, further attempts were made to classify material for use in the base course rather on the basis of CBR values. In Table 3, rather very high CBR values of the samples were found. For example, in S. No. 10 and 11, CBR values were 280 and 210; yet the material had been graded R-3.

In the same Table, S. Nos. 22 and 25, CBR values ranging between 50 and 69 were found; yet the materials had been graded R-1. So he was not clear why departure was being made from the known method of classification based on the CBR value. The method of classification based on plasticity index was likely to classify materials of rather low CBR values as good material.

Shri P. L. De sought clarification on a few points. He said that in para. 5.2 for the recommended method of construction with group R1 material, the rolling was to be done at optimum moisture. The optimum moisture was determined on material passing 10 mesh whereas the material under that group contained a large proportion of the coarse fraction. He requested the Authors to suggest the procedure to be adopted for the determination of the actual amount of water to be added for the compaction of such material.

He then stated that most of the samples under groups R-2 and R-4 could not be called as 'aggregates' but 'soil.' Hence it was better to modify suitably the title of the Paper to cover mechanical stabilization of soils.

Lastly, he pointed out that in para. 3.1 the samples had been divided into two groups, viz., coarse fractions and fine fractions with 2 mm. size as the margin whereas in Table 2 the results of mechanical analysis had been shown in inches and mesh Nos. It would have been more clear if the corresponding sizes in mm. or at least the standard of the sieves (i.e., whether B.S. or A.S.T.M.) had been given along with the mesh Nos., so that one could know at a glance the quantity of the different fractions. Of course, the laboratory man knows that 2 mm. nearly corresponds to A.S.T.M. No. 10, but others might have to consult text books.

Shri A. K. Deb pointed out that the Authors had taken only 55 samples and grouped them into four groups and tried to divide them in four different zones and recommended one specification for each zone. Now with so few samples and with so large a scale and with so few variables only the grading and PI had been used by the Authors. If the grouping as determined by the Authors were considered as valid, certainly the zoning was not at all convincing. With only four zones in the entire State of Rajasthan, he doubted whether any constructional engineer, if he located his soft aggregate samples in a certain zone, would have enough confidence to accept the specification recommended for the zone because the specifications were based on a limited number of tests and a limited number of samples. The best approach to this problem, he believed, was to make an engineering soil map of a State first and the zoning of the aggregates would come as a necessary corollary because the soil and aggregates would have the same pedological origins.

Commenting on the use of granular soils in stabilized roads he said that in the absence of experimental data, the Authors were apt to recommend specifications arbitrarily and, therefore, suggested that the problem should be tackled in a more rational way. Inviting attention to the commendable efforts of the C.R.R.I. for the design of flexible pavements he stated that, if the same procedure was employed for the design of soil stabilised roads, namely, the CBR tests, some definite conclusions would be arrived at and the specifications could be recommended with confidence.

Shri E. A. Nadirshah commented that the Authors appeared to have outstepped the scope of the work by generalising certain recommendations without the support of field experiments. It would have been much better if they had merely presented the data from the tests in the first part of the Paper instead of concluding the results.

The observation in para. 3.2.1, that all soils whose coarse fraction varied from 10 to 90 per cent would permit screening to be carried out economically, appeared to him to be too optimistic and, considering the fact that investigations were directed towards the use of such material in low cost road construction, the consideration of screening need not have been taken into account.

Both the Aggregate Impact Test and Aggregate Crushing Test were significant for evaluation of aggregate strengths particularly when they were used for concrete, but such tests were not necessary in the present case.

The soils were also described to be non-plastic and, if due account was to be taken of their high bearing capacity as reflected by the group indices given in Table 4 of the Paper, it was obvious that for very low cost road construction (at least under the existing stringent conditions of finance), roads could be best made by providing proper grades and surface drainage and maintaining them by the use of either manually propelled graders or motor graders, until such time as conditions of traffic warranted such roads to be upgraded to medium traffic roads.

Even for improving this material for roads to carry medium traffic, it was quite likely that cement stabilisation would prove more economical than screening of materials, addition of clay fractions for improving of binding qualities, etc.

Referring to para. 4.1, he stated that the re-grouping of the soils into four categories appeared to be superfluous because it only brings together several sub-groups of PRA classification which would be more useful from the point of view of determining the field controls for such construction. Unless enough investigational work on soils was carried out in India to evolve a separate system of classification, the PRA classification system should be adopted for highway work.

Regarding para. 5.2, he stated that the reference that C.B.R. test would enable determination of the softening action of water appeared to be incorrect as C.B.R. test would only give the resistance to penetration and was only a miniature plate bearing test. Likewise the reference in para. 5.3 saying that C.B.R. values of about 25 to 35 per cent showed the need for moisture resisting layers over such soils was also incorrect. Actually as the shearing strengths of soil increased pro-rata with the C. B. R. values it indicated that layers of higher shear strengths would be required over such soils to enlarge periphery of shear deformation of soils at their level.

All the references to weather proofing of such soils with water-proofing materials were mere solutions towards construction of medium and high traffic roads rather than to have low cost roads as was the intention of the Authors.

Shri J.S.Narasimham observed that the material taken for study contained varying percentages of coarser fraction and therefore, suggested that it would be better to call that material as 'soft aggregate soil mixture' instead of 'soft aggregate'. Referring to the contents of the Paper he opined that the Paper would have been of more practical value if, instead of basing their conclusions on C.B.R. test the Authors had based their conclusions on the PRA classification with necessary limitation for the use of these aggregates, as sufficient data was available with regard to the service performance of roads, based on PRA classification system.

He thought that the classification based on the PI values and the mechanical analysis tests, would be misleading. To a certain extent, these 'soil aggregate mixtures' could be compared to the soil-coal cinder mixtures because of the severe degradation of the soft aggregates brought about under the dynamic stresses developed under traffic loads. These soft aggregates got crushed and their gradation would change within a few months after the construction of the base course or the sub-base. The degree of degradation of these soft aggregates brought about under traffic loads had not been studied by the Authors in their investigations except for carrying out the Los Angeles abrasion test and the impact test. These tests, however, did not give any indication of the percentage of degradation under traffic. Also, it was not correct to assume that the CBR test would ultimately give higher values in actual construction, because the coarser fraction would get pulverised under the traffic loads. It was, therefore, clear that any classification based upon the gradation characteristics, without taking into consideration the degree of degradation, would not conform to field conditions.

It would perhaps be more appropriate if the C. B. R. test was done on the minus No. 4 sieve fraction after the soil aggregate mixture was subjected to a suitable degradation test. The design based upon the results of this test, perhaps, would be more rational.

Continuing, he said that most of the W.B.M. roads failed due to lack of cohesive binder material. It could, therefore, be suggested that in an arid area like Rajasthan, soil binders having PI values equal to 15 should be used so as to give the minimum cohesive strength necessary to keep the soft aggregates from disinterlocking themselves. He felt that PI range of 5–10 fixed for the groups R1 and R2 was not suitable.

In a problem like this a suitable stability test for the base or the sub-base other than the C. B. R. test was essential. Soft aggregates specially in Rajasthan area contained fairly high percentage of sandstone which by nature appeared to have enough cohesive strength, but on rolling, were crushed to powder. To evaluate the stability of these mixtures, it was, therefore, necessary to determine the cohesive strength of the soil fines under the moisture conditions that were likely to prevail in that area. Such a test would serve as a better yardstick and would enable to predict more accurately the service performance of these soil aggregate mixtures. Cementitious property developed under wet rolling was, however, an important characteristic feature of these soft aggregates. It was this cementitious property brought about during the wet rolling that contributed the required cohesive strength to keep the aggregates bound well together. This property should be taken advantage of in view of the poor cohesive characteristics of the soil binder at the moisture content prevailing during summer months.

Lastly, he pointed out that the method of soil stabilisation mentioned in Appendix I of the Paper might be suitable in areas where there was some rainfall but he felt that it was not suitable for application to arid areas like Rajasthan.

Dr. H. L. Uppal (the Senior Author) in his reply to **Shri G. C. Sharma's** suggestion about the additional tests such as crushing strength, unit weight in lb per cu ft., absorption per cent, per cent wear and toughness or impact test, pointed out that work carried out recently in Road Research Laboratory, London, had shown that crushing values and impact values were almost identical and for purpose of convenience the simpler test had been adopted. This had already been explained in the Paper. Since the quantity of material was not enough, Los Angeles test which gave abrasive resistance of the material could be carried out only for a few samples.

Since the aggregates were mixed with soft materials, the quantity required in the field would depend upon the density that could be achieved with the compacting unit available. Therefore, it would not have been an additional advantage to know the unit weight in lb per cu. ft. This information had, however, been indirectly given in C.B.R. test which in addition to density also gave the maximum moisture likely to be absorbed by the aggregate.

Regarding the other comments for determining the shape of the particles and affinity for water, etc., the resistance of the aggregates to water was actually included in the mechanical analysis which was done on sample previously in contact with water for 24 hours and thereby eliminating the percentage of the soft material. He invited the attention of Shri Sharma to his opening remarks where it had been stated that no study of that nature could be comprehensive and it would, therefore, require a thorough study of each quarry before the material was used in the construction.

The aggregate impact test was carried out on fraction passing ½ in. and retained on 3/8 in. according to standard procedure.

Regarding the density of compaction, this had already been taken care of when determining the suitability of these materials on the basis of California Bearing Ratio Test.

He pointed out that the use of samples in various groups had been suggested in accordance with some of the standard systems of road construction like (a) Mechanical stabilization, (b) Mehra's method of stabilization which had to their credit large milage of road construction. He further pointed out that since the materials of R1 and R3 were naturally graded and that of R2 and R4 could be also well blended with sand available at site, it was not necessary to try the effect of bitumen or cement binder.

Regarding the points raised by **Shri N. S. Bawa**, it was pointed out that the Authors were glad to find that even aggregate impact value could also separate the two materials—moorum and kankar—into two separate groups. The crushing strength of kankar was fairly high while that of moorum was fairly low.

Replying to the question regarding various weathering tests, it was stated that these were certainly important for those areas where freezing and thawing, wetting and drying conditions occurred frequently. It was considered that such tests would be out of place for conditions prevailing in Rajasthan.

The Authors stated that Shri Bawa had not taken into consideration the voids in the brick aggregate and it was pointed out for his information that when 8 parts of soil were mixed with 4 parts of brick aggregate the resultant volume was 10 parts. Therefore, percentage of aggregate as worked out should be 40 and not 33 as considered by him.

Referring to the impact test, the Authors stated that it was better to adopt aggregate impact value for such projects because it was more convenient to do this test in the field.

Referring to the points raised by **Brig. S. K. Bose**, the Authors pointed out that the study was done with two objectives in view, (a) the use of material as such, (b) and its use after necessary treatment.

To determine the use of material as such for base course or base coat, the test adopted was the C.B.R. test and it was suggested that when C.B.R. values were low, the material could only be used for base course and when it was high of the order of 100 or above, it should form a base coat to take up surfacing. Attempt was, however, made to see how far with the addition of sand or other material locally available, the strength of the mixture could be improved. C.B.R. test was generally adopted for worst conditions of subgrade moisture, but on account of arid conditions in Rajasthan it was likely that the material would give better performance.

Regarding the comments made for high C.B.R. values for sample No. 10 and 11 and putting them in group R3, the Authors replied that the proposed classification had not been carried out on C.B.R. values and these two samples seemed to be an exception because values of all other samples of this Group were below 80. The matter was, however, being investigated to find out the reason for this exception. This would apply also to some of the exceptions in group R1.

In reply to **Shri P. L. De's** comments regarding the procedure to be adopted for optimum moisture determination for R1 group, the Authors suggested that this could be done the same

way as for wearing course mixture in Mehra's method of soil stabilization. The optimum moisture was determined on fraction passing 10 mesh and in addition to this an additional 3-4 per cent was provided for evaporation losses and absorption by stone. The additional combined moisture would, therefore, vary with climatic condition and percentage of stone.

With reference to the comments regarding the inclusion of group R2 and R4, they stated that though the quantity of the aggregate in these two groups was small, yet the nature of the soil had an important significance because it could be conveniently blended with sand which was readily available at site after the coarse material had been made up to 35 per cent, the mixture could be used according to Mehra's method of soil stablization in low cost roads.

They stated that the desired information was given in the gradation size distribution curves where both the sieve numbers and size in mms. had been shown.

Replying to **Shri A. K. Deb**, they stated that mechanical stabilization was too well known a method. Therefore, it would be out of place to discuss it in the Paper. As per recommendations based on Mehra's method of soil stabilization, the Authors would like to say that the method had stood the test of time for a period of 10 to 12 years and the specifications recommended were not arbitrary but were based on a definite scientific data collected. It was also established that addition of 35 per cent aggregate gave the maximum strength. This had been ascertained by the plate bearing test.

Referring to the suggestion for use of P.R.A. system, it was pointed out that this classification had also been attempted and results obtained showed that no such classification was possible.

Regarding the C.B.R. method, it was stated that the method had come to stay as a standard method for determining the thickness of the pavement. The thickness could be built up with different materials in such a way that the top most crust should not have less than 80 C.B.R. value when $2\frac{1}{2}$ in. thickness of waterproof pavement should come over it. It would, therefore, not be incorrect to say that the material with C.B.R. 25 or so could go as such into the sub-base and a material more resistant to softening action of water placed above it to serve as a base coat.

Replying to the points raised by **Shri E. A. Nadirshah**, the Authors said that they had also tried to restrict themselves to the analytical part of the study, but when the whole data was put on the chart, they could not help seeing that the entire samples of

Rajasthan got themselves grouped without much effort on the part of the Authors. When these groups were plotted in the map of Rajasthan, they got themselves again separated into four belts.

Referring to the study of coarse fraction in various materials, they stated that the object was to know if the material was very strong enough and still existed without much of fine material with it. Then it could be used only as aggregate in place of some of the conventional standard road stones. In case the material was not strong and also mixed up with fine fraction, then it would be more economical to use it in low cost road construction.

The Authors entirely agreed with Shri Nadirshah that all the aggregate tests were not essential when the material was going to be suspended in soil for use in road construction.

Replying to **Shri J. S. Narasimham** in regard to his points pertaining to the use of P.R.A. system, it was stated that the system had many shortcomings as it took into consideration the percentage of the coarse material and not its strength and thereby rated only as subgrade material. Attempts had, however, been made to classify the material in P.R.A. system but it was not found very helpful. It was, therefore, included in the Paper for academic interest only.

The Authors agreed with the suggestion that the tests should have been carried out not at the saturation moisture but at the moisture likely to be absorbed by such material in actual practice. Since this information was not available, tests could only be carried out at saturation moisture.

Work on the subgrade moisture study had already been taken up by the Central Road Research Institute with the object of finding out the highest moisture likely to occur in the subgrade in various parts of India.

He further stated that Rajasthan was not as arid as considered by Shri Narasimham. The rainfall varied from 10-20 inches in most parts of the State and, therefore, the method of soil stabilization recommended in Appendix 1 would be found applicable to Rajasthan even if the views expressed br Shri Narasimham were correct.

Shri H. R. Gupta (Chairman), in winding up the discussion, stressed the importance of the study of the type outlined in the Paper. He thanked the Authors for their interesting Paper and the various speakers for their comments

Discussion on Paper No. 198*

"Indian Bridges"

By

Y. GUYON

Monday, 13th May, 1957

(Readers of the Journal would perhaps like to have an introduction to M. Yves Guyon whose Paper read at the Shillong session of the Indian Roads Congress is published in this Volume of the Journal. Graduating from the Ecole Polytechnique in Paris, M. Guyon devoted the subsequent part of his career to the study of prestressed concrete. A pupil of M. Eugene Freyssinet, M. Guyon is a rare combination of mathematician and practical engineer and has had extensive experience both in the design and construction of prestressed concrete structures. He has to his credit a large number of valuable Papers published in various parts of the world, and he was the first to study the elastic behaviour of statically indeterminate structures in prestressed concrete; his Paper on the subject entitled "Etude sur les poutres continues et sur certains systemes hyperstatiques en beton precontrainte" has drawn considerable attention. Perhaps his most important contribution to engineering literature is his book entitled "Prestressed Concrete" published in 1953 in which he deals at length with the basic phenomena of prestressed concrete, treating many of them in an original and ingenious manner, and develops their application to the problem of statically determinate straight beams. M. Guyon is now the Technical Director of the Societe Technique pour l'Utilization de la Precontrainte).

Shri E. P. Nicolaides (Chairman) called upon the Author to introduce his Paper.

Mons. Y. Guyon (Author) while introducing his Paper desired that for the last four lines in Para. 5 of his Paper, the following lines may be substituted:

"But (instead of however) the quantity of steel is reduced by about 28 per cent in the case of continuous span, being only about 6.7 lb per sq. ft. against about 8.2 lb (see curve 2s, Fig. 1) required for bridges of type 1C. Therefore, the saving of steel for Coleroon bridge would be only $\frac{4.8}{6.7} = 30$ per cent."

Continuing, he said that he wanted to be clear on the type of bridge shown in Fig. 2. This type was useful when a single foundation could be provided for the short span at lower cost than separate foundations. Where separate wells were required for each pier, the proposal had to be reconsidered since the cost of

*Published at pages 614 to 619 of this Volume.

foundations may then be practically the same as in the case of equal spans having the average length of the two spans $\frac{(\text{short} + \text{long})}{2}$ of Fig. 2. He had shown in his Paper* presented in London that the solution with equal spans was generally lighter, as far as the quantities were concerned.

However, that statement would not give a complete picture, because the solution with equal spans would be lighter only under certain conditions.

For instance, if in the case of equal spans a solution was adopted of the same kind as Fig. 2, with balanced cantilevers and suspended spans (but with $l = \frac{L}{2}$ instead of the dissymmetry sought in Fig. 2) then the quantities would work out definitely smaller than for unequal spans. The cost, however, may not follow the quantities, the necessity of casting in situ a double cantilever of this length being a great handicap, reduced on the contrary to a minimum if l is small. On the other hand, if with equal spans, a solution with simply supported beams of uniform depth was adopted, the alternative with unequal spans offered the advantage of making possible an increase in depth over the supports and in the short span.

The comparison was, therefore, a matter of circumstances and he was of the view that, retaining the conclusions of paragraph 9, three or four different types of spans could be standardized namely:

(a) Coleroon type.

(b) Type according to Fig. 2 of his Paper with L = some 220 ft—simply supported beam of some 110/120 ft span.

For rock foundations, multiple portals on the lines or paragraph 15 (La Boa Bridge) could be considered.

Shri K. F. Antia stated that in India, as M. Guyon had himself indicated, there was the problem of foundations for large bridges. The criterion used by the bridge engineers in the country for economical designs was to make the cost of the superstructure equal to that of the substructure. The larger the span obtained at a low cost the more economical would be the bridge. With steel bridges they had spans of 400 feet, but spans in prestressed con-

* Long span prestressed concrete bridges constructed by the Freyssinet system — The Institution of Civil Engineers, 5th February 1957, London.

crete were 150 feet only in India at present. He liked to know the size of spans to which the prestressed concrete bridges could be constructed. He had in mind the arch type prestressed bridge, such as the one built by the Freyssinet system over the river Marne in France. He wondered why this type of construction had not been followed up when steel spans of 4,000 feet (if his figure was right) had been built in the form of suspension bridges in which America had taken the lead. He wondered whether it was not possible to design some form of prestressed concrete arch of equal magnitude.

Further, prestressed concrete, although found to be economical for bridges, did not appear to have the same advantage with other types of structures and buildings. With the assistance of Shri Nicolaides he had tried to apply prestressed concrete to factory structures of various shapes and sizes. Except for liquid retaining structures and containers, prestressed concrete was not found to be more economical than reinforced concrete. He requested M. Guyon to indicate the lines of development of prestressed concrete in Europe.

Shri K. K. Nambiar wanted some clarification on one or two points which, though they had not been dealt with in this Paper, yet they had an important bearing on it and regarding which some people entertained some doubts. Prestressed construction was compartively new to this country, and only those engineers who had poineered the work had acquired the necessary confidence in the use of its technique. There were still so many both among laymen and engineers who had not taken the pains to acquaint themselves with this new technique, and who entertained some sort of scepticism with regard to the durability and soundness of prestressed concrete constrction. The report that the Railways in France have not taken largely to the technique of prestressed concrete construction for their bridges might also lend support to their misgivings. Hence an authoritative statement from M. Guyon would go a long way to dispel such doubts. The first point was whether there was sufficient data to show that fatigue would not, in the long run, affect the soundness of the structures particularly due to the repetition of loads and reversal of stresses where tension was permitted in concrete. Would not the same conditions as obtained at the time of construction last indefinitely for many years? Surely, M. Guyon would be able to say something on this point which would go to reassure the sceptics.

The other point which M. Guyon himself had referred to was regarding the diaphragms. M. Guyon had dealt with that point in para. 14 of his Paper. He had mentioned that the diaphragms need not be too numerous. He requested Mon. Guyon to illustrate the point further. A small span bridge might be considered as a scale model of a large span bridge and if 6 diaphragms for a 100 ft span bridge at intervals of 20 ft were put in, 6 diaphragms at 30 ft intervals for a 150 ft span bridge would do. One need not be frightened about 30 ft spacing in the latter case.

Shri E.P. Nicolaides stated that Mon. Guyon had drawn their attention to the very low amount of high tensile steel per square foot of decking, achieved at the Coleroon bridge. He gave this amount as 4.8 lb per sq. ft. of decking and since Coleroon had an overall width of 33 ft, the amount of H.T. steel per ft of decking would be $\frac{33 \times 4.8}{112} = 1.42$ cwt. per ft run.

He had been looking recently at similar figures of H.T. steel consumption per ft length of bridges designed by Gammons and he had found that they were between 1.12 to 1.13 cwt. per ft length of decking for spans comparable to the Coleroon; the details of the 150 ft spans of Bhima bridge given in Paper No. 189, discussed earlier in this Session, gave the H.T. steel per ft length of decking as 96 to 100 cables of 12 Nos. 5 mm. diameter wires, i.e., about 1.1 cwt. per ft run. Shri Nicolaides' figures did not provide for the cross prestressing of the decking as they had not done any, but he was interested to know if their designs compared favourably with those mentioned by Mon. Guyon as regards economy in high tensile steel.

On the subject of cross prestressing of the decking, there had been a tendency recently to press more for its use and the Roads Wing of the Ministry of Transport had expressed the opinion that the distribution of live loads between the main girders of a bridge without a cross prestressed deck slab should be taken as more unfavourable than in the case where cross-prestressing without tension was adopted.

He disagreed with the latter opinion. Perhaps Mon. Guyon would be good enough to tell whether or not a design of a bridge with girders prestressed only longitudinally and with an ordinary R.C.C. deck slab and cross beams, suitably designed, could be considered as good a construction as the case of a cross prestressed decking.

He would certainly prefer to use cross-prestressing but from his findings he could say that it was really uneconomical in comparison to ordinary R.C.C., where the fairly heavy additional cost of anchorages was only to be distributed over the short length of 20 to 30 feet of cross-prestressing cables.

Mon. Guyon had mentioned for the Coleroon bridge deck design the advantages of adopting a single hinge per span against the usual alternative with balanced cantilevers. It appeared there was a gain in economy but from the military point of view this design might be heavily censured on account of the fact that damage of a single span would cause the successive collapse of all the spans from the unbalancing of reactions at cantilever ends.

Mon. Guyon had also mentioned in his Paper that the design live loads for bridges in France were higher than those adopted in India. As far as he remembered, when the present I.R.C. live loads were established by the Bridges Committee some ten years back, they had made a comparison with live loads applying for Europe and America and it was then proved that the class A and AA Indian live loads were certainly on the upper limit of all others. Mon. Guyon could perhaps give a brief specification of live loads used in France to elucidate the point.

In para. 9 of the Paper, the Author had touched upon the very important relation of type and depth of foundation to the span of superstructure and had attempted to draw general conclusions on the possibility of standardizing spans for Indian conditions. Shri Nicolaides felt that every bridge site was and would always remain a problem in itself and general rules for standardization of deck spans, however ; judiciously applied, could never lead to economical results. Standard designs of deckings could only help in a first rapid comparison of the relative costs of foundations and piers as compared to the decking, from which the final selection of the most economical span would emerge; otherwise, blindly adopted standard spans for all bridge sites were bound to lead to severe loss in economy.

In para. 10 of his Paper, Mon. Guyon had opined that the Indian point of view would appear to be the same as the American one for better designs, i.e., to save skill and labour as against the European practice of laying greater emphasis on saving in materials. Well, it was his experience that in India saving in labour was definitely a secondary factor for improved economy in design, mainly because the cost of Indian labour was much lower than in Europe and vastly more so in comparison to America. India might be behind these continents in skill but he would say that skilled and semi-skilled Indian workers once they had learned the job did maintain a uniform standard of workmanship as steady, if not more so, as their counterparts in Europe and America. Economy of design in India would thus definitely hinge on a reduction of the volume of materials such as steel and concrete and much less so on saving labour.

He had taken due note of Mon. Guyon's caution against very thin webs and high principal tensile stresses at ends of girder; he ventured to suggest, however, that cracks observed at times in the webs may be due, very often, to shrinkage effects as a result of insufficient stirrups and mild steel longitudinal reinforcement.

He further enquired whether a defect, apparently of secondary importance to safety, appearing only once in about hundred occasions, and from obscure causes, would call for an increase in web thicknesses over those adopted in the past, without any further investigation for a clearer explanation of its occurrence.

During the discussion on Bhima bridge, he had mentioned the need to allow an early prestressing of a part of the cables as a preventive measure against the effects of shrinkage and he would once more urge the adoption of this procedure.

He was glad to have Mon. Guyon's views on the spacing of cross diaphragms as given in para. 14 of his Paper; their function was of course the lateral stiffening of the decking and the problem of their spacing hinged on an adequate ratio of longitudinal to lateral rigidity of decking in consonance with the degree of uniformity adopted in distributing the live loads to the main girders for their individual design.

Mon. Y. Guyon in his reply stated that **Shri K. F. Antia** had asked what could be the limiting spans for prestressed concrete and why portal bridges like Esbly were not used more widely.

To the first question, he had given some indications in the Paper presented in London. So far, the bottleneck appeared to be the magnitude of the prestressing force, on account of the space required for accommodating the cables. It had been said in this Paper that in normal conditions, and for the need of good embedding of cables, the prestressing force could reach a maximum value of 225 tons per linear foot of cross-section. This figure could be raised higher, if necessary, and developments were in the course of perfection for obtaining a greater density of the wires. But under Indian conditions, the maximum mentioned was sufficient for getting an idea of the practical limits.

The limiting spans could then reach some 240 to 260 ft for bridges simply supported at their ends and 380 to 420 ft for continuous bridges (with unequal spans) and for portals. But for spans too near to the span limit, the solutions became very heavy and uneconomical. From the economical point of view, a 220 ft

span appeared to be the practical maximum for a simply supported bridge.

As for portal bridges, their adoption was on the increase in Europe; there was an increasing tendency to connect rigidly the beams with the piers, whenever possible, and thus reduce the reversal of moments in the span, with consequent advantage. But in the case of India, it appeared generally more difficult to get foundation conditions adequate to resist the thrust, and for this reason he had proposed providing the fixity of the ends by other means without resorting to statical indetermination.

In the matter of buildings, a large number of these were being built in Europe with prestressed concrete and there was no reason why the same could not be done in India. He mentioned, however, that these were generally always statically indeterminate structures and the regulations drafted for statically determinate structures would not, logically, apply. More liberal regulations should be adopted for continuous structures and tensile stresses of at least 300 p. s. i. should be allowed.

The question of durability raised by **Shri K.K.Nambiar** must be answered in the affirmative. Well designed prestressed concrete bridges were much better, from the point of view of fatigue, than R. C. bridges, due to the great reduction of variations in the steel stresses and the elimination of cracks.

Regarding rail bridges, as to why prestressed concrete bridges were not considered by the French Railways, there were in fact some of these in France. Slab bridges had been used since 1944; the viaduct of Voulte (Boussiron, with B. B. R. V. system) had just been completed; Galion and Joazeiro bridges (130 ft and 147 ft spans) were combined road and rail bridges in Brazil; as well as the Wouri Bridge (150 ft) in Cameroon.

For railway bridges, tensile stresses in concrete should not be allowed, to avoid the possibility of cracks. If the bottom fibre remained always in compression, the phenomenon of fatigue could not develop in steel and experience showed that under these conditions the structure resisted millions of repetitions of loadings. In confirmation of this, it could be said that prestressing had been successfully applied to the foundation of a large power hammer; this foundation was previously made of R. C. and had to be rebuilt every two months. By prestressing, the reversal of stresses had been removed, and the foundation had stood for 6 years now without any further incident.

On the subject of spacing of diaphragms, all those who had studied this question from the theoretical aspect, agreed on the fact that they could be reduced to a few only in number per span.

Regarding **Shri E. P. Nicolaides'** query on the economy of transverse prestressing, this would depend on the method of calculating slabs. If they were designed on the basis of the elastic theory, the spacing of cables became absurdly small, compared with what the tests proved to be necessary. With 40-ton cables and 7 in. slabs, one cable every 4 ft or 4 ft-3 in. was generally enough; under these conditions prestressing of slabs would afford economy and safety. The case of Coleroon on this point would be discussed in Shri Nambiar's Paper.

Regarding the statement that live loads in France were slightly greater than in India, there might have been a confusion. The standard vehicles considered in France were 6 wheeled cars of 25 tons; for a bridge of the width of Coleroon, four such cars (2×2) would be applicable. The beams must be designed for this loading or alternatively for the load of a 100 ton tank, or for a uniform load on the roadway of 816 k/m^2 (162 lb per sq. ft.) whichever worse; a load of 400 k/m^2 on the kerbs (80 lb per sq. ft.) was to be added. A co-efficient of impact on all these loads was to be added. This information would allow comparison to be made between the two loadings.

He did not agree with the remark that if only 1 per cent of beams would crack, due to very thin webs, this would not be very significant. Of course, the figure could be much lower. Anyhow, all precautions must be taken to prevent practically any risk of cracking; for this reason, knowing now better than some years back the behaviour of slabs, the transverse spacings of the main beams had been progressively increased, allowing thus an increase in the thickness of the webs without increasing the weight of the bridge, but on the contrary reducing it. He thought that this was the correct procedure. Reference on this subject might be made to his Paper on "Long Span Prestressed Concrete Bridges" previously mentioned, read before the Institution of Civil Engineers.

As for the weights of beams, he agreed that too heavy weights would result in increasing the difficulty of launching. He considered, however, that upto 100 tons launching could be achieved relatively easily, and this would correspond to a suspended span of some 120 ft where the type of bridge according to Fig. 2 was adopted.

On the query of stability, in the event of destruction of one span—this being a military aspect of the question—it was a matter of the ratio between the short span (longitudinal distance between the two piers) and the long span. A ratio of 1/4 appeared to be enough to ensure this stability.

Discussion on

"General Report on Road Research in India"*

Tuesday, 14th May 1957

Shri P. L. Varma (Chairman) called upon Shri S. R. Mehra to introduce the Report.

Shri S. R. Mehra in his introductory remarks stated that the idea in having a special session set apart for discussion of research work done in the country during the year was twofold. Firstly, the discussion at the session would bring out important points emanating from research. Research workers would benefit by the experience of others and correct themselves and avoid duplication. Secondly, the discussion would bring about the proper type of approach between the points of view of the research workers on the one hand and the construction engineers on the other. This would naturally accelerate the application of the fruits of research thus raising the quality of work and promoting economy and expeditious execution.

At the request of the Indian Roads Congress, the Central and State Governments and other organizations had sent more research workers to this session. In view of the usefulness of the discussion, it was hoped that more and more research workers would participate in the discussions in future. It was obviously not possible to discuss the whole research work done in the country in 3 hours time. Therefore, the procedure which was followed in International Conferences, where there was a large number of Papers to be discussed, had been adopted.

The General Report was no doubt brief. The whole subject of highway engineering was divided into heads and sub-heads according to international practice and the entire information available on research work done during the year was given. At the end of each sub-head some salient points were given to encourage discussion but it was not the intention to confine discussion to those points only.

A discussion on different sections of the "General Report on Highway Research" ensued and the comments by different speakers are summarized below :

* Published at pages 355 to 377 of the Journal of the Indian Roads Congress, Vol. XXI-3, April 1957.

RIGID PAVEMENTS

Shri C. G. Swaminathan stated that from the specifications for grouted rigid pavements proposed by the Central Road Research Institute, it could be seen that, for the determination of the consistency of the grout, a flow cone had been suggested. He doubted whether it would be possible to get an exact idea regarding the consistency based on this method. In principle, it appeared to be similar to the orifice viscometers that were adopted in the field of bitumen technology. He desired to know whether there were any other methods by which this consistency could be determined in a more exact way since a grout could not be considered to be a simple viscous fluid.

Shri N. S. Bawa agreed with Shri C. G. Swaminathan that the flow cone had certain defects. The possibility of employing apparatus at present being used in the case of binders, i. e., rotating vanes which would be affected by the segregated sand, was being examined. But the study had not been started so far. Further investigations on vanes rotating in the grout to find out whether there was segregation of water or not would be made and the results reported next year.

Shri K. F. Antia felt that it was good, that the possibilities of grouted concrete pavements had been indicated, among salient points. But he would like to make another suggestion which was entirely from the point of view of economy. It related to the question of investigating the possibilities of lean concrete or rolled concrete pavements. By this he meant mixes as lean as 1 to 14 or so.

This type of mix had been adopted in some places and he had seen it himself in one of the satellite towns near London where it had been used not as a pavement but as a base course and, to his knowledge, had given very satisfactory results. The underlying object was simply that one could save considerably on cement provided the concrete could be compacted adequately. In the case mentioned by him the concrete was compacted by roller and the idea was to mix the concrete with very little cement and fairly low proportion of water.

An experiment was carried out by the Bombay P.W.D., about two years ago on the Bombay-Goa road. He was, however, not aware of the results and whether they were satisfactory. But even if they were not satisfactory he thought it was worth while to make further investigations.

Shri K. K. Nambiar stated that Shri K. F. Antia had referred to lean concrete base with surfacing on the top. He

himself had made a comparative study of cost of this type with the usual type of construction in Madras and had found that the cost was more or less the same as W.B.M. There might be places where lead for stone was perhaps higher than that in Madras and the cost might not work out cheaper in such places. But he thought the lean concrete base with dressing on top had possibilities worth investigation. Reference had also been made in this Report to rolled concrete. An experiment with this type of construction was made in 1937 and it was repeated about four five years ago. The results had been very satisfactory. The only point to be remembered about rolled concrete construction was the fact that on steep slope the length that could be rolled before initial setting took place was limited. In the approaches of Coleroon bridge, with a slope 1 in 30, this difficulty was experienced. A sizeable length had to be taken for rolling so that about 150 to 200 ft length could be spread for being rolled before initial setting took place.

The metal had to be spread and if the slope was considerable the length had to be very short. In the case of rolling, a certain length was needed for the roller to go forward and backward and so that was the main difficulty. A batch mixer was also necessary.

Shri R. N. Dogra stated that the previous two speakers had referred to rolled concrete. In Denmark, it was used not only for a base course but also as a top course with surface dressing on it. The condition of the surface dressing was satisfactory. The rolling was done within half an hour of the time of mixing: no difficulty was found in rolling. The concrete was then allowed to mature before surfacing was given on the top.

The subgrade had to be rolled very carefully. Any variations in the subgrade were likely to affect rolled concrete and, therefore, it was to be ensured that the subgrade was rolled to a uniform density.

Another type of pavement that had been used in Punjab in recent experiments consisted of bricks with the joints filled with concrete, but without a concrete top, with surface dressing on it. This road was constructed somewhere in 1935 and was found in satisfactory condition.

Shri P. J. Jagus observed that in the research connected with the design of rigid pavements, the correct evaluation of temperature stresses played a very important part. According to the procedure to be adopted by the Central Road Research Institute for the measurement of temperature gradients in concrete pavements, a number of stations with almost identical variations of temperature had been included. This duplication of observations should be avoided.

He also felt that the period of observations on temperature variations and temperature differentials should be increased from three days to a fortnight and preferably a month and the selection of the month should be made on the basis of past meteorological reports as to which month in the year would generally have the most severe temperature variation at that station. The scope of the work would be maintained within a reasonable magnitude, in spite of this increased observation period, as the number of stations at which the readings would have to be taken would get reduced.

In addition to the warping stresses due to temperature and moisture differentials, the overall changes in the volume of the slab due to temperature variations from season to season were also very important. These variations would cause elongation and shrinkage of the pavements depending upon the temperatures prevailing during construction which, in turn, would affect the design of the slab, particularly the spacing of the joints. One phase of the study undertaken by the Central Road Research Institute should also be devoted to this investigation.

Shri Jagus said that grouted concrete method by which nearly 25 miles of roads had been laid in the country showed a definite saving in cost of construction over the conventional premix method. The economy would be still greater if the size of the work undertaken at a time was large enough to justify partial mechanization.

Referring to Shri Swaminathan's remarks with regard to the method of measurement of the fluidity of the grouts and the use of the flow cone, he said that it had been tried very hard to substitute an alternative method to the flow cone for measuring the fluidity of the grout but without much success. The flow cone as a measuring apparatus might be simple to look at, but it was found very useful in correct measurement of the fluidity. As regards Shri Swaminathan's suggestion for the use of equipment similar to that used in measuring the fluidity of bitumen binders, he stated that a cement grout was heterogeneous in nature, consisting of cement, sand and water. Unlike bitumen binders, there were problems like segregation, stoppage of flow, etc., connected with cement grouts.

He mentioned a very interesting observation made at the Central Road Research Institute. The index of fluidity was the length of flow time through the flow cone. Thus, grouts with

higer water contents flowed quietly giving shorter flow time. However, using fluidity admixtures, (like Cheecol and Lissapol 'N') it was found that the flow time instead of decreasing increased over that for plain grouts with identical cement and water content. It was expected that the investigations in progress would throw more light on this phenomenon in the near future.

With regard to rolled concrete construction, while agreeing with other speakers from the view point of strength of concrete and the economy in cement, he wished to point out that rolled concrete surfaces would not be very suitable for wearing courses as it was extremely difficult, if not impossible, to get a uniformly smooth level surface by the rolling operation alone to avoid the wave like undulations in the surface of grouted roads. Use of vibrating screeds in conjunction with rolling had given better results but here, too, a lot of good judgment was found necessary before satisfactory results could be obtained, as rolling and vibration provided coercion and coaxing respectively of the concrete and these had to be done alternatively to get satisfactory compaction and surface finish. For base course and sub-base construction, however, rolled concrete had undoubted superiority over conventional specifications.

Speaking on the work done on pozzolanas, he said that the findings of the Central Road Research Institute research work done so far were very valuable because they had revealed certain gross misconceptions regarding the selection of soils and proper manufacture of surkhi therefrom. The most important finding was that the soils which were generally suitable for brick making were not necessarily suitable for surkhi manufacture. The sandy fraction in brick making soils which ranges in percentages from 10 to 25 was totally inactive from the point of view of the activity of surkhi. It was only the clay constituent of the soils which would contribute to the pozzolanic activity when calcined. Besides, the degree of activity varies substantially from one type of clay to another and also with the burning temperatures. Generally montmorillonite and kaolin clays gave highly reactive surkhi at burning temperatures varying between 600 to 800°C. Burning above or below this optimum temperature range would cause a reduction in the activity leading to a positive disadvantage.

He then referred to the problem of alkali aggregate reactivity and its inhibition in concrete construction, the use of solid and liquid membranes for curing as a substitute to conventional wet curing methods. A Paper on alkali aggregate reactivity had already been published in the Road Research Bulletin No. 3, of the Indian Roads Congress. It was apprehended from the work done so far that the general American opinion

on the high alkalinity of the cement being the chief source of trouble might not be totally correct. Study on this fundamental aspect involved observations on the effects of varying alkali contents simultaneously with aggregates of varying types and reactivities. On the applied side, answers were also being found regarding types of inhibitors which could be suitably employed for counteracting this reaction.

Shri S. R. Mehra said that with regard to lean concrete it might be worthwhile in doing some research work on the use or replacement of sand in the lean mixtures with soil because for quantity and strength it was likely that with suitably graded soil mix much less cement would be needed than otherwise for equal strength. The second idea that followed from this was whether, instead of using stone in the lean mixes, where stone was expensive, an alternative material like moorum, laterite, etc., where available could be used provided sufficient excess of mortar was used to surround the soft aggregate in order to protect it from crushing. A certain amount of research in this direction might lead to useful results.

He agreed with Shri Jagus that observations of temperature variations on rigid pavements should be taken over a longer period than 2 to 3 days at certain selected stations.

In regard to surkhi as pozzolana, he thought the subject was of so much importance to the country that as many research stations as possible should do work on this aspect of the problem. A certain amount of basic research work had been done in the Central Road Research Institute with a view to understand what were the fundamental reactions that brought about pozzolanic action and what were the fundamentals involved in selecting soils and fixing burning temperatures to produce most reactive surkhis. The aim was that in course of time it should be possible for small industries to be set up all over the country for producing surkhi scientifically. Before that could be done, it was necessary that the methods of selection of soils and burning them should be simplified in such a manner that small scale industries could intelligently use temperatures and produce surkhi which when mixed with cement in proper percentages would give the required strength and result in economy.

He then referred to thin concrete pavements and their place in road economy. A fair amount of experience on this type of construction had been gained particularly in the U.P. and in order to decide as to whether research work should or should not continue on this particular aspect of concrete road construction he would be glad if members could give some more information on the subject.

Shri M.S. Bisht stated that many miles of 3 in. thick C.C. slabs had been laid in the various parts of Uttar Pradesh. They behaved satisfactorily for several years but on account of increase in total traffic as well as weight of individual vehicles these slabs were found to develop cracks as a result of crushing of the subgrade material. 3 in. thick slabs were, therefore, not sufficient for present day loads and a minimum of 4 in. thickness would be required.

Brig. S. K. Bose stated that as temperature in concrete was definitely related to the modulus value of concrete pavements, it would not be possible to obtain rationalized data if the measurements of temperature differentials were done in respect of existing concrete pavements. It was desirable that ideological conditions should be obtained for such studies. These could not be properly carried out on existing roads which were already subjected to heavy traffic and moisture conditions, etc. Nearness of the field to the laboratory for such a study was one of the important factors.

He recommended that a draft specification should be evolved and the various research stations be entrusted with its study and they should work more or less on uniform basis. Unless that was done it would be very difficult to correlate the results. He also suggested that reasons for developing of cracks in concrete roads all over the country should be studied.

Referring to thin pavement, he stated that it could not be anything more than a wearing course of 3 in. or 2 in., and whenever it had to act as a pavement, it was bound to fail.

From the investigations that were being carried out, he had found that where there was subgrade of low bearing capacity, it was more advantageous to have rigid pavement. On the other hand, where there was hard surface, say, 13 in. thick moorum, it was useless to put any concrete because full advantage of it would not be taken. So he suggested that some criterion should be fixed for deciding the type of surface to be adopted on a road.

Shri C. C. Bagchi stated that even in the case of a thick pavement it had been found that where the traffic was very heavy the pavements had given way. It was, however, for the research workers to study whether the breaking was horizontally or vertically.

He then pointed out that the two stretches, one of rolled concrete and the other of grouted concrete, laid by the P.W.D. near Lucknow Railway Station had failed. He was, however, not aware of the reasons of this failure.

FLEXIBLE PAVEMENTS

Shri C. G. Swaminathan stated that experimental work on bituminous surfacings carried out in the Central Road Research Institute so far indicated that the high viscous binders were better in certain respects than the low viscous ones. A series of shear tests on pre-coated aggregates showed that the 30/40 bitumen gave higher values than the 80/100 grade. Also, in the design of a sand-asphalt mix, the mix with a 30/40 bitumen had higher stability than the one with 80/100 bitumen. He felt that from the workability point of view, if it was necessary to have a low viscosity initially, a hard grade of bitumen could be fluxed or cut-back with a suitable solvent so that in course of time, with the loss of volatile fractions, the high viscosity of the bitumen could be made to play its part by affording an increased resistance to displacement.

Some laboratory investigations had been carried out in the Central Road Research Institute on the stripping of binders from aggregates. He felt that a proper test method for the evaluation of stripping was needed to be developed. The immersion tracking test that had been developed in the Road Research Laboratory, Harmondsworth, gave reliable results. From the qualitative test that was conducted in the Central Road Research Institute, it was found that the use of a high viscosity binder was better from the point of view of stripping, once the aggregates were properly coated. It was also found that the presence of dust and moisture in the aggregates was injurious. Limits for flakiness, etc., had also been studied.

The problem of binder-aggregate relationship for surface dressing work was also in hand in the Institute. The proper size and quantity of aggregates to be used had been worked out. It was found that about 40 lb of bitumen should prove quite satisfactory when used with an aggregate quantity so as to yield a single stone layer.

There appeared to be two different opinions regarding the relative merits and demerits between the two coat surface dressing and the premix carpet. In his opinion, the superiority of the one over the other depended upon the nature of the aggregates. If the aggregates were hard and tough, the premix carpet was likely to behave better. However, there can be no doubt that a well-designed dense grade premix would be the best.

Among other problems that had been taken up for study in the Institute, the identification of bitumens based on absorptiometric analysis was one and it was hoped to use this method for the study of weathering and oxidation effects on road tars.

Shri K. K. Nambiar laid emphasis on the need for uniformity in the nomenclature of pavements for the whole country.

He would not like to enter into the controversy of two coat surface dressing versus premix carpet, as what might be suitable at one place might not be equally suitable at another place. However, he might say that two coat surface dressing was quite good.

With regard to Shri Swaminathan's observations about experiments with 30/40 asphalt graded mix giving better results than ungraded mix, he would like to mention that in this comparison two variables were involved and so definite conclusions could not be based on that. He had been keeping in touch with the developments in California and the engineers there had expressed the opinion that softer aggregate should be used for the premix carpet. But now the tendency was to use hard stone with 50/60 asphalt. Unless the experiments were identical with only one variable, results could not be quite conclusive.

Shri Sujan Singh stated that the Indian Roads Congress had already done a good deal of work on bituminous treatment of wet aggregates, and the data already available should be taken into account when doing further research work in this matter.

Regarding the surface dressing report, Shri Swaminathan had particularly laid stress on the shear stability test done for surface dressing. He felt that this was not a right type of test for surface dressing. Shri Swaminathan had stated that he had got good results with 80/100 bitumen. But if a cut-back was used, he was sure none of the cut-backs would come up to Shri Swaminathan's standard because cut-backs being more fluid would not stand this test at all. Taking bituminous emulsion where the peneteration was round about 200, he was afraid none of them would stand shear stability test. Harder grades would give better shear stability. Therefore, he suggested that if this particular test was to be retained then other factors should also be taken into consideration when taking any decision. From his experience on a stretch of road in Lahore, he would suggest that in all laboratories tests should be done under three different temperatures.

Prof. O. W. Mintzer suggested that more attention be given to the trial of certain new techniques and specifications. Once the in-situ-performance results of the new ideas had been evaluated, road designs and specifications, particularly applied to the pavement, could be prepared on a sound engineering and economic basis.

He then suggested a number of flexible pavement problems that could be solved by means of test roads.

Viscosity of asphalt. Normally Indian specifications required use of 80/100 penetration type asphalt regardless of temperature or traffic requirements. It is believed that the 40/60 or 60/80 penetration type asphalt would be better for the areas of high intensity of traffic and high range of temperatures.

Stability of bituminous aggregate mixtures. Research outside India had shown that in a given bituminous aggregate mix, the more stable and better field-performing-mixes were those which had larger voids in the given mix filled with small aggregate sizes. The addition of mineral filler had been found to increase the mix stability. No doubt these ideas were well known and applied wherever it was possible under Indian conditions. However, he would like to suggest that where conditions of traffic, climate, soil and drainage warranted, a study of the influence of aggregate-sizes and voids should be tried in new construction as a test road. In addition, laboratory testing should be applied first to determine the mix design best suited from the point of view of availability of local meterials. The bituminous aggregate mix should then be applied in the test road. The pavement performance could then be recorded for a few years, following which proven good ideas could be incorporated into State specifications.

Waterlogging. Research was justified to determine the design and specifications of roadway for waterlogged conditions. The Central Road Research Institute had offered some valuable suggestions. However, since each State had its own individual problems, some new techniques should be tried, whenever possible, both in new construction and repairs of old heavily travelled roads. He then made the following suggestions for trial. (a) Use a bituminous membrane and wrap up the entire roadway with a membrane of materials suitably treated with asphalt, and (b) Construct the soling course using 6 in. to 9 in. size crushed stone, hand laid and rolled. Fill the voids with smaller size aggregate and build up a 9-inch layer of Telford-like base course.

If any of these suggestions were tried in the Punjab, he desired that the Post-graduate students of the Punjab Engineering College should be associated with the work.

Shri J. S. Narasimham stressed the necessity of having State laboratories for checking the specifications adopted.

Shri S. A. Swami stated that while bitumen was the residue-product in the distillation of petroleum, tar was pri-

marily a product of condensation, constituting the volatile, oily decomposition obtained in the pyrogenous treatment of bituminous and other organic substances. Hence bicumen and tar have fundamentally different characteristics, even though they look alike.

Tar was more susceptible to temperature changes and its oil fractions evaporated quickly on exposure to atmosphere, whereas bitumen was more stable to temperature changes. However, tar had the advantage that it required less heating for construction purposes. Hence it was essential to take great care in the choice of binder for road construction from the point of view of climatic, traffic and other considerations.

WATER-BOUND MACADAM AND GRAVEL ROADS

Dr. H. L. Uppal stated that there were many kinds of gravels in India which were not being made use of. A study was carried out some time back and it was found that, if suitable methods were adopted, a stable gravel road could be constructed which would last for many years. There were areas in West Bengal and Cooch-Behar where gravel was available in plenty and certainly with the help of laboratory testing it should be possible to make use of such gravel in road construction. The strength of gravel roads, however, depended upon the interlock of materials. It was, therefore, very essential that the whole material should be properly graded right from coarse to fine.

Regarding the use of low grade aggregate like brick bat in place of stone in water-bound macadam, some work had been carried out in U. P. and he would like some light to be thrown on the subject.

Some of the methods that had been suggested were not found very economical and a new and ingenious methods had, therefore, to be developed to suit the local conditions.

Shri H. G. Verma, referring to the use of low grade aggregate in water-bound macadam, stated that so far the standard practice had been to use stone ballast for the base course. In U.P. plains, stone quarries were located at considerable distances. The cost of stone worked out to Rs 100 to 110 per 100 cubic ft. For this reason it was not possible to modernize a large number of miles. They, therefore, had been examining the possibility of finding an alternative for stone ballast and during the last 4 or 5 years they had been experimenting with overburnt brick ballast. Overburnt brick ballast had been used in several miles and it had proved quite successful.

The only care that had to be taken was that bricks should be really overburnt and the time between consolidation and laying of first course should be only about 1 to 2 months, and between first and second course it should be three months. During the last six months they had been experimenting with the manufacture of high class bricks. In the laboratory also they had been able to manufacture bricks up to the strength of 10,000 lb per sq. in. and some of them gave as good a strength as 12,000 lb per sq. in. They hoped to manufacture bricks of about 10,000 lb per sq. in. by controlling the soil as well as the heat.

Shri N. Das Gupta invited attention to Paper on "Maintenance of Gravel (Moorum) Roads Under Heavy Traffic"* by B. B. Gupta. The method of road construction was also an alternative method for use of cheaper material for road construction. The gravel (moorum) used on the roads mentioned in that Paper was of various kinds, ranging from the fine grained quartz variety with a large proportion of clay, to pure laterite moorum.

It was reported after one year's use that this surfacing was standing up to the trafic conditions. Such work could be carried out at a low cost. He, therefore, desired this matter might be looked into and the question of carrying out further experiments under similar conditions might be considered.

Shri S. R. Mehra before giving his comments wanted to clarify one point. He stated that the Central Road Research Institute had no intention to lay down any definite directions emanating from the results which had been obtained. The idea was that the minds of the various research workers should be pooled together so that they could benefit mutually from this procedure. So far as laying down of standards or policies was concerned, the idea was that this should be done by the Indian Roads Congress in a manner acceptable to all those who were going to use them.

With regard to the efficiency of the vibration roller, the roller which was tried out actually was an 8-ton roller. It gave good results. A 10-ton roller also gave good results on water-bound macadam and the vibration roller was no improvement on the other rollers available in the country. No recommendation had been made for and against it.

The method of assessing the efficiency of water bound macadam crust by measuring the angle at which the stone lay in

* Published in the Journal of the Indian Roads Congress, Vol. X-2, pages 211 to 217.

the compacted crust had been brought forward, and it was felt that this method of assessing the quality of water-bound macadam could be employed as a control to improve the quality of the work.

Regarding gravel roads, there were deposits of gravel in various concentrated areas in the country and it was known that gravel roads were durable roads and were in vogue not only in this country but in many other countries also. So there seemed to be no reason why gravel which was available as a cheap local material should not be used as a road building material specially when some success had been achieved in this direction.

With regard to low grade aggregate, the intention was to refer to those locally available aggregates which were popularly considered as unsuitable for road construction because of their being classed as low grade aggregates. For instance, some types of laterites and moorums, according to the physical tests laid down, satisfied all the requirements for stone metal used in water-bound macadam. There was no reason why they should not be used in first class road construction just because they happened to be called low grade. The idea was to see by experimentation and research which of the so called low grade aggregates could be used as regular road construction material.

Shri M. S. Bisht pointed out that brick ballast was no longer an experimental material in the U.P. It was one of the standard materials in use for improving the road surfaces where stone was costly.

There was nothing to be surprised if they had obtained a strength of 10,000 lb per sq. in. for bricks made in the laboratory. He had been told that in Holland 60 per cent of the road surfaces were made with overburnt bricks without any topping. This had given them a clue and they were following this method. Of course, practical use had to be made of the laboratory work and so they had started a pilot kiln to burn bricks giving a strength of 6,000 lb or more per sq. in. Bricks had definitely proved a good road building material where stone was costly.

Shri C. C. Bagchi stated that his experince showed that it was economical to use good kankar as a binder instead of moorum for consolidation of water-bound macadam roads.

Shri Bhupinder Singh stated that at present proper attention was not being given to the grading of soil gravel mixture in road construction. Therefore, after a few repetitions of loading,

as the surface course got dried, the lighter soil particles were flown away by the action of moving wheels leaving behind almost single sized gravels. Density would become very poor as a result of the increase of void ratio. Bearing capacity of the mixture decreased and hence the surface would be unable to withstand heavy loads. Ravelling would occur resulting into big pot holes. Maintenance of such roads would result in more expenditure. Hence it was necessary to have a scientific control on the construction of soil-gravel roads in the country. Shri Bhupinder Singh further stated that the principal properties affecting the bearing capacity of compacted granular materials were internal friction and cohesion. Internal friction was provided by gravel while cohesion was provided by clay fraction.

Fuller had shown that relatively high dry density of a soil mixture was obtained when its particle size distribution followed a certain law, i. e.

$$\text{Per cent passing any sieve} = 100 \frac{\text{The Aperture of that sieve}}{\sqrt{\text{The size of largest particle}}}$$

But the law does not provide good proportion of the material passing No. 200 mesh and hence no sufficient cohesion for a stable mixture. So an adjustment had to be made for this purpose. Proportioning of the material was a most important factor for such roads.

The method of proportioning of such materials as suggested by the Road Research Laboratory, London, was as follows:

(1) Not less than 10 per cent should be ratained between each pair of successive sieves, excepting the largest pair.

(2) The two smaller sized materials, viz., 3/8 and 3/16 in., might have upto 35 per cent stone not larger than $1\frac{1}{2}$ in.

(3) The limit passing No. 36 B. S. sieve or 40 U. S. Std. sieve was:

For bases—plastic index 5 to 7.

For surfacing—plastic index 8 to 10.

SOIL ROADS INCLUDING STABILIZATION

Shri K. F. Antia observed that one way of obtaining low-cost roads was to have stabilized soil base with some surfacing which would withstand the bullock-cart traffic. Intensive research was, therefore, necessary to achieve satisfactory results in this direction.

Shri A. K. Deb commenting on stabilization with black cotton soil stated that, in 1953, an experimental stabilised black cotton soil road was constructed in the CME Estate in Kirkee. The road was of a total length of 2000 ft and divided into several strips having different specifications as given below :

Strip	Length	Subgrade	Base course	Surface course
A	500 ft	Moorum	Moorum (filling 2 ft-6 in. to 1 ft)	Stabilised moorum 5″ (10% cement+2% lime)
B	350 ft	Clayey moorum	Moorum 4 in.	Stabilised moorum 5″ (10% cement + 2% lime)
C	640 ft	Black cotton	,, 6 in.	Stabilised black cotton 5″(14% cement +5% lime)
D	260 ft	do	Black cotton 4 in. (dry rolled)	Black cotton/moorum(80 : 20) 5″ (12% cement+3% lime)
E	160 ft	do	Black cotton 4 in. (dry rolled)	Stabilised moorum 4″ (10% cement+2% lime)

The black cotton soil used for the stabilised surfacing was generally uniform in its physical characteristics. Mechanical analysis and index limits are given below :

Gravel per cent	> 2 mm. – 19 per cent	Liquid limit – 55
Coarse sand per cent	>0.2 mm. – 9 per cent	Plastic limit – 35
Fine sand per cent	>0.02 mm. – 11 per cent	P.I. – 20
Silt per cent	>0.002 mm. – 21 per cent	
9 Clay per cent	<0.002 mm. – 40 per cent	

Crushing strength of 200 gm cylindrical specimens of black cotton soil+14 per cent cement+5 per cent lime, compacted at O.M.C. in the Abbot compacting cylinder after 7 days damp curing gave a value of 305 lbs/per sq. in.

The construction of the road was completed on March 15, 1953. Mixing operations were done by hand as use of existing plant, viz., sieman pulvimixer and spike teeth of motor grader were not found very satisfactory with this soil. Compaction was done by an 8-ton smooth wheel roller. Curing was done for 7 days by keeping a cover of wet earth on the surface. No black top was provided and the road which circumscribes a residential area and bears only a limited amount of light traffic had been in commission since March 1953.

The road surface was reasonably good during the period of 1953 monsoons, though little heaving was perceptible in strip E. However, after the monsoons, cracks began to appear on the surface and the condition of the strips in May 1954, still not provided with a black top and kept continuously open to traffic, is given below.

Strips	Condition in May 1954	Remarks
A	Very good	Only slight abrasion has taken place.
B	– do –	– do –
C	Fair	In few places small longitudinal cracks have developed. Hair-cracks in large Nos. have also developed, but they appear to be harmless and do not show up unless it rains. Surface abrasion has taken place.
D	Poor	Longitudinal cracks of $\frac{1}{2}$ in. — $\frac{3}{4}$ in. width and sometimes 20 ft – 30 ft long at the surface have developed. Otherwise hard and good for fair weather traffic. Surface abrasion is also noticeable.
E	Poor	– do – Abrasion has been more prominent in this strip as well as the appearance of the cracks. During monsoons, sufficient ingress of water took place in the subgrade due to lack of proper surface drainage. This may be the reason for the heaving noticed in this strip during the monsoons. This portion presents an undulated surface in appearance.

It would be seen on comparison of the results of C and D that the poor behaviour of D was most probably due to the heaving of the black cotton soil below the stabilised surface course and there was not much fault to be found with stabilised layer itself which behaved fairly well. Both the strips D and E were re-done in 1955 putting a moorum base course and the entire road was provided with a black top.

From the above experiments, he felt that, so far as the stabilisation of black-cotton soil for road purposes was concerned, there was no objection to the use of a cement + lime stabilised surface course preferably with a wearing course on top, but there must be a suitable base course of adequate thickness, say, 1 ft or more, depending on the importance of the road between the black cotton soil subgrade and the surface course consisting of moorum or some other granular, non-heaving type of soil.

TRAFFIC AND TRAFFIC SAFETY—GEOMETRICS, ECONOMICS, STATISTICS AND SAFETY

Shri T. S. Khanna while laying emphasis on traffic engineering studies stated that research work in this field was being carried out by the Central Road Research Institute with a view to evolve standards to suit Indian conditions.

He also pointed out that there could be no doubt about the practical application of research in this field as conclusions were reached only after careful field observations and field trials.

He further pointed out that since the traffic conditions were over changing, there would be more and more demand for research in this field. He, therefore, suggested the need for setting up traffic engineering executive units that might give traffic problems the deserving attention and after properly understanding them try to apply the results in practice.

Prof. O.W. Mintzer stated that all road improvements required financial support and the improvements were generally justifiable on the basis of the public requirements, i.e., the road user. Rail roads obtained financial support, and the improvements were justified principally because there was a return on the investment. Highway projects must also show a return on the investment for a given improvement. However, under present conditions of accounting for road funds it was difficult to show a return on the investment, such as could be done in the case of railroads. Therefore, economic surveys were required. The surveys should show that given proper road links and other road improvements, agricultural products were brought to the market with a minimum loss and with a maximum of turnover into cash accruing to the farmer.

Shri C. L. N. Iyengar stressed the need for laying down standards for the design of roads for pneumatic traffic under Indian conditions.

He also laid stress on the subject of road safety which he considered was an equally important study. So far as traffic was concerned, study had to be carried out to correlate it with the width of road. This study might sound very simple but it was a very complicated study. In the U.S.A., it had taken 30 years to complete it. Mixed pattern of traffic made it even more complicated.

Another study being carried out in other countries was on scientific aspects of road accidents. Many accidents occurred and generally the drivers were blamed for them. But quite possibly in many cases accidents occurred due to the fault of the road engineer who designed a particular road. In England, the police reports stated that only 1 per cent accidents took place due to defective road design and 90 per cent occurred due to drivers' fault. But when an engineer had studied the problem, his opinion was almost the reverse.

Shri Iyengar also added that research in traffic engineering had its economic value. If any aspect of traffic engineering was studied from the economic point of view, the results would be convincing.

Shri T. R. Sehgal stated that there was a close relationship between traffic engnineering and economics. In traffic engineering, efforts were directed to achieve economic benefits by savings in operational cost and human sufferings. The data collected was essentially the study of human behaviour on roads. Thus traffic engineering devices served as a means to achieve economic ends.

He then explained the work in hand in the Traffic Engineering Division of the Central Road Research Institute. One aspect of this work related to the design of cycle tracks. Observations had been made about the behaviour of cyclists when negotiating different gradients uphill in order to determine the limited and unlimited lengths of gradients suitable for cycle tracks. The other important aspect of the study related to the volume of traffic that warranted the layout of separate cycle tracks. This study was guided by two factor, viz., (1) the speed of cars when cyclists were using the carriageway and also when cyclists were

diverted to the cycle tracks during peak-flow hours of traffic, and (2) the percentage of motor vehicles using the opposite lane when cyclists were using the carriageway.

Lastly, he stated that the subject of highway economics was also being studied taking into account not only the annual road cost but also the annual operational cost.

Shri K. K. Nambiar stressed the need of research with regard to traffic capacity.

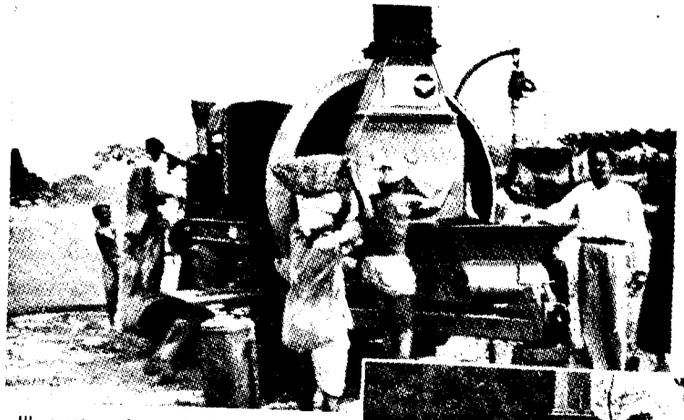
CONCLUDING REMARKS

Shri P. L. Varma (Chairman) in his concluding remarks stated that the foundations of research had been laid and he had found from the discussions that they had been well laid. He, however, emphasised the necessity of quick application of results of research for the benefit of the people at large.

The second point was that accelerated research should be done in waterlogged areas. For the last 5 to 6 years, the Punjab was becoming a wet region. Whatever might be the causes, in certain areas the roads which never experienced trouble before were now waterlogged and every year floods played havoc.

The third point which he thought very vital and important was about the evolution of right type of specifications suitable for particular cases.

The fourth point was about the selection of good personnel for research. In this connection he referred to the method adopted in France for selecting personnel for highway research. A little extra work was taken from the engineering students during the peried of their education for three years. In the third year either they got used to it or they got out. And in the fourth year an interest was created in the minds of the university students towards research work. This was one of the methods of selecting the right type of men and minds for research.



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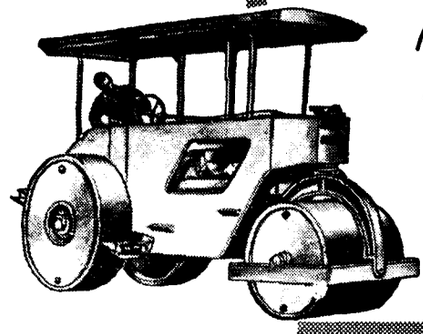

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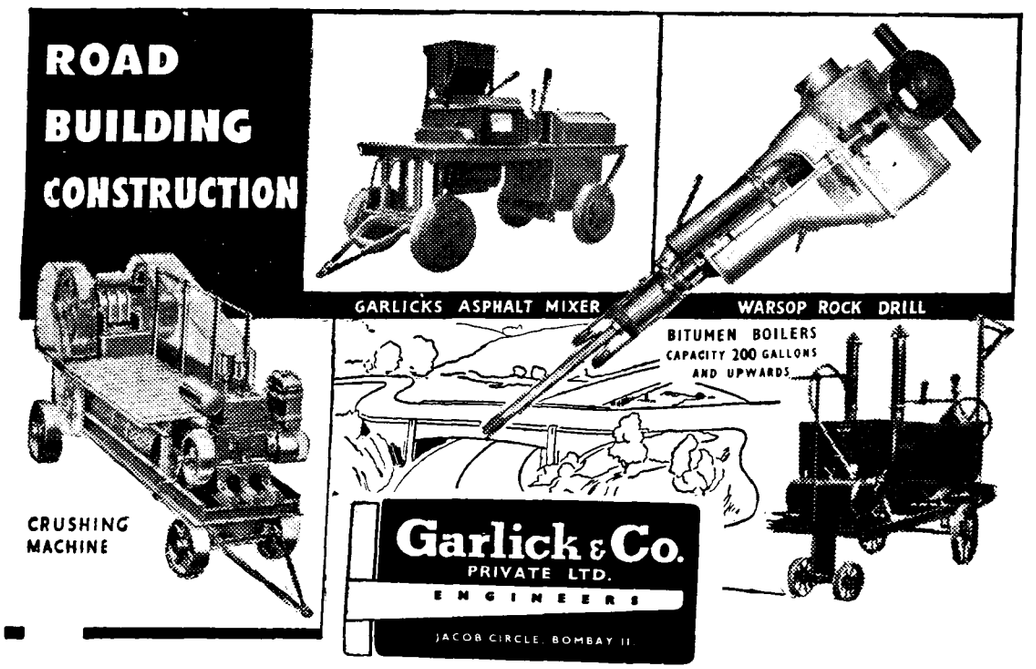

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