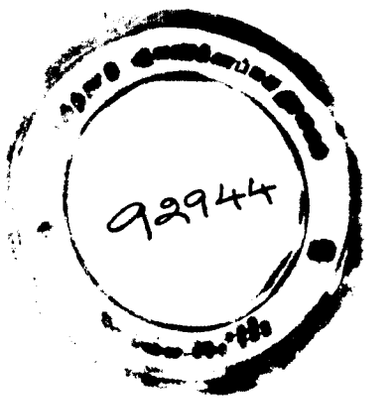
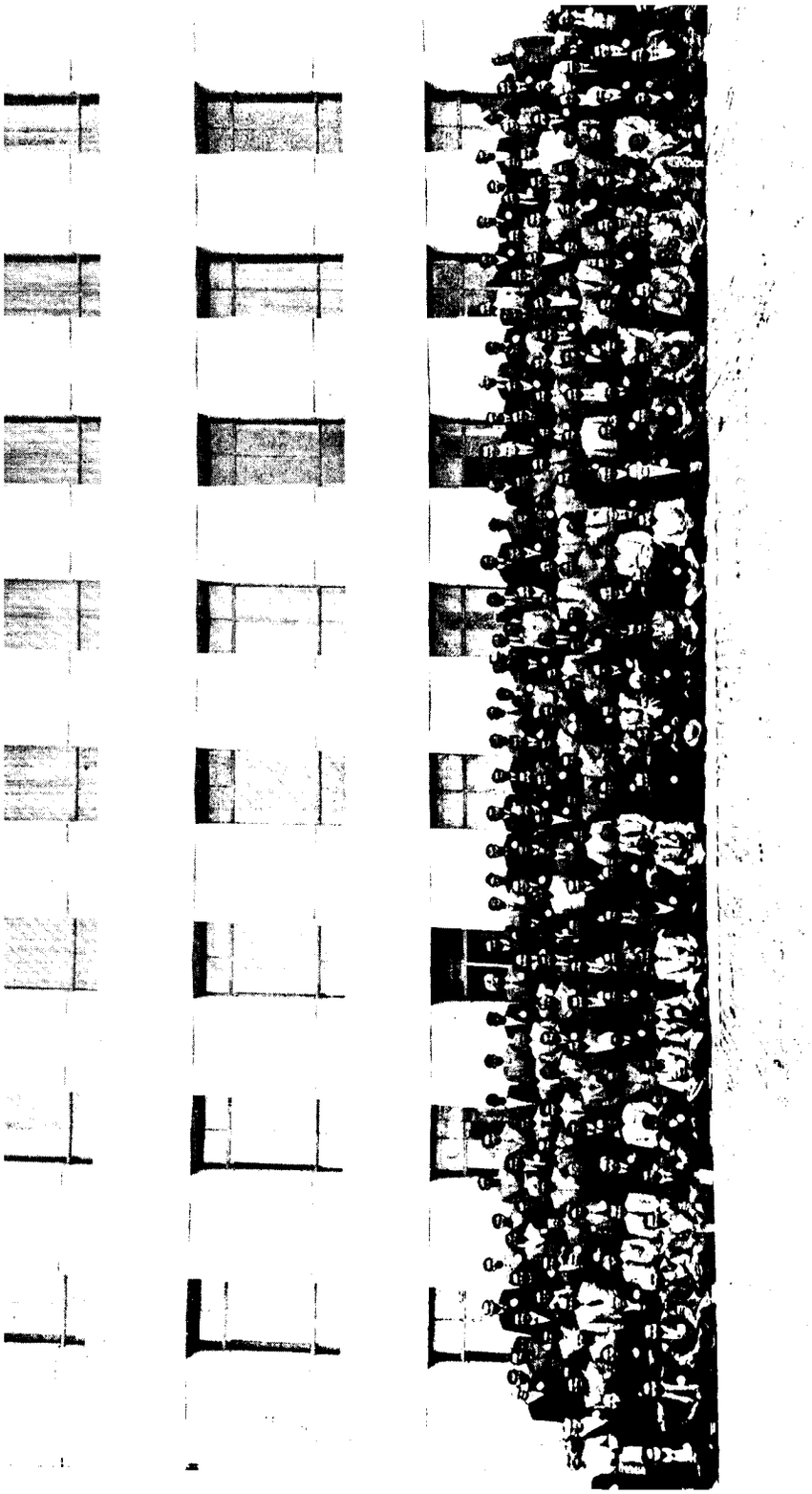
The Indian Roads congress.

LIST OF MEMBERS OF THE COUNCIL FOR 1957–58

1. F. P. Antia
2. M. P. Apte
3. A. D. Dhingra
4. E. A. Nadirshah
5. P. D. Shivdasani
6. L. C. Verman
7. I. C. Desai
8. Shoba Ram
9. R. N. Dogra
10. S. K. Ghosh
11. R. K. N. Iyengar
12. H. G. Verma
13. N. Durrani
14. B. Prasad
15. W. X. Mascarenhas
16. D. N. Gupta
17. V. Gopalakrishna Ayyar
18. K. K. Nambiar
19. H. R. Gupta
20. H. Ananthachar
21. B. S. Jootla
22. D. P. Nayar
23. D. N. Endlaw
24. R. C. Roy
25. Brig. S. K. Bose
26. M. L. Nanda
27. S. R. Mehra
28. P. L. Varma
29. H. P. Mathrani





INDIAN ROADS CONGRESS. TWENTY-SECOND SESSION. NEW DELHI. JANUARY 1958.

SHRI M. S. BISHT, President, 1957–58.

Shri Madhab Singh Bisht was born in Naini Tal on April 7, 1903. He received his early education there and later joined St. George's College, Mussoorie. He subsequently joined St. Joseph's College at Naini Tal and from there passed into Thomason Engineering College, Roorkee, in 1922. After graduating from Roorkee in 1925 as an Assistant Engineer he was posted to Sarda Head Works Division, which he joined in October the same year. Subsequently he completed his apprentice period in II Division Sarda and after spending 1½ years in Irrigation Department, he was transferred to B & R Department in April 1927. He remained Assistant Engineer until the end of 1937 during which period he carried out important construction works including remodelling of the Ganges Bridge in 1931.

He was elected as a Member of the I.R.C. in 1937.

As Executive Engineer he was responsible for the construction of many aerodromes during the War period and carried out important Military projects. He was decorated by the then Government for his outstanding work in this connection in January 1944.

He became Superintending Engineer in April 1944. In April 1947 he went with the Second Road Delegation to America where he spent 5 months. On his return he was appointed as Chief Engineer (East) in December 1947. As Chief Engineer, U.P. since February 1952, he has been responsible for considerable Roads, Buildings and Bridge Projects, being executed under his direction.

INDIAN ROADS CONGRESS

NOTICES AND ANNOUNCEMENTS

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

The next General Session of the Indian Roads Congress will be held at Hyderabad in January 1959. The exact dates and programme will be communicated in due course. Members are requested to contribute Papers on any subject connected with Highway Engineering for discussion at the Session.

2. **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.

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

From past experience it is observed that most of the Members send in their contributions at the last moment, when the Congress Office is busy on work connected with the Session. As it takes a long time to get Papers printed in the Journal and as it is desirable that Members should have 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 likely to be carried over to the next year.

4. The younger engineers are particularly requested to contribute Papers which, if required, will be suitably edited by the Indian Roads Congress Office before publication.

5. **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.

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

7. Rules and Regulations for the contribution of Technical Papers and the award of Medals are published on pages 9 to 14 of Volume XXII, Part 1 of the Journal of the Indian Roads Congress —November 1957.

II. NEW ADMISSIONS

LIST OF MEMBERS OF THE INDIAN ROADS CONGRESS ENROLLED FROM 1-12-1957 TO 10-4-1958.

Serial No.	*Roll No.*	*Name*	*Address*
1	2334	B. A. Kapadia	68, Charni Road, **Bombay-4.**
2	2335	G. Ayyaswami	Lecturer in Higher Engineering, College of Engineering, Guindy, **Madras-25.**
3	2336	M. K. Mital	Assistant Engineer, P. W. D., B. & R., **Datia** (Madhya Pradesh).
4	2337	G. Dastagir	Assistant Engineer (H), **Chintapalli,** (Vizag District).
5	2338	M. M. Yussouf	Assistant Engineer, P.W.D., J. & K., **Banihal** (J & K State).
6	2339	M. P. Dhir	Senior Scientific Officer, Central Road Research Institute, Okhla, **New Delhi-20.**
7	2340	K. G. Kale	Executive Engineer, P. W. D., 10, Walkeshwar Flats, Malabar Hill, **Bombay-6.**
8	2341	R. K. Dutta	Sub Divisional Officer, P. W. D., Doboka P. O., **Nowgong District** (Assam).
9	2342	R. P. Srivastava	Assistant Engineer, P. W. D., At & P.O. Madhipura, **District Saharsa** (Bihar).
10	2343	S. M. Mohiudeen	Bitumen Engineer, Burmah Shell, **Madras-1.**
11	2344	Capt. L. V. Rama Krishna	Staff Officer, Planning Section, Army H. Q., Engineer-in-Chief's Branch, Kashmir House, **New Delhi.**
12	2345	A. D. Midha	Junior Engineer, Thatipur Colony, Morar P. O., **Gwalior** (M. P.).
13	2346	V. N. Ramdos Rao	Assistant Engineer, Highways Research Station, **Madras-25.**
14	2347	G. Palanivelu	Junior Engineer (Highways), Highways Workshop, Guindy, **Madras-25.**

Serial No.	Roll No.	Name	Address
15	2348	B. Venkataramaiya	Technical Assistant to Chief Engineer (General), **Bangalore** (Mysore).
16	2349	Dr. M. L. Puri	Senior Scientific Officer, Central Road Research Institute, P. O., CRRI, **New Delhi-20.**
17	2350	R. C. Mangal	District Engineer, P. W. D., **Sultanpur** (U.P.).
18	2351	D. S. Thakur	Senior Assistant Engineer, Bombay Municipality, Mohan Bagan, 60-Khareghat Road, Hindoo Colony, Dadar, **Bombay.**
19	2352	Basavanna Kenbhave	Executive Engineer, P. W. D., **Gulbarga** (Mysore State).
20	2353	B. B. Sarkar	Technical Assistant, Burmah Shell, 24-A, Napean Sea Road, **Bombay-6.**
21	2354	B. Sudhakar Rai	Junior Engineer (Highways), Mudabidri Post, **South Kanara District** (S. India).
22	2355	M. C. Rudraiah	Junior Engineer, Office of the Chief Engineer (General), **Bangalore-1.**
23	2356	N. Madhava Murthy	Supervisor, Office of the Chief Engineer, (General), **Bangalore-1.**
24	2357	H. S. Verma	Assistant Engineer, Govt. of West Bengal, 54, Hari Ghose Street, **Calcutta-6.**
25	2358	A. K. Sircar	Assistant Engineer (W & B), Govt. of West Bengal, Marikpara Road, P.O. Isharpur, Nawabganj, **Dist. 24-Parganas** (W. Bengal).
26	2359	N. C. De	Assistant Engineer, Development (Roads), West Bengal, 66/1, Sashi Bushan De Street, **Calcutta-12.**
27	2360	J. S. Gurnani	Deputy Engineer, P. W. D., 16-A/6, Sion Sindhi Colony, Sion, **Bombay-22.**
28	2361	M. K. Noble	Executive Engineer, Poona R & B Division, **Poona.**
29	2362	P. R. Bellubi	Assistant Engineer, P. W. D., Kumta, **Dist. Karvar** (Mysore State).
30	2363	D. N. Varma	Executive Engineer, P. W. D., **Gaya** (Bihar).

Serial No.	Roll No.	Name	Address
31	2364	T. Sethuramaiah	Assistant Engineer, Corporation of Madras, Ripon Buildings, **Madras-3.**
32	2365	S. A. Balu	Assistant Engineer, Office of the Chief Engineer (B & R), Motimahal, **Gwalior** (Madhya Pradesh).
33	2366	Durga Dutt	Superintending Engineer, C. P. W. D., **New Delhi.**
34	2367	Harish Chandra	Executive Engineer. C. P. W. D., **New Delhi.**
35	2368	Ashoke Sen Gupta	Assistant Engineer, Development (Roads), 153, Mannatha Dutt Road, **Calcutta-37.**
36	2369	K. C. Ayya	Deputy General Manager, Hind Constructions, 8, India Exchange Place, **Calcutta.**
37	2370	P. N. Roy	Executive Engineer, Provincial Division, P. W. D., **Gorakhpur** (U.P.).
38	2371	T. C. Muthukalyani	Technical Assistant to the Chief Engineer, Highways, 32, Harrington Road, **Madras-5.**
39	2372	Manmohan Das Seth	Assistant Engineer, P. W. D., Bridges, **Basti** (U. P.).
40	2373	Jagdish Chandra Tayal	Assistant Engineer, P. W. D. Research Institute, **Lucknow.**
41	2374	Surrendra Kumar Ojha	Assistant Engineer, P. W. D., Bridge Design Division, U. P., P. W. D., **Lucknow.**
42	2375	Suresh Chandra Jain	Assistant Engineer, C. P. W. D., 105, Daryaganj, **Delhi-7.**
43	2376	Jagmohan Lal	Assistant Engineer, U. P., P. W. D., **Shahjehanpur** (U. P.).
44	2377	P. P. Thomas	Assistant Engineer, Bridges Sub-Division, **Mairbkara P. O.** (Kerala State).
45	2378	N. K. Vaswani	Principal, Polytechnic, University of Roorkee, **Roorkee** (U. P.).
46	2379	M. C. Sarvate	Executive Engineer, Yeotmal Division, **Yeotmal** (Bombay State).
47	2380	C. V. Sarma	Municipal Engineer, **Guntur** (Andhra Pradesh).

Serial No.	Roll No.	Name	Address
48	2381	B. K. Panthaky	Drawing Section-in-Chargo, C/o Hindustan Construction Co., Ltd., Ballard Estate, Fort, **Bombay.**
49	2382	J. F. Mistry	Assistant Engineer, Mahavir Swami Pole, Raopura, **Baroda** (W. Rly.).
50	2383	K. Krishnamurthy	Junior Engineer (Highways), C/o. Chief Engineer, Highways, **Hyderabad** (Andhra Pradesh).
51	2384	N. R. Sadarangani	Executive Engineer, C. P. W. D., Services Division, **New Delhi.**
52	2385	V. P. Chaphalkar	Executive Engineer, P. W. D., Roads & Buildings, **Aurangabad** (Bombay State).
53	2386	G. George Jacob	Assistant Engineer, Highways, 5, Racquet Court Lane, **Tiruchirapalli** (Madras State).
54	2387	Harbans Swaroop	Executive Engineer, Sub-Soil Water Division, **16-B**, Havelock Square, **New Delhi.**
55	2388	A. Ethirajan	Assistant Engineer (Designs), Office of the Chief Engineer, P. W. D., B/R., **Gwalior.**
56	2389	Prithvi Singh Kandhal	Junior Engineer, P. W. D., B/R., P. O. Bhadra, **Dist. Sriganganagar,** (Rajasthan).
57	2390	Y. P. Chhabra	Junior Engineer, Design Section, Chief Engineer's Office, Motimahal, **Gwalior.**
58	2391	S. N. Agarwal	Assistant Municipal Engineer, Municipal Board, **Lucknow.**
59	2392	Mohd. Karimulla Khan	Assistant Engineer, P. W. D., Farhat Manzil, Somaji Guda, **Hyderabad Dn.-4** (Andhra Pradesh).
60	2393	A. Suryanarayana	Chief Instructor, Soils, Roads & Airfield School, C. E. Wing, C. M. E., Kirkee, **Poona-3.**
61	2394	R. A. Andiappan	Junior Engineer (Highways), East Street, Rajavallipuram, **Dist. Tinnevelly.**
62	2395	M. Chokkalingam	Junior Engineer (Highways), 55, Luz Church Road, Mylapore, **Madras-4.**
63	2396	N. K. P. Sinha	Assistant Engineer, District Board, **Gaya** (Bihar).

Serial No.	Roll No.	Name	Address
64	2397	A. K. Deb Barman	Assistant Engineer (W. & B.), C/o Sj. Jogesh Ch. Deb Barman, **P. O. Agartala** (Tripura).
65	2398	T. M. Guru Siddaiah	Assistant Engineer, P. W. D., **Bellary** (Mysore State).
66	2399	M. L. Passi	Assistant Engineer (Roads), (Planning & Designs), Chief Engineer's Office, Himachal Pradesh, P. W. D., **Simla-4.**
67	2400	S. C. Jain	Student Engineer, P. W. D. Office, **Muzaffarnagar** (U. P.).
68	2401	Hari Prakash Vyas	Junior Engineer, Bhakra Roads Projects, **Hanumangarh Town** (Rajasthan).
69	2402	R. Siddaiah	Assistant Engineer, **Kolar** (Mysore State).
70	2403	Brij Gopal Sharma	Assistant Engineer, P. W. D. (B/R), Tehsil Bhadra, **Dist. Ganganagar** (Rajasthan).
71	2404	G. B. Jahagirdar	Taluka Officer, P. W. D., Post Chincholi, **Dist. Gulbarga** (Mysore State).
72	2405	B. K. Agarwal	Executive Engineer, P. W. D., Temporary Division, **Kheri** (U. P.).
73	2406	P. K. Lahiri	Building Design Division, Chief Engineer P. W. D., B/R's Office, **P. O. Shillong** (Assam).
74	2407	Ved Pal Gupta	Assistant Engineer, **Kathua** (Kashmir).
75	2408	D. P. Maitra	Assistant Engineer, Development (Roads) Department, Govt. of West Bengal, P. O. Plassey, **Dist. Nadia** (West Bengal).

ASSOCIATE MEMBERS

1	69	M/s. R. C. Abrol & Co., Ltd.	'E' Block, Mercantile Bank Building, Connaught Place, **New Delhi.**
2	70	The Railway Testing & Research Centre	Ministry of Railways, Alambagh, **Lucknow.**
3	71	The Municipal Board, Ghaziabad.	The Executive Officer, Municipal Board, Ghaziabad, **Dist. Meerut** (U. P.).

III. DEATHS

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

Serial No.	*Roll No.*	*Name*	*Address*
1	1677	S. Raghbir Singh	Retired Chief Engineer, B/16, Hauz Khas Enclave, **New Delhi-6.**
2	670	C. Janardan Rao	Executive Engineer, P. W. D., Special Division No. 1, **Kurnool** (Andhra Pradesh).

IV. ADDRESSES WANTED

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

Serial No.	*Roll No.*	*Name*	*Address as last known*
1	2113	Adhiraj, T.	Assistant Instructor, Engineering College, Guindy, **Madras-25.**
2	2112	Anantha Krishnan	539, Pioneer Hall, University of Minnesota, Minneapolis-14, **Minn.** (U. S. A.).
3	1410	Asim Mukherjee	1523, 6th Street, **Minneapolis-14.** (U. S. A.).
4	1634	Chakravarti, A. C.	District Engineer (Retired), Quarter No. C/15, East Gardiner Road, **Patna-1** (Bihar).
5	168	Eccleston, W. T.	300, Greenford Avenue, Hanwell, **London, W. 7.**
6	652	Guruswamy, S.	No. 8, Appaswami Koil Street, P. O. Mylapore, **Madras.**
7	1302	Mehndiratta, M. R.	Boarthur Avenue, S. E., Minneapolis-14, **Minnesota** (U. S. A.).
8	183	Nawab Ahsan Yar-Jung Bahadur	Afsar Manzil, Jubilee Hill, **Hyderabad-Deccan.**
9	417	Parang, Hari Ram	Retired Executive Engineer, Lal Chowk, Qila Gujar Singh, **Lahore** (Pakistan).
10	589	Rao, B. M.	Resident Engineer, Messrs. Thadani & Co., Ltd., 6A/DBZ (South), **Gandhidham** (Kutch).
11	194	Sankaram, G. B.	Door No. 8.12.6, Police Club Road, Gandhi Nagar, Kakinada, **East Godavari District** (Andhra Pradesh).
12	12	Sowani, D. G.	Bhide Wada, Shevde Bol, 851-A, Sadashiv, **Poona-2.**

V. REMOVALS FROM ROLLS OF THE SOCIETY

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

Serial No.	*Roll No.*	*Name of Member*
1	152	M. A. Rangaswamy
2	176	N. H. Vakil
3	423	M. W. G. Mani
4	611	P. R. Guha
5	715	M. K. Siva Subramaniam
6	1021	E. U. Philipose
7	1048	P. K. Kurup
8	913	P. K. Chatterjee
9	928	H. S. Sathaye
10	1162	A. K. Bannerjee
11	987	K. C. Ray
12	1200	D. N. Prasad
13	1298	N. Krishnan
14	1330	L. K. Kujur
15	1340	B. N. Sarkar
16	1386	A. N. Thusu
17	1498	M. N. Guha
18	1585	S. R. Shah
19	1629	G. S. Desai
20	1713	K. Krishna Mohan Rao
21	1734	R. S. Melkote
22	1736	J. T. Dikey
23	1738	K. Pattabhi Ram Reddy
24	1769	H. H. Mamtani

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

Vol. XXII-Part 4 NEW DELHI January 1958

PRESIDENTIAL ADDRESS

The Twenty-Second Session of the Indian Roads Congress was held at New Delhi from the 4th to the 8th January, 1958, and was formally opened by Dr. Rajendra Prasad, President of India at 12-00 noon on the 5th January, 1958, in the spacious premises of Vigyan Bhavan. The proceedings opened with an Address by Shri M. S. Bisht, the President, the full text of which is given below:

It is a privilege and an honour to extend to you, Sir, a most respectful welcome on behalf of the Indian Roads Congress. We are most grateful to you for the honour you have done us in having graciously agreed, and found time amidst your manifold engagements and urgent affairs of the State, to be present with us and inaugurate this, the 22nd Session of the Indian Roads Congress, in the Capital of our Country.

This is the second time that a Session of the Indian Roads Congress is being held in Delhi; the first was held in December, 1934. Since then much water has flowed under the bridges and great changes have taken place during recent years.

The country is pulsating with new life and energy and fresh hopes fill the heart of the nation. During the ten years of our independence vast changes have taken place and decades of inaction are being wiped out by the collective effort of the nation to develop the country and thus ameliorate the condition of the masses. All this creates new horizons for all of us.

In this short period of our freedom we have marched forward in the face of incredible difficulties and registered successes, economic, political and social, which to the future historian may seem miraculous. The partition brought in its wake serious disruption of our economy and truncation of our already inadequate and overstrained transport system. The uprooting of millions of people from their homes when the country was already in the grip of food shortage caused by the Second World War

tended to paralyse the nation. In those distressing circumstances we had little to support us but the courage in our hearts and the faith in our destiny. Much of this now seems past history and we look back with satisfaction at what has been achieved under your wise guidance and the brilliant leadership of our Prime Minister. The nation has survived the crisis and continues to forge ahead.

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

We have made spectacular progress on all sides. Big river valley projects have been undertaken and many successfully completed; great strides have been made in generation of electric power; rail transport system is being rapidly rehabilitated and strengthened; big and small industries are springing up and giant steel plants are coming up. In the matter of road transport, too, much has been done and our National and State Highways have been considerably improved and extended. Many missing bridges have been built and many more are in the course of construction. Many miles of missing road links have been constructed and road surfaces improved. Considerable work still remains to be done

to make our road system play its proper role in the expanding economy of our country.

We have abundance of manpower but are short of equipment and some essential materials of construction. Many industrial plants are producing materials in increasing quantities but production is outpaced by the demand arising from the ascending pace of developmental activities all round.

We completed the First Five-Year Plan successfully and are now in the midst of the Second Five-Year Plan. During the First Five-Year Plan period, a sum of Rs 27.62 crores was spent in the Central Sector on the development of National Highways; 636 miles of missing road links and 30 major bridges were constructed. Also, the surface of 4,000 miles of existing National Highways was improved and asphalted. A sum of Rs 6.75 crores was spent on improving the surface of selected roads other than National Highways and a sum of Rs 15 crores was spent from the Central Road Fund in addition to Rs 106.46 crores (including expenditure on Community Project Schemes) in the State Sector. Thus, the overall expenditure was about Rs 155.83 crores. It is gratifying to say that the targets set were not only achieved but exceeded in some cases. Modest as the sum provided was, it helped in a significant measure to integrate the road system of India in accordance with the Nagpur Plan and to encourage development of road transport. Since money was required for so many purposes, roads received a modest share of the available resources.

The Second Plan makes a provision of Rs 263 crores for roads and road transport. The share of National Highways is Rs 55 crores and this provides for construction of 1,200 miles of missing links and construction of 116 major bridges. At the close of the Second Five-Year Plan, the National Highway system will have emerged stronger and better capable of meeting the transport needs of the country with practically all the missing links completed and most of the major bridges either completed or in the course of construction. In the State Sector, the Second Plan provides for expenditure of 164 crores of rupees under which 60,000 miles of new roads of which 18,000 miles would be hard surfaced, would be constructed. At the close of the Second Five-Year Plan, the country will have in all 1,44,000 miles of hard surfaced roads and 2,35,000 miles of unsurfaced roads against the Nagpur Plan target for 1,23,000 miles of hard surfaced and 2,08,000 miles of unsurfaced roads. It should, however, be pointed out that although the targets of the Nagpur Plan in terms of milage will have been more than reached at the close of the present Plan, there will be several shortcomings such as

unbridged river crossings, sub-standard road surfaces and road widths, etc.

The share of roads in the Second Five-Year Plan continues to be modest. We are also facing certain difficulties, particularly in the construction of bridges where foreign exchange is involved. Although foreign exchange required for road projects is modest, even that is not available. I bring this to the notice of Government so that this difficulty is not allowed to hamper the road plan.

With the targets of the Nagpur Plan about to be achieved, we have now to formulate a new road development Plan. This we are in the process of doing.

I would like to mention some of the salient features of the new plan for road development for the next 20 years after the Second Plan.

1. No village should be more than 3 miles from a metalled road.
2. No village should be more than 1½ miles from an unmetalled road.
3. Every town with a population of 2,000 in the plains, 1,000 in semi-hilly areas and 500 in hilly areas should be connected by a metalled road.
4. All industrial and development centres, places of pilgrimage, places of historical importance, places of excursions for tourists and health resorts should be connected by metalled roads.
5. All administrative units of a district such as Tehsil Headquarters, Police Outposts, etc., should be interconnected and connected to District Headquarters, which in turn should be connected to adjacent District Headquarters.
6. Rail milage should not be taken into consideration in working out the total milage required as the two systems have distinctly separate functions to perform.

At this stage it will be as well to compare our achievements at the close of the First Five-Year Plan in respect of road development with other countries of Asia and Europe. I have purposely refrained from mentioning America because they are decades ahead of us in the matter of road development and because of the inexhaustible funds that are made available for development of their highway system.

Against 23 miles of surfaced roads per hundred square miles of area in this country, United Kingdom had 209 miles, France 237, Italy 89, Ceylon 70 and Germany 95. On population basis, against 82 miles per lakh of population that we have, France had 1502, Australia 5769, U.S.S.R. 840. It will thus be seen that we are much behind the aforesaid countries in the matter of road development on both area basis and population basis. A great deal of leeway has, therefore, to be made in this respect. Road development must keep pace with development in other fields in the country and in fact in many respects precede it. Many developmental activities cannot proceed smoothly in the absence of roads and rural development in particular is handicapped.

Seminar on "Low-Cost Roads"

The main objective of our Second Five-Year Plan is to build up a "Socialistic Pattern of Society" and to achieve this aim rapid industrialisation of the country will be necessary. With the increasing tempo of economic activity, the pressure on the means of communications, particularly roads, is bound to increase necessitating more and better roads. At the end of the First Five-Year Plan we had 1,21,617 miles of metalled roads out of which only 31,240 miles were modernised and the rest had low type water-bound macadam surfaces. The unmetalled road milage was 1,95,051, but this was largely fair weather, being neither raised nor bridged and unusable for some months in the year. If this milage is to be upgraded and made all-weather, it is not difficult to imagine what colossal amount of capital will be required according to the normal specifications.

Alternative methods of road construction and maintenance have, therefore, to be evolved so that we should be able to construct our roads at a comparatively low-cost. This problem is not only peculiar to India but to all the under-developed countries. I am glad to say that with this Session of the Indian Roads Congress we are going to hold, under the auspices of the ECAFE, a Seminar on "Low-Cost Roads." I trust this Seminar will evolve suitable processes for the construction and maintenance of low-cost roads utilising as far as possible different materials available locally in these countries. Naturally, the study of soils will play an important part in these discussions. We cannot think of any other material so cheap and so useful for the construction of roads as earth. I am sure the Seminar will devote its careful attention to the utilisation of earth for the construction of low cost roads. We hope that, as a result of the deliberations in the Seminar, we may be able to find a proper solution to the baffling problem of providing more roads at cheaper cost for the under-developed countries of the world.

Work of the Indian Roads Congress

Until this Congress was founded 23 years ago, there was no forum for Highway Engineers and allied professional bodies of men and they shared a common platform along with the other engineering Institutions. Perhaps, until then roads were very much in the background and with an ever increasing railway system, roads had been relegated to a secondary position.

It was only with the invention of the internal combustion engine and the advent of the automobile that roads began to take on a new meaning. As the automobile began to be manufactured in larger numbers at a reasonable cost, the demand for roads grew. I am mentioning all this because the automobile was slow in making its appearance in this country and in becoming a popular mode of transport. It was only in the late twenties that motor vehicles in any appreciable number began to use the roads and the road user began to make his voice felt.

During all these years since its inception, this forum of the Indian Roads Congress has been well utilised by highway engineers and its voice has been heard by Governments. In formulating our road policies, this Congress has had a dominant voice. That is only appropriate. After all who else could speak more authoritatively on matters concerning highways? The Indian Roads Congress and the Roads Wing of the Transport Ministry have, between them, helped to bring out prominently the need for developing an efficient highway system designed and built to meet the growing transport needs of this country. With the passage of time and with the alround development that is taking place, these needs are becoming more and more complex every day. Standards that were good enough 20 years ago are not so now and it would be prudent to look well ahead in both administrative and technical matters. The responsibility on this Congress has, therefore, assumed greater purpose and it is not enough to merely pass resolutions and to end up the Session by discussions. We have to make our voice more effective, and in dealing with technical problems, apply our minds more seriously. That this Congress has been standing up to its responsibility is fully borne out by the fact that in recent years various aspects of highway design and execution have been codified and we have now standards which ensure uniformity throughout the country.

Importance of Roads

A very careful examination of the targets for the production of commodities mentioned in the Second Five-Year Plan has shown that there will be an increase of about 110 per cent in the transport requirements of the country as compared to 1950—51 facilities. It is estimated that by 1961 the total traffic to be moved will be of the order of 181 million tons. The railways expect to make a big contribution towards meeting the increasing demand by large scale procurement of rolling stock, increase in line capacity and improvement in the operational fields. According to the Planning Commission they will not be in a position to carry all the additional traffic and the facilities provided by them may fall short of the estimated requirements by about 10 per cent.

The Indian Roads & Transport Development Association has put this at a higher figure and consider that against a shortfall of 18 million tons it may well be 33 million tons. In any case, it is obvious that there is going to be a big gap between the traffic offered and traffic moved and efforts have now to be made to provide alternative means of transport for movement of this traffic.

It is certain that to carry this traffic the present road vehicle capacity plus the annual growth of road transport will not suffice. Either we shall have to increase the output of motor vehicles in this country or to import them from abroad. The latter seems to be out of the question because of foreign exchange difficulties. The solution lies in speeding up manufacture of goods vehicles.

On this subject it would be as well to consider what burden the road transport carries in this country. Various authorities have assessed taxation of motor vehicles in India as higher than anywhere else in the world. Motor vehicle taxation here stands at Rs 2,070/- per vehicle per year against Rs 800/- in France, Rs 950/- in Austria, Rs 1,300/- in U.K., Rs 1,550/- in Italy and Rs 1,200/-in Germany. The taxation consists of:

(a) **The Central taxes comprising:**

1. Central petrol duty.
2. Import duty on the vehicles or such conveyances as are imported.
3. Import duty on spares.
4. Excise duty on tyres and tubes.

(b) **The State taxation comprising:**

1. Vehicle Tax.
2. Petrol sales tax.
3. Sales tax on vehicles and accessories.

The sum total works up to a formidable figure.

Certainly, the high cost of vehicles plus similarly high cost of fuel does not help to lower the operation cost or encourage the growth of road transport. If it is developing in spite of these handicaps it only serves to emphasise the great demand for it.

Perhaps, with the increase in the number of motor vehicles and increase in the overall consumption of motor fuel, it would be possible to lower the taxation burden as after all it is the overall revenue that matters and not the incidence of taxation per vechicle or per gallon of fuel oil. If by lowering the overall taxation, more vehicles can be put on the road, then surely revenue is not likely to suffer and the cause we all have at heart, i.e., growth of road transport will be greatly helped. In this matter the automobile industry can play a very notable part by reducing prices and it is to be hoped that the Oil and Gas Division of the Govt. of India will also play an equally notable part in the matter of fuel in the near future.

The Govt. of India have already taken a lead by amending the Motor Vehicles Taxation Act of 1939 which imposed many unnecessary restrictions on road transport. More and better roads will undoubtedly go a long way in helping road transport, and if all these factors are taken into consideration collectively, we shall have provided the necessary stimulus for accelerating the growth of road transport.

Also, allied with this problem is the one of permissible laden weights of motor vehicles on roads. There is a general demand on the part of trade for higher laden weights. The introduction of diesel driven trucks and buses has helped to reduce operating cost by permitting heavier loads to be carried, but our roads are not always fit to carry these heavy loads. I have seen many modernised roads go to pieces under these heavy diesel trucks because these roads were not designed and built for either high speed or the weight of these heavy vehicles. Roads with a low crust thickness are utterly unsuited for modern vehicular traffic. Then the widths of our roads are also an important consideration. Therefore, the problem of widening our roads and improving their carrying capacity is assuming very great urgency. Serious consideration has to be given to this question and required funds have to be made available to meet this important problem before it develops into a crisis.

The Road Transport Development Committee of the Indian Roads Congress which went into this question have submitted

their report recently. They have suggested the following measures:

1. Maximum permissible limit—laden weight of vehicles be raised to 27,000 lb.

2. Truck trailer combination or articulated vehicles be permitted.

3. Short distance railway traffic be diverted to roads by adopting the following measures:

   A. Railway freights on "Small" should be so adjusted as to divert to roads the bulk of this traffic.

   B. The first limit in the railway class rates should be raised from 300 to 450 miles.

4. In view of the large gap in the transport capacity, provision for road development in the Plan should be increased by 50 per cent.

The Committee has worked out in great detail that additional requirement of trucks and buses up to 1960-61, exclusive of replacements, would be of the order of 3,20,000.

It is obvious that unless our production of these vehicles is considerably increased, nothing like this number will be available.

Employment considerations are strongly in favour of road transport, as it provides employment to a very large number of people at comparatively cheaper cost. Currently, the Indian Roads Transport employs about 15 lakh workers and it is controlled by some 47,000 operators. Considerable employment is found for our labour both skilled and unskilled in road construction as well as maintenance. It is estimated that at the current rate of construction and on the overall milage that we have, some 628 thousand men are employed per day on new construction and 554 thousand on maintenance, bringing the total to 1 million 182 thousand. In this way some 2 million 700 thousand people are employed in road transport.

I shall now give some practical instances of how rural economy is helped by construction of a new road. In the Tarai region of Uttar Pradesh, farmers had been struggling to develop their farms by clearing forest land, cutting bushes, and breaking up land with the aid of tractors. The Tarai region is noted for its malarial character, surrounded by dense forest and inhabited

by wild beasts of every description. There is a meter gauge railway line running through this region and it has been in existence for over half a century. Land reclamation did not seem to be making much progress in spite of the best efforts of agriculturists and farmers aided by modern machines and implements. Construction of a road through this region was taken up. It took over three years to build this 40 miles length of road through swampy infested region. The moment the road became fit for carrying trucks and vehicles, the condition of these farms began to change. In a couple of years the grass lands had been cleared and the forests cut down, the land completely broken up and food began to grow. In the scheme of things there was only one missing factor and that was good road communication. I have already stated that the railway line existed there for a long time and yet only when the road made its appearance, the whole 40 mile belt of territory on both sides of the road developed in a new way and took on a new meaning.

In another case, up in the hills, cash crops like fruits and potatoes used to be exported to the nearest railhead some hundred miles away on pack ponies and mules. As soon as the motor road was built connecting these fertile regions with railhead, freight dropped from sixteen rupees to about three rupees a maund and the producer began to earn 100 to 200 per cent more than what he had been earning before. I will cite an even more glaring case of orchards situated at a distance of 15 miles from a motor road. The moment the motor road was built, freight on a 10 seer box of apples dropped from Rs 2/8 to annas eight and the producer began to save Rs 2/- straightaway on 10 seers of fruit. These instances only serve to show that there can be little incentive to a grower or a farmer to grow cash crops for export if he cannot market them economically at a price which would mean some saving to him.

How dangerous it can be to depend too much on one type of transportation system was borne out in the last war, when the seas became unsafe to go round India and everything had to be transported from the ports by rail. Great quantities of materials accumulated at the ports. These had to be moved by road. It was a common sight to see military convoys of a thousand vehicles or more passing every day on some of our arterial roads across the country. The roads were bad, disconnected and great efforts had to be made to make them fit for use. The importance of roads was realised none too early by the then Government. Much was done during the war inspite of so many handicaps to build roads and when that great military strategist, Lord Wavell, later ascended the Viceregal Gadi, he gave the highest priority to roads.

Highway Economics

Highway economics comprehends the following essential phases or factor groups:

1. Costs
2. Revenue
3. Benefits

Every problem in this field can be directly studied through the proper co-relation of these factors and the soundness of any development or extension project can be measured by the various ratios of their inter-relation.

Revenues must be sufficient to balance costs, otherwise eventual bankruptcy will be inevitable. Highway revenues must not only be sufficient to meet costs but must, in addition, be warranted and backed up by the resulting benefits, else the set-up eventually collapses for lack of public support and sanctions.

The benefits of highway transport are many and varied and they impinge upon several groups of beneficiaries in different ways and in different degrees. It is from these beneficiaries that revenues must be derived, and therefore it becomes necessary not only to evaluate total benefits but also to effect a benefit segregation so that revenue imposts may follow benefit distribution in an equitable manner. The beneficiaries may be grouped as follows:

A. The Governments because of improved facilities furnished by faster transportation of short distance hauls, facilities for inter-State commerce, and other factors.

B. The road user because of decreased vehicular operating costs, increased riding comfort and safety and other factors.

C. The general public because of decreased commodity costs, promotion of public health, better police facilities, etc.

D. Abutting and/or adjacent property because of certain special benefits accruing thereto over and above general community benefits.

In regard to 'A's, it would be appreciated that highways have legitimate claim on the general financial resources of the country because of the benefits accruing to the Government,

While it is true that all the taxes on fuel, petrol, lubricants and oil, etc., in fact, all revenues derived from road taxation are being ploughed back into road development, yet little is being made available from general revenues. Total revenues derived during the year 1955-56 are estimated at Rs 43.83 crores by the Centre and Rs 27.58 crores by the States. The total revenue derived by both Centre and State Govts., thus comes to Rs 71.41 crores. Against this, allocations from the Central Road Fund and other grants for roads have amounted to Rs 76.70 crores.

Under 'B', the road user, I mean the motorist and the truck owner, pays perhaps the highest taxation imposed anywhere in the world as already stated.

The same, perhaps, is not true in the case of bullock cart. Suggestions for imposing wheel tax have been coming up now and then, but for certain reasons it has not been possible to take up this form of taxation seriously and an important source of revenue is being missed.

It is estimated that the number of bullock carts in this country is in the neighbourhood of 102 lakhs and even if a tax of Re 1 per month is imposed, the total revenue from this source would be about 12 crores of rupees. Were this money to be set apart entirely for development of rural roads it would mean that something like 5,000 to 6,000 miles of katcha village roads would be metalled and made all-weather roads every year. What this would mean to the rural road user in lowering the cost of transport of his village produce, heavier loading capacity of his bullock cart, increase in the life of his cattle and appreciation in value of land and property, does not need to be narrated at length.

Under 'D', although there is no taxation on property but a betterment tax is usually levied in other countries. Assessment is based on the value of land and improvement. This betterment levy is only imposed for a limited period, i.e., up to such time as the expenditure on the road is redeemed by the tax after which betterment-levy ceases. If an area on an average of three miles on either side of a new road is benefited, then for one mile of new road construction the area liable to be taxed would be 3,840 acres. Assuming for the sake of argument that Rs 2 per acre is imposed as a betterment levy, then for one mile of new road construction the yearly revenue would be Rs 7,680. At the close of the Second Five-Year Plan, the metalled road milage is expected to be 1,44,000. Therefore, the total revenue from this source would be about Rs 110.0 crores.

It will be seen that so far the burden of taxation has been mostly carried by the motorists whereas other beneficiaries are not paying though they also derive benefits resulting from road development. It is only reasonable that they should share the taxation burden and help promote road development and road transport.

Non-lapsing Funds

I would also like to draw the attention of our administrators to the necessity of providing a non-lapsing fund for the construction and maintenance of roads. My predecessors in this office have stressed this point time and again and I would like to refer to it once more. We are all fully aware how road works and programmes have suffered in the past on account of the uncertainty of funds. Many a time in the past the road programme has had to be drastically cut down by the Government after we had overcome the difficulties in the initial stages of construction. To place the highway budgets outside the realm of uncertainty, it is essential to create a statutory non-lapsing fund for financing the development and maintenance of roads. We have at present the "Central Road Fund" which does not lapse and a similar fund can be created in each State for the State works to which the budgetted amounts passed by the Legislature each year may be credited. Such a step will enable the Road Enginaer to plan his projects on a more rational and scientific basis.

At present, the expenditure on roads is much less than the user taxes collected by the Centre and the States. It will go a long way to improve the standard of our roads if all the taxes collected from road users are credited to the Statutory Road Fund and their diversion to other purposes is prohibited by law.

Road Research and its Benefits

Systematic road research was not carried out in India in the past, mainly due to lack of facilities. However, at present the position is different. We have now had the Central Road Research Institute functioning at New Delhi for some years. Other Research Laboratories and Institutes are also functioning in several States, finding solutions to many problems referred to them by the field Engineers. There are still some States where laboratories have not yet been set up. It is very essential that these States have such laboratories as early as possible. Already a broad scheme for establishing such laboratories has been prepared by the Central Road Research Institute, Delhi, and this should be implemented as early as possible.

The function of a road is to enable traffic of all kinds, whether of car drivers, cyclists, pedestrians, lorry drivers, or of farmers with their animals and their bullock carts, to move safely, expeditiously, economically and comfortably.

The Government and the local authorities have, however, limited funds at their disposal. We must perforce compromise and do our best to give the greatest return for the money that we can spend. Each road, whether it is a district road or a main highway, is to be constructed to perform efficiently, safely and economically the task for which it is built according to its class. The traffic to be catered for and the type of road-making materials near at hand largely determine the type of construction employed. All these aims, including improvement of design and layout, promotion of safe traffic flow, reducing operational costs and adopting different methods of construction, can be achieved by a systematic and co-ordinated research work.

It is very essential that activities of all the Research Organisations in the country should be co-ordinated. Already some committees of the Indian Roads Congress, like the Road Research Organisations and Soil Research Committees are doing useful work in this respect by including representatives of various Research Organisations in these committees.

Application of the results of research is very necessary. We have already embarked on an ambitious programme of constructing many thousands of miles of roads of all types and this opportunity of applying results of research carried out in this country and elsewhere should not be lost.

The primary bottleneck appears to be lack of funds to the extent required. Besides, we should be prepared to take certain risks and not be daunted by failures in experimental work.

It has been sgggested that a small percentage of the funds for construction may be earmarked for road research. In America, 1½ per cent of all available funds are set apart for research and there is no reason why we should not follow the same policy.

The Council of Scientific and Industrial Research have constituted a committee known as the "Road Research Committee" in order to promote, guide and co-ordinate road research in India. This committee is initiating and fostering road research by recommending financial grants when required for various schemes. All possible efforts should be made by engineers and research workers to take advantage of this financial assistance.

Geometrics

I would now like to deal with Geometrics on our roads. Geometric design of highways deals with dimensions of the visible features of the highway such as alignment, sight distances, widths, slopes, grades, etc., as distinguished from structural

design which deals with the thickness of pavements, composition of materials, load carrying capacity, etc.

Available finances do not always permit of construction of the ideal in highway design. It is generally believed, however, that when economy is necessary it should be practised on some feature of the highway design other than the geometric. The road section can always be improved and widened at a reasonable cost if necessity arises. Likewise, the pavement can be widened and strengthened when finances permit but the geometric features of alignment, grade and sight distances when once moulded into the landscape and tied down to the pavement surfaces, are most expensive and difficult to rectify.

There is a tendency at present to align the road along the old existing village tracks and footpaths to avoid acquisition of land. The result is that many of our roads are generally crooked and unfit for fast-moving traffic. This tendency has to be curbed, as there is little room for compromise in this regard. We must follow the set geometric standards invariably in all new constructions. Particular attention must be paid to the curves and grades. Traffic on our roads is growing faster than we can anticipate. It is not only necessary to construct the new roads for the present-day requirements but to plan ahead and cater for the traffic likely to develop, say, in another 10 to 20 years' time. Even existing highways must be improved for safety and economy of vehicles plying on our roads.

This naturally brings us to the necessity and importance of road safety measures. In progressive countries, traffic has multiplied many-fold in the last decade. The number of mechanical vehicles now plying on the road has increased the traffic intensity considerably, throwing up problems of safety and control. Vigorous road safety campaigns are conducted in this country periodically by the Government in co-operation with the local authorities, Police and Education Departments. A system of pedestrian crossings has been introduced at many heavy traffic points and at some places where subways are under construction for pedestrians. But much more remains to be done. We have to apply our minds to this problem and lay down certain standards regulating the conduct of road users. The drivers of motor vehicles as well as bullock carts and also the pedestrians have to be trained so as to develop proper road sense.

Need for Scientific Design of Rigid and Flexible Pavements

It is well over a century since Macadam pointed out that the entire load imposed by traffic on a road, together with the

weight of the road itself, are really borne by the soil beneath, yet it was not until some twenty or twenty-five years ago that soil became the subject of systematic engineering investigation.

The reason why research on soils was neglected for so long is that no effective means existed of tackling the problem. The subject of soils does not lend itself to simple theoretical treatment in the same way as the theory of structures and the strength of materials which developed rapidly in the past century as branches of applied mechanics. No real advance in Soil Science was made till Terzaghi developed soil mechanics as a partnership between applied mechanics and the study of the physical properties of soil as they exist in the field.

One of the most important applications of soil mechanics to road engineering lies in the formulation of methods of calculating the thickness and strength of pavement which is to be placed on a soil foundation to provide a stable riding surface for specified traffic loads. This problem is known as pavement design. The rigid pavement, as we all know, includes all concrete roads, whereas flexible pavements cover all bituminous, water-bound macadam and kankar roads.

As the considerations involved in working out a purely rational method for the design of pavements are very complex, it has not been possible so far to evolve such a method anywhere. In the absence of well-established rational design procedure, various organizations in the world have adopted mostly empirical methods based on experience within their own spheres. It has now been realised by all highway engineers that correct application of reliable methods of design can lead to important economies by avoiding costly failures and wastage due to over design which are matters of special importance to us at the present time.

In the past and even at present in most cases in our country, the design is based merely on the past experience. Much the same thickness of construction is sometimes placed on a weak clay as on a strong gravel subgrade. It has happened that in some cases insufficiently thick pavements have been laid on weak subgrades leading to failures. A small expenditure on preliminary soil testing and the intelligent use of design methods will lead to fewer road failures and lower the cost of construction.

The road system in India is developing at a fast rate and thousands of miles of roads will be constructed within the next few years. It is, therefore, very essential that the best possible

use should be made of available empirical methods of design (such as the California Bearing Ratio method) by adapting them to the conditions existing in the country as regards traffic, climate and subgrade conditions, etc. Investigations should be directed to this aspect immediately and results made available to highway engineers. It is also necessary to develop method or methods of design of pavements suitable for our country.

For the evolution of suitable methods of design of road pavements, a lot of research and investigation work will be necessary both in the laboratory and in the field. In order to arrive at some conclusions early, co-ordination of such work among the various Research Organizations is essential. The Indian Roads Congress can fulfil this task very effectively and it is hoped we shall soon be able to evolve suitable methods of design for different conditions existing in this country.

Bridging Activity

Bridges are vital links in a communication system and without bridges roads are generally rendered impassable during the rainy season. Even in summer, absence of bridges limits the utility of roads.

Bridges are, however, the most expensive single item in the communication system and, as such, their construction is usually postponed to a later date. Unfortunately, in this country this postponement has done great harm because construction of bridges over big rivers has been postponed right from the last century up till now, i.e., ever since roads began to be built in this country.

However, a great deal has been done in the last five years. Many big bridges have been constructed, for instance, Palar, Pugalur and Coleroon in Madras; Pennar in Andhra; Kathjuri and Kuakhai in Orissa; Ghaggar and Bein in Punjab; Mahi in Bombay; Baigul, Bhakra and Jhararghat in Uttar Pradesh; Mahanadi in Madhya Pradesh; Barakar, Kiul and Akaraghat in Bihar; Kaljani and Darakeshwar in West Bengal.

As already stated, all told some 40 bridges were completed in the course of the First Five-Year Plan and in the Second Five-Year Plan, 116 major bridges are proposed to be built.

Bridge building is a precise and complicated branch of engineering. Collection of the correct hydraulic data of the rivers to be bridged is the first essential and thorough knowledge of river training works and river characteristics is another

essential. Foundation problems are often difficult both in design and execution and the decision as to the right type of bridge to be built is yet another matter that needs sound judgment. There is a variety of types to choose from and very often the most economical type decides the choice.

While reinforced concrete was the material of choice for superstructure when cement and steel were easy to procure we are now beginning to adopt prestressed concrete because of the economy in both cement and steel.

High tensile wire is not being manufactured in this country and we have to import it. This brings us to the great difficulty of foreign exchange. Ordinary steel is in short supply and has to be imported in large quantities. Therefore, no saving in foreign exchange accrues by adopting reinforced concrete in preference to prestressed concrete. It is hoped that manufacture of high tensile wire will be taken up before long in this country.

For building our big bridges over alluvial rivers, foundation difficulties are very considerable and conservative methods of sinking wells are both difficult and expensive in comparison to the modern methods of sinking caissons. Air-lock system has to be adopted in certain circumstances.

It is heartening to see a number of big engineering firms in this country taking up bridge construction and adopting modern methods. Bridge construction activity on a large-scale has no doubt helped in this transformation and I hope we shall before long have many firms undertaking big bridge construction with modern equipment on a rising scale.

So far as engineering personnel is concerned, I am glad to say that a great majority of States are undertaking both construction and design of bridges—large and small—with courage and ability and have rendered a good account of themselves in this respect. Training of engineers in modern technique is, however, important and we must continue to send engineers abroad for advanced training for sometime to come.

Engineering Personnel

As our road-system is growing and more money is being invested for more and better roads, it is essential that we should have a regular flow of skilled and trained engineers for designing and executing road works. Highway Engineering is no longer a guess work for engineers. It is a highly scientific branch of engineering and requires considerable skill and knowledge both

in design and execution. To mention some of the aspects of highway engineering, we have surveys both geological and geodetic and sometimes aerial surveys, soil surveys, traffic surveys, pavement designs, bridge designs, river training, etc. Specialist engineers are required to deal with these various branches of highway engineering. Up till now we had Civil Engineering Colleges imparting general knowledge to engineers in a three-year course. After this, engineers were drafted to different branches, Railways, Irrigation, Roads, etc., and they gradually picked up work in these branches. Naturally, it took some time for the young engineers to gain proficiency and until then they remained a liability. The need for imparting post-graduate training to qualified engineers was keenly felt and many Engineering Colleges in India now offer training in different branches of Highway Engineering. This is appropriate because such engineers will undoubtedly prove valuable assets to the Highway Departments of the States.

Many States have now separate Highway Departments. Until a few years back, many States had but one department of the P.W.D. under one Chief Engineer who was expected to know all about Irrigation, Roads, Buildings and Public Health. Luckily, this state of affairs has ended. Now as far as I know, roads and buildings have been separated from other branches in nearly all the States. Although in some States, Roads and Buildings continue to be one department, yet some States have made a further advance by separating roads from buildings and developing Highway Departments. Generally speaking, both the Highway Departments and the Roads and Buildings Departments are functioning properly in their respective spheres.

The time for having various expert engineers under the Chief Engineer in these various branches has come. All these experts should work either under the supervision of a Superintending Engineer in charge of Planning and Research or two Superintending Engineers, one in charge of bridges and the other in charge of Planning and Research, should the expenditure involved justify it. In other words, the time for specialisation in Highway Engineering has come. This is so in other countries and the benefit that accrues thereby is very considerable.

Ladies and Gentlemen, I have taken quite a good deal of your time and I shall not tax your patience any longer. Briefly to recapitulate what I have said, I have stressed the importance of roads and road transport in the implementation of our Five-Year Plans, discussed the question of highway economics—how the factors of costs, revenues and benefits have to be correlated for a balanced development, pointed out the need for co-ordinated

road research and a scientific approach to the problem of design of pavements and road structures, and last but not the least, focussed attention on the question of engineering personnel and specialisation in our P.W.D. or Highway Departments.

In conclusion, I might say that we advance by a series of efforts and progress by a succession of strivings towards the goal. Each session of the Indian Roads Congress is a milestone in the long and uphill task of building roads through the length and breadth of this sub-continent, a humble contribution in the mighty adventure of building up the nation.

May I now request you, Sir, to declare the session open.

INAUGURAL ADDRESS

by

DR. RAJENDRA PRASAD

President of India

New Delhi, January 5, 1958

It gives me great pleasure to be here today to inaugurate the Session of the Indian Roads Congress. I welcome this opportunity to associate myself with this function, because though I have been the patron of the Indian Roads Congress for some years, this is the first time that I could participate in a function connected with it.

The President of India delivering the Inaugural Address

In a vast country like India which is known for its long distances and for the variety of its terrain and the modes of its transport, roads constitute one of the most important means of communications. At the present time we have a network of railway system and a fast-developing airways and a system of river transport both traditional and modern, yet all this advance in the manner and speed of transport has not detracted a whit from the importance which roads occupy in our system of com-

munications. In actual fact, far from having an adverse effect on the role of the roads, the present-day developments have tended to make it more and more necessary to improve surface transport of which roads constitute such a significant part.

During the last ten years or so we have been busy implementing our reconstruction programme. The improvement of old roads and the laying of new roads have attracted a good deal of attention. We have now centralised most of the important roads and declared them as National Highways. Their maintenance and upkeep are directly the concern of the Union Government. The national highways generally connect the various States with one another and are therefore of great strategic importance. They fully deserve the attention which the Government and the Indian Roads Congress are devoting to them. I am glad this Congress as also the Union and State Governments have not overlooked the fact that the feeder roads connecting the various districts and the countryside with the national highways are of equal importance. Actually the development of these roads bringing the far-flung villages and even the remotely situated hamlets within the network of our communications system is so imperative that without accomplishing it our plans of economic development would ever remain incomplete and infructuous. If our road system has to supplement the railway system and other means of communications, it must look for coverage in the field which it has not been possible for our Railway to cover.

It is clear that field belongs to our rural areas which have for centuries maintained a remote existence, cut off from the stream of our national life because of the inadequacy of communications. What are known as backward areas or tribal belts existing in various States and hill tracts have remained so far backward primarily because the absence of roads or any dependable links of communication with other areas segregated them, throwing them on their own resources and imposing upon them an atmosphere of remoteness. **I, therefore, consider the existence of good roads as a vital factor in determining whether our society can become an equalitarian homogeneous one or will continue merely as a conglomeration of social groups leading their own separate lives and maintaining different levels of social and economic development**. This social and cultural aspect of roads is not in any way less important than the economic aspect. After all, it is not human beings alone who travel by roads. It is not goods or commodities of various kinds alone which are transported through roads. The traffic of ideas also takes place through social inter-mingling which is made possible by roads. This last aspect of roads is, in my opinion, of

fundamental importance, particularly for a country like ours which is populated by communities and groups belonging to varying levels of economic and social development.

When we have recognised these facts, nothing much need be said about the role of roads in a nation's life. Our nation is inspired by the ideal of equal opportunities for all and of speedier development of the backward areas so that they catch up with the more developed areas. This is a problem for the solution of which the development of our road system is very essential. I, therefore, attach great importance to the work of the Indian Roads Congress. Though this work belongs to the science of engineering and has to be executed by engineers, I have always looked upon it as having a tremendous bearing on our economic development, our social awakening and our political advance. You can legitimately feel proud of the great potentialities of your undertaking and work in that spirit for the improvement of the roads that we have and the providing of roads where none at present exist.

In the modern age road making, particularly the construction of bridges, is a highly technical undertaking, and it has developed as an independent branch of engineering. With the progress of researches in the field of science and the advance in our knowledge, the technique of road-building has also undergone great many changes. Modern engineers are called upon to construct roads which may be able to stand the inclemencies of weather, the none too infrequent vagaries of nature in the forms of floods, earthquakes, etc., and the great strain which traffic might put upon them. For evolving suitable techniques to meet these requirements a co-ordinated study of road problems and persistent research in the materials used for constructing them are necessary. It is in this respect that your Congress has done yeoman service by advising the Government on technical matters. Functioning as it does through various technical committees, the Indian Roads Congress has successfully evolved standard specifications in respect of various items of road work and new techniques and methods involved in constructing roads. You have rightly laid emphasis on guiding and co-ordinating research in road and bridge engineering. What has, however, particularly interested me is your study of the problem of low-cost roads in India, because our requirements in the matter of roads are vast and our resources are limited and even so there are too many other claims on them. No road programme which does not eliminate wastage and ensure the most economical use of the material available and provide for the longest coverage at the cheapest cost can be practical for our country. I am very happy to know that you have not only kept this point in view but have

been conducting field experiments for the achievement of this objective.

I congratulate the Indian Roads Congress on its success in evolving highly useful and practical methods which have proved of considerable utility to the State Governments in carrying out their road-building programme. I hope you will continue this useful work and achieve still greater success in your efforts for equipping India with a road system in keeping with our plan of development and suited to our economic resources.

I wish the Indian Roads Congress and all those connected with it the best of luck, and have great pleasure in inaugurating this Session of the Congress.

I.R.C. PRESIDENT'S CONCLUDING REMARKS.

On behalf of the Indian Roads Congress and on my own behalf I wish to express my deepest gratitude to Dr. Rajendra Prasad for giving us his valuable time to-day to inaugurate our Annual Session. His presence here is a source of inspiration to us and will greatly encourage us in our task in contributing our mite to the service of the country. We gather inspiration from his towering personality and his life of dedication to the cause of the country.

We of the Indian Roads Congress have had the real privilege of listening to his counsels of wisdom and it shall be our duty to follow his advice in the minutest detail.

I thank our numerous distinguished guests for responding to our invitation and for gracing the session by their presence.

I thank you all ladies and gentlemen.

May I now request you to award "The Indian Roads Congress Medal" to Messrs K. C. Ray, R. Subramoniam and S. Badaruddin for the following Paper contributed to the Indian Roads Congress at their last Session.

> Paper No. 193 - "Influence Fields for Finite Concrete Slabs supported freely along Two Opposite Edges and free at the other Two".

I also request you to announce that the following Papers have been highly commended :

(1) Paper No. 191 - "Resistance to Abrasion of Concrete Pavements" by Messrs P. J. Jagus & M. R. Chatterji.

(2) Paper No. 192 - "Design and Construction of a Prestressed Concrete Bridge Across River Coleroon" by Messrs. K. K. Nambiar & P. G. Nambiar.

MESSAGES

to

The 22nd Session of the I.R.C.

SHRI K. C. REDDY,

Minister for Works, Housing and Supply, Govt. of India.

"Highways of the country are the arteries of Industry and any effort towards the improvement of our Highways will materially contribute towards the industrial advancement and the economic progress of the country. I wish the Congress all success".

2. Wishes for the success of the Session have also been received from the following:

(i) Prime Minister.

(ii) Governor of Uttar Pradesh.

(iii) Minister for Finance, Govt. of India.

(iv) Sir Kenneth Mitchell.

(v) Shri G. M. McKelvie.

(vi) Shri J. B. Vesugar.

Institutions:

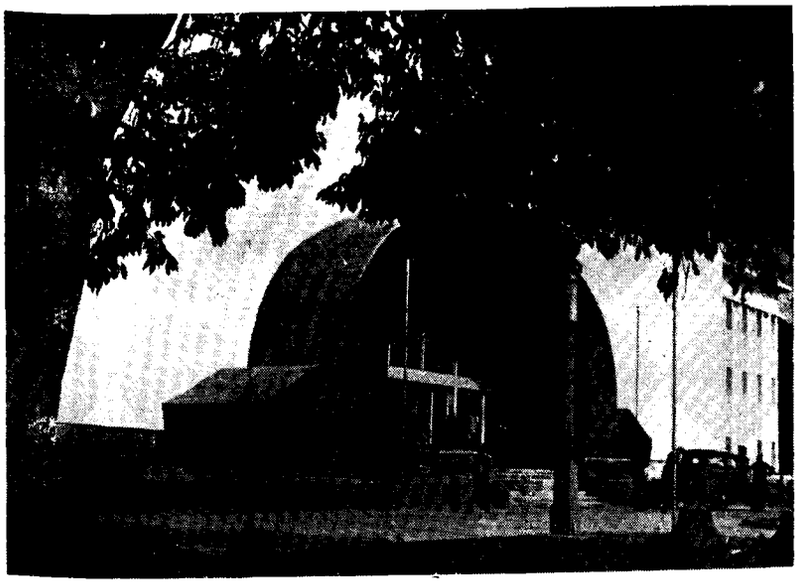
1. American Society of Civil Engineers.
2. The Bureau of Public Roads, U.S.A.
3. Highway Research Board, U.S.A.
4. American Road Builders Association.
5. The Institution of Civil Engineers, U.K.
6. The Institution of Engineers, Australia.
7. Main Roads Department, Australia.

THE INDIAN ROADS CONGRESS

TWENTY-SECOND SESSION—NEW DELHI—JANUARY 1958

New Delhi, the Capital of our country, played host to the 22nd Annual Session of the Indian Roads Congress. The 5th January 1958 was a proud day for the Congress when the President of India inaugurated the Session. Three hundred and two delegates from various parts of India attended the Session. This was the second time that a Session of the Indian Roads Congress was held in New Delhi: the first was held in December 1934.

All meetings were held in the spacious premises of *Vigyan Bhavan*, the venue of the recent UNESCO Session.



Vigyan Bhavan, the venue of the I.R.C. Session

Shri M. S. Bisht, Chief Engineer, Public Works Department, Uttar Pradesh, in his Presidential Address explained the significance of the new All-India Road Development Plan. He also dwelt at length on the subject of Highway Economics. He stated that highway revenues must not only be sufficient to meet costs but must, in addition, be warranted and backed up by the resulting benefits. The benefits of highway transport are many and varied. It is but proper that revenues should be derived from

the beneficiaries, and therefore, it becomes necessary not only to evaluate total benefits but also to effect a benefit distribution in an equitable manner. So far the burden of taxation had been mostly carried by the motorists whereas other beneficiaries were not paying though they also derived benefits resulting from the development. It is only reasonable that they should share the taxation burden and help to promote road development and road transport.

The President of the Indian Roads Congress also emphasised the need for providing a non-lapsing fund for the construction and maintenance of roads. Such a step will enable the Road Engineer to plan his projects on a more rational and scientific basis. The need for setting up separate Highway Departments in every State was also emphasised.

Other subjects dealt with in the Presidential Address were need for utilization of the benefits of road research, adoption of proper geometric standards on highways, scientific design of rigid and flexible pavements, etc.

The President of India in his Inaugural Speech gave a new touch to the subject of roads when he said that he considered the existence of good roads as a vital factor in determining whether our Society can become equalitarian homogeneous one or will continue merely as a conglomeration of social groups leading their own separate lives and maintaining different levels of social and economic development. The traffic of ideas also takes place through social intermingling which is made possible by roads. This last aspect of roads is, in his opinion, of fundamental importance, particularly for a country like ours which is populated by communities and groups belonging to varying levels of economic and social development.

The President of India arrives to inaugurate the Session

The President also stated that development of roads

bringing the far-flung villages and even the remotely situated hamlets within the network of our communication system was so imperative that without accomplishing it our plans of economic development would ever remain incomplete and infructuous.

In the end, the President congratulated the Congress on its success in evolving highly useful and practical methods which have proved of considerable utility to the State Governments in carrying out their road building programme. He hoped this useful work would be continued and wished the Congress good luck.

"The Indian Roads Congress Medal" was awarded to Messrs K. C. Ray, R. Subramoniam & S. Badaruddin for their Paper No. 193–"Influence Fields for Finite Concrete Slabs supported freely along Two Opposite Edges and free at the other Two." Two other Papers which were highly commended are: (1) Paper No. 191–"Resistance to Abrasion of Concrete Pavements" by Messrs P. J. Jagus & M. R. Chatterji, and (2) Paper No. 192—"Design and Construction of a Prestressed Concrete Bridge across River Coleroon" by Messrs K. K. Nambiar & P. G. Nambiar.

The President of India awarding the Medal

Messages of goodwill from the Prime Minister of India, Governor of U.P., Minister of Works, Housing & Supply and several others were read. The Chief of the Transport Division. ECAFE also read out a message of good wishes for the Congress,

Seven Papers were discussed. About seventy-five speakers took part in the discussions.

With a view to obtaining and exchanging up-to-date information and experience on the use of soil in all-weather road construction, a panel discussion was arranged.

The Report on Road Research carried out in India for the period ending the 31st March 1957 also came up for discussion. Many speakers took part in the discussion. This was the second report, the first report was discussed in May 1957. The discussion aroused keen interest among engineers engaged in construction and research workers working in various fields of research. It is believed that such an open discussion on the subjects of common interest will help a great deal for the proper blending of research and its application in actual practice which is a pre-requisite for scientific advancement of highway engineering. The discussions will also help in avoiding duplication of work.

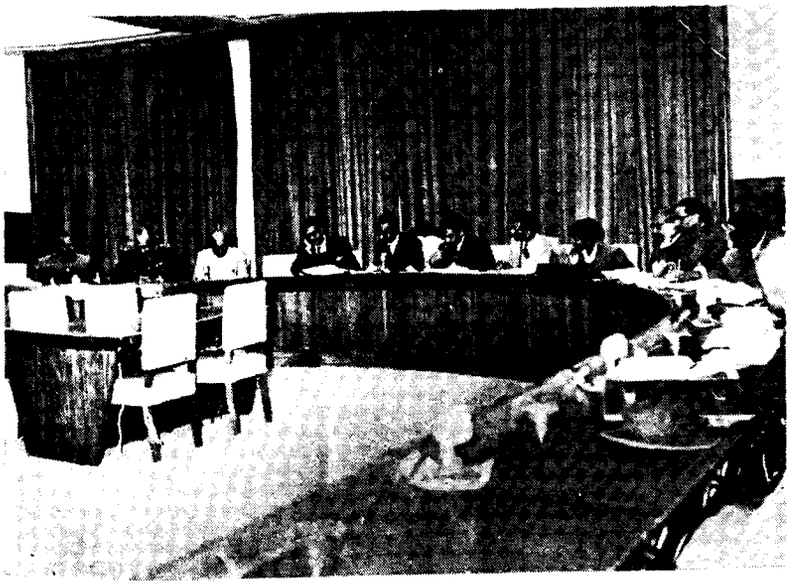
Various Committees of the Congress also met during the Session and examined various problems entrusted to them. The Specifications and Standards Committee discussed the design and location of petrol service stations so that they do not prove a hindrance to traffic. The next question which came up for discussion was design of cycle tracks. The results of research carried out by the Punjab P.W.D. and the C.R.R.I. were discussed. It was felt that the problem of cyclists was more important in Delhi than at any other place and it might continue to be so for some more time until some other cheap transport was available. The problem needs serious attention as the same difficulty might be faced in other cities also when the number of cyclists increases there. The Committee also discussed the method of numbering bridges and culverts on account of the adoption of kilometers on our roads.

The Test Track Committee discussed various specifications being tested at the Road Test Track, Calcutta.

The Education Committee discussed the question of including Highway Engineering as one of the subjects in the curriculum of Engineering Colleges. Another subject discussed by this Committee was about Refresher Courses for Engineers. It was pointed out that the States should be urged to spare engineers for this course. Another subject which came up for discussion was syllabus for Refresher Courses for junior engineers. A sub-committee was appointed to look into the question.

The Road Transport Operation Cost Committee which was appointed at the instance of the Government of India to study (i) the cost of operation of motor vehicles on different classes of roads and (ii) the economy resulting from road

improvements, considered the results of the various experiments carried out by Bombay and Uttar Pradesh State Transport undertakings according to design and specifications supplied by this Committee. The experiments are being conducted both on katcha and pacca roads. The Committee studied the Report on the analysis of the data received so far. The data revealed some deficiencies in observations and it was decided to evolve a more rational form of co-relating the primary data. It was further decided to widen the scope of the study by including hill roads also and Assam and Himachal Pradesh Governments would be approached to conduct similar experiments.

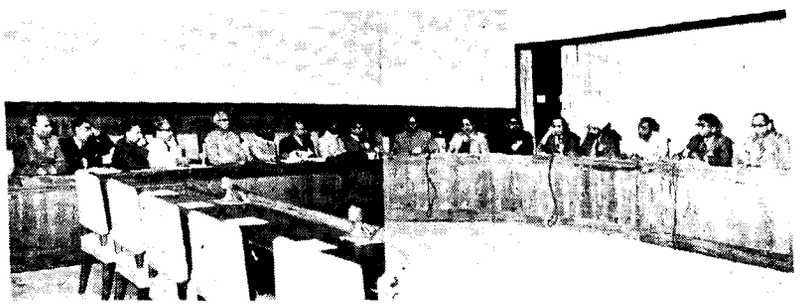


A meeting of Research Organization Committee

The Research Organisation Committee examined the points arising out of the discussion on the first Road Research Report discussed at the last Session of the Congress. The Road Research Report of the period ending 31-3-1957 was also discussed.

The Soil Research Committee discussed the stabilization of black-cotton soil in India. Other subjects which came up for discussion by the Committee was soil-cement blocks for urgent river protection works; specifications for stabilized soil base courses and wearing courses; applications of results of researches, sponsoring the use of soil as a road making material etc.

The Traffic Engineering Committee at their meeting decided a programme of their Work. It was also suggested that 'Study Weeks' in Traffic Engineering and Road Safety should be organised as is done in various foreign countries and the I.R.C. should associate itself with this work.



50th Council meeting

The Council at their 50th meeting in addition to transacting the ordinary business of the Congress, made very important recommendations suggesting ways and means to increase the road transport capacity both on a long-range basis and for the implementation of the Second Five-Year Plan. One of the main recommendations was that the Central and State Governments should be requested to allocate more money for roads in order that it may be possible to cope with the increased transport requirements. Particular emphasis was laid on improvement of existing roads to enable them to carry heavier loads.

The General Body of Members at their meeting held on the 8th forenoon transacted the ordinary business or the Congress. They also reviewed the work done by various Committees and the Council. The new Council was also elected.

51st Council meeting

The meeting of the new Council was held in the afternoon. Sri W. X. Mascarenhas, Chief Engineer, P.W.D., Bombay was elected new President of the Indian Roads Congress. The new Vice-Presidents elected were Messrs. J. M. Rijhwani, Sujan Singh and D. C. Sharma. Shri A. J. D'Costa was re-elected as Secretary.

I.R.C. Delegates visit the Central Road Research Institute

On the 9th January after paying homage at Rajghat the delegates visited the National Physical Laboratory and later inspected the Hindan Bridge near Gaziabad. In the afternoon, they were taken round Central Road Research Institute.

On the occasion of the Session an engineering exhibition an account of which is given elswhere in this issue was also organized by the Congress.

INDIAN ROADS CONGRESS

TECHNICAL EXHIBITION

JANUARY 1958

On the occasion of the 22nd Annual Session, the Indian Roads Congress organized an Engineering Exhibition at Exhibition Grounds, Mathura Road, New Delhi. The exhibition was opened on the 5th January 1958 by Shri Raj Bahadur, Minister of Shipping, Government of India. Speaking on this occasion, the Minister stated that the need for such exhibitions was very great. They enable the Highway Engineers to know the improved methods and techniques of design and construction developed after prolonged research and tests. These exhibitions also serve to educate the common man about the scientific methods and their application. Some details of the exhibits are given below. Complete text of the speech of the Minister is reproduced elsewhere in this issue.

A Stall at the Exhibition

(1) Central Road Research Institute, Okhla, New Delhi

In the soils section, exhibits dealing with the strengthening of black cotton soil, stabilized soil road construction, importance

of subgrade treatment, etc., were shown. In the concrete pavements section, apparatus for measuring abrasive resistance of concrete, use of surkhi in place of cement, membrane curing, sonic method of testing concrete without destroying it, concrete cutting machine, etc., were exhibited. In the bituminous carpet section various design charts, suggestions for use of sand in bituminous work, etc., were on view. In the road design and construction section, several design charts of traffic movement, traffic counters, line markers, brake testing equipment, etc. were displayed. In addition to these, the Institute actually laid three sections of road constructed to three different specifications.

Stall of the Central Road Research Institute

(2) Ministry of Transport & Communications, Department of Transport, Roads Wing

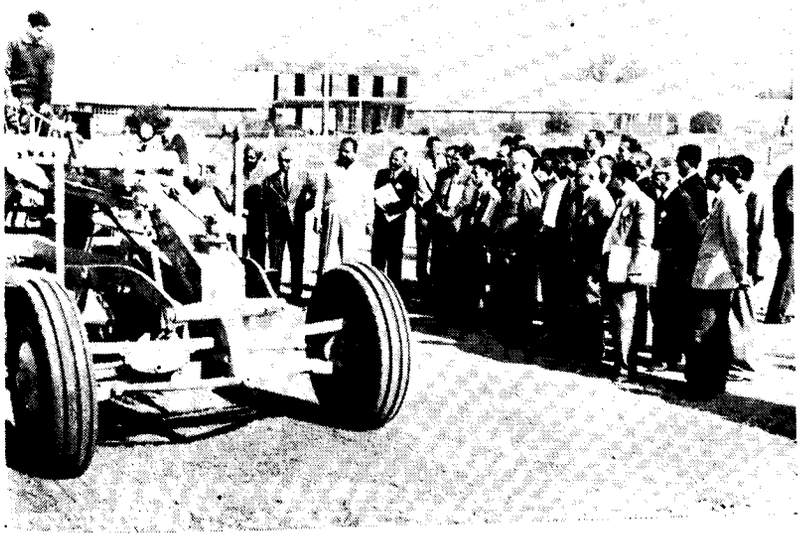
Models of the Jawahar Tunnel, roads in various stages of development and designs of difficult road junctions were exhibited. Photographs of important bridges and road maps showing National Highways and other roads were also shown. Statistical charts of interest to road and traffic engineers were the other exhibits displayed. Models of intersections and grade crossings were also on the view.

(3) Ministry of Works, Housing & Supply & National Buildings Organization

The Ministry of Works, Housing & Supply and National Buildings Organization showed work done on building research and low-cost housing.

Stall of the Roads Wing of the Ministry of Transport and Communications

Stall of the Govt. of West Bengal



Delegates watching an item of Road Making Machinery

Stall of the Govt. of U. P.

(4) Central Public Works Department, New Delhi

The Central P. W. D., showed various models and photographs of buildings and roads.

(5) Indian Council of Agricultural Research, New Delhi

The Indian Council of Agricultural Research showed results of improved methods of agriculture and animal husbandry.

(6) Government of West Bengal

The more important exhibits were the models of approaches to Calcutta, low-cost bridges, and reinforced concrete bearings. In the research section were indicated methods of collecting undisturbed soil samples and of determining bearing pressure of soils.

(7) Government of Bombay

Charts showing progress in the first and second Plans of the State and models of prestressed, bowstring girder, steel truss, etc., types of bridges in the Bombay State.

(8) Government of Rajasthan

In keeping with the position of Rajasthan in the field of production of precious stones, a road map made with stones of different colours was exhibited. Other exhibits were models of important bridges constructed or under construction on National Highways and other roads of the State.

(9) Government of Uttar Pradesh

On exhibits were models of an ideal road crossing with the meeting of roads at different levels, Garhmukteswar bridge, Banaras Ghat, Alaknanda bridge, etc. There were also charts of traffic flow, the second plan, etc.

(10) Punjab P.W.D. Laboratory, Karnal

In the general section, soil samples, constituents and blocks were shown. In the roads section models of surfaced and unsurfaced stabilised soil roads were exhibited. In the buildings section sun-dried bricks with waterproof plaster, bricks of cement and saw dust, etc. were shown.

(11) Government of Bihar

A road map of Bihar, models of several bridges, two models showing steel reinforcement in bridges and various samples of stones found in the State were exhibited.

(12) Government of Madras

Charts showing progress in the first and second plans, pictorial representation of several soil stabilized roads including the road leading to the pilgrim centre of Rameswaram, models of prestressed concrete bridges across Palar and Coleroon rivers and a model of a proposed grade separation in Madras City were exhibited.

Other participants in the exhibition were the following:

The Associated Cement Companies Ltd.

(The Concrete Association of India)

M/s Associated Instrument Manufacturers (India) Ltd.

M/s Burmah Shell Oil Storage Distributing Co. of India Ltd.

M/s Escorts (Agents) Private Ltd.

M/s Kailash Bros. Private Ltd.

M/s Marshall Sons & Co. (India) Ltd.

M/s Millars' Timber & Trading Co. Ltd.

M/s United Provinces Commercial Corporation.

M/s Voltas Limited.

M/s Willcox (Buckwell-India) Private Ltd.

SPEECH

by

SHRI RAJ BAHADUR,
Minister of Shipping, Govt. of India

Mr. President, Ladies and Gentlemen,

It is both a pleasure and a privilege for me to declare open this Technical Exhibition organized in conjunction with the 22nd Annual Session of the Indian Roads Congress. I am indeed grateful to the Indian Roads Congress for giving me this opportunity of meeting you all here.

Evidently the need for such exhibitions as the one you have organized here is very great. On the one hand they enable the Road Engineer to acquire in a concrete form an idea of the improved methods and techniques of design and construction developed after prolonged research and innumerable tests; and on the other, they help to educate the common man about roads and road-building activities going on in the country, along with the scientific methods and their application, the various processes and materials employed in the construction of roads and bridges. As a tax payer, he comes to know how the available funds are being utilised to the best advantage and this enables him to understand and appreciate the difficulties and problems that confront us today regarding the improvement, expansion and maintenance of our road system. An exhibition of this type thus serves to establish the much-needed contact between the "road builder" and the "road-user".

Our country today is engaged on a vast and unprecedented programme of development on all fronts—be it education, health and sanitation of the community, harnessing of turbulent nature in the shape of training wayward rivers or generating power. These gigantic developmental activities have unleashed colossal demands and pressures on roads and road transport system of the country, as not all the construction materials and other requisites, and the output of our farms and factories can be transported by railways. Even if they could do so, to reach the railheads from the widely scattered villages which dot our countryside, roads and road transport are of primary importance.

I would, therefore, like to emphasise that our energies and efforts should be directed towards providing cheaper roads to connect villages with the nearest markets or the railheads, so that the farms can transport their produce economically to the consumers and, in turn, be able to receive their requirements from outside. We have to ensure that in our zeal to provide good roads in cities, we do not neglect the villages. After all, roads are vital to the social and economic prosperity of every region.

The Community Projects and National Extension Services, which have been embarked upon during recent years, have gone a long way towards the much-needed awakening of rural India and have focussed attention on rural communications. In order that this work may be continued more intensively and extensively roads will have to be given the topmost priority. Without roads all progress is tardy or temporary.

In this connection, as a layman, I would suggest that more investigations should be carried out on the utilization of local materials for the construction of roads, so that materials like steel and cement, which are in short supply, could be diverted for use on urgent schemes of development. It may also be seen whether road construction could be done in stages so that, as our economy improves, the road crusts could be gradually built up to carry more and heavier loads.

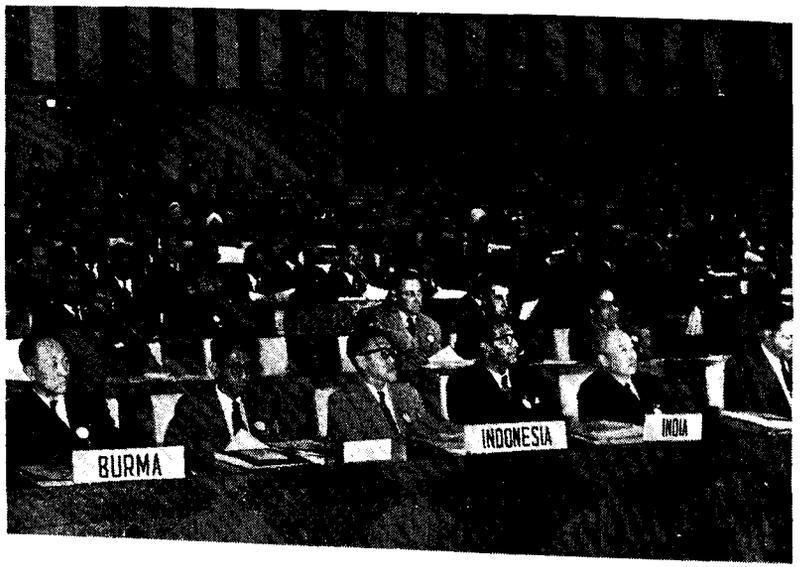
It gives me great pleasure to learn that your Organization has already done a lot of research work in providing roads at a low-cost by making use of stabilized soil and other similar methods of construction, so that a greater milage of roads be built for the benefit of many. In this modern age when startling progress and development are being made in the realm of science and technology, more and more emphasis is being laid on the use of mechanical equipment in the various schemes of development.

In a country like India where there is no dearth of manpower, mechanization would not be a substitute for manual labour but a complimentary aid to it. It has a part to play in all forms of development not excluding construction of roads and bridges. I hope the deliberations of the Congress and the Seminar on Low-Cost Roads, under whose auspices this exhibition has been arranged, will evolve some way of making use of mechanized equipment side by side with the utilization of available local resources in the construction of cheap and durable roads suited to the needs of the country.

ECAFE SEMINAR ON LOW-COST ROADS AND SOIL STABILIZATION

NEW DELHI—JANUARY 1958.

New Delhi was the venue of the Seminar on Low-Cost Roads and Soil Stabilization organized by the Economic Commission for Asia and the Far East. The meetings were held in Vigyan Bhavan from the 10th to the 18th January, 1958. Delegates from 15 countries including Malaya, Burma, Indonesia, Thailand, Japan, North Borneo, U.S.S.R. as well as the U.S.A. and the U.K. attended the Seminar.



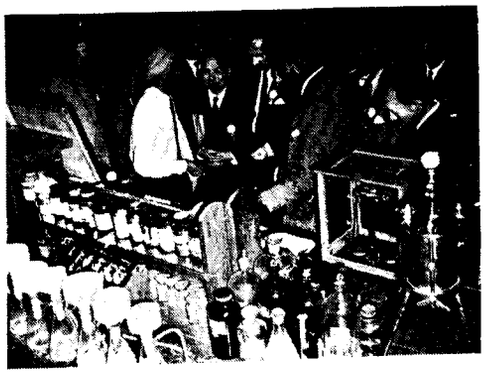
Delegates at the Inaugural Session of the ECAFE Seminar

The Seminar was inaugurated by Shri Lal Bahadur Shastri, Minister for Transport and Communications, Government of India. Addressing the Seminar, the Minister said that a formidable task which faced the under-developed countries of the region was to build themselves up. What was needed was an all-out and concerted effort in practically every sphere of activity including transport. The present condition of road transport facilities in the ECAFE Region was not generally satisfactory. The countries concerned need lifting their transport system to a higher level so as to meet the demand which was being rapidly generated by development plans. The most serious handicap

was that of finance. With the present cost of construction it was obviously impossible for the under-developed countries to have an adequate road system which would meet the demands of development programmes and the resultant expanding economy. Hence there was an immediate and imperative need for cheapening the construction of roads. The techniques, which encouraged the use of local materials to the maximum extent possible, greatly reduced the cost of transport of materials of road construction, thereby resulting in an appreciable reduction in highway construction costs. The techniques required some knowledge of soil science and the countries should try to arrange for the necessary training of their personnel in this field.

The Minister also expressed the view that a special fund for financing rural road development plans should be created. He also suggested that the Member countries of the ECAFE should help each other by throwing open their training institutes for providing training to the engineers.

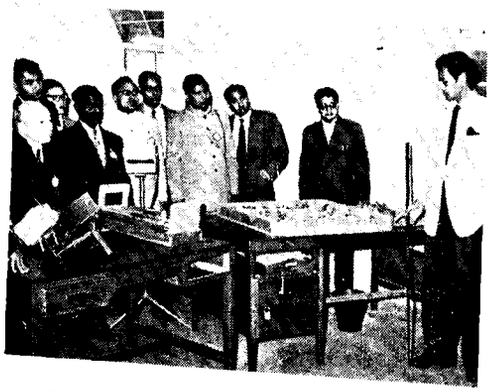
Shri M. S. Ahmad, Chief of the ECAFE Transport Division welcomed the experts to the Seminar. He also thanked the Government of India for the facilities for holding the Seminar and the Indian Roads Congress for their co-operation. In his address to the Seminar, he stated that to meet the requirements of rural transportation, it was essential to develop a type of road which was easy to build, while utilising simple techniques and available local resources, so that initial investment might be kept down to a minimum employing at the same time to the maximum possible extent the cheap and abundant manual labour available in many parts of the region.



Delegates seeing Soils Division, Central Road Research Institute

Shri Sujan Singh (Vice-President of the Indian Roads Congress) was happy to associate the Congress with the Seminar and he briefly explained the work done by the Congress.

Delegates seeing Bitumen Division, Central Road Research Institute



Delegates seeing Traffic Division, Central Road Research Institute

The Semnar elected Shri H. P. Sinha, Consulting Engineer (Road Development) and Joint Secretary to the Government of India as its Chairman. Luang videt Yontrakich (Thailand) and Shri T. Mori (Japan) were elected as the first and second Chairman respectively. The delegates then formed themselves into different groups to deal with various subjects. A general report was later on compiled from the recommendations made by these

groups and this report was discussed and adopted at the plenary session on the 18th January 1958. The recommendations made by the Seminar included a suggestion for the establishment of a separate road fund, for the building of which taxes on various items were suggested. The definitions of a Low-Cost Road and procedure for Route investigation were also laid down by the Seminar.

The Seminar also recommended that the allotment of funds for Road Development should be non-lapsable. Stressing on the development of rural roads, the need for earmarking an appropriate portion of the Road Fund for these roads was suggested. Other subjects on which the Seminar made recommendations are: (1) training of engineers in the technique of low-cost road construction; (2) standards for the construction of low-cost roads such as land widths gradients etc.; (3) cheap type designs for the

A social function at the Central Road Research Institute

construction of culverts and bridges on roads. The Seminar also recommended that all authority with regard to traffic control should vest in the proper highway authority. Another most important recommendation made by the Seminar was about stabilization of soil. Improving the properties of the soil met with at the site of the road with a view to enable it to withstand the disintegrating effects of traffic reduces the cost of the road to a minimum. Many miles of soil stabilized roads have been constructed in India and in some other countries of the region. The Seminar

pooled the knowledge available in this branch of engineering and made recommendations on the technique of design and construction of such roads. The adoption of the recommendations, it is expected, will reduce the cost of construction considerably, especially in areas where the conventional road-building materials are costly or are not available.

Delegates inspecting surface treated stabilised soil roads near Batala (Punjab)

The technique evolved to withstand bullock cart traffic has been used with some success in India. The method, in brief, consists of suspending soft aggregates, which can withstand the wear and tear of the wheels of the bullock cart, in a matrix of soil whose properties have been improved by suitable blending of different types of soil. It is found that this type of road

Delegates inspecting stabilised soil roads near Batala

could stand low traffic intensity. When the traffic increases the surface could be improved by the application of a bituminous surface. Specifications in regard to this technique were recommended at the Seminar.

The delegates were taken round the Central Road Research Institute on 14th January. On the 18th evening, they went on Inspection Tours to Batala and Bhakra Nangal. They travelled by a special train to these places. The delegates inspected the stabilized soil roads near Batala on the 19th January and the next day they visited the Bhakra Nangal Project and saw the various stages of construction of the mighty Bhakra Dam. Thus the Seminar came to a successful end.

Minutes of the 50th Council Meeting of the INDIAN ROADS CONGRESS held at New Delhi on the 4th January 1958

Present :

M. S. Bisht — President

M. P. Apte
Brig. S. K. Bose
U. J. Bhatt
S. K. Ghosh
D. G. Bhagat
K. Barua
R. N. Dogra
N. Durrani
A. D. Dhingra
N. D. Daftary
I. C. Desai
C. J. Fielder
H. R. Gupta
C. S. Ganapathy
V. V. Gopalkrishna Ayyar
Dr. R. K. N. Iyengar
B. S. Jootla
Kishore Lal
W. X. Mascarenhas
S. R. Mehra
E. A. Nadirshah
S. C. Nayak
B. Pershad
D. C. Sharma
P. L. Shivdasani
Shobha Ram
H. P. Sinha
P. L. Varma

Dr. L. C. Verman

A. J. D'Costa — Secretary

The following co-opted members attended :

N. D. Daftary
J. M. Rijhwani
Sujan Singh

The following attended by invitation :

M. S. Ahmad
J. K. Banerjee
D. D. Suri
J. M. Trehan
R. S. Bhalla

1. Confirmation of the Minutes of the 49th Council meeting.

The minutes of the 49th Council meeting held at Shillong on the 16th May 1957 published at pages 589 to 593 of Volume XXI-part 4 of the Journal of the Indian Roads Congress were confirmed.

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

The Minutes of the meeting of the Executive Committee held at New Delhi on the 30th November 1957 were approved.

3. Audit Report for the year 1956—57.

The Report of the Auditors for the year 1956—57 was recorded.

4. Draft Report of the Council to the General Body of Members for the period 1st January to the 31st December 1957.

The draft report was approved.

5. Budget.

The budget estimate for 1957—58 was approved.

6. Definition of the nominal sizes of road stones and tolerances.

The Council considered the recommendations of the Specifications and Standards Committee that the British Standard on the definition of the nominal sizes for road aggregates and tolerances as well as the method of determining the Flakiness Index (B. S. 63 : 1951) may be tentatively adopted. It was agreed that the matter may be further reconsidered by the Committee in view of the difficulties that might have to be faced due to the change over to metric system. A representative of the Indian Standards Institution should also be co-opted on this Committee.

7. Recommendations of the Road Transport Development Committee.

The Council considered in detail the various recommendations made by the Road Transport Development Committee and decided that the Central and State Governments should be requested to take necessary action on the following recommendations :

1. The Committee's estimate of the truck requirements should be sent to the Planning Commission for scrutiny and action.
2. On portions of roads (even if they are not very long) capable of carrying loads of 27,000 lb and more States should be urged to issue permits for these loads under Section 72 of the Motor Vehicles Act. Also such lengths of roads as are capable of carrying 27,000 lb should be notified to encourage applications for permits for heavy vehicles.
3. For this purpose portions of roads between main towns or trading centres should be treated separately and heavier loads allowed on them, lighter loads being allowed on weak portions.
4. Where warranted by fairly uniform and adequate standards of geometric design permits for articulated vehicles and truck-trailers should be issued. By

1960—61 about 2,000 miles of National Highways will have two-lane widths. In addition there will be some State Highways also.

5. In sections where bridges are weak and the rivers and nallahs are dry for 6 to 8 months in a year diversions should be provided as temporary measures until the bridges are strengthened to carry loads of 27,000 lb so that there may be continuous traffic at least for a good period of the year.

6. In the case of District Roads the permissible limit may not be below 18,000 lb and may be well above this figure.

7. To subject all bridges and culverts, which prima facie are considered weak, to a static test of 3 times the standardload of 27,000 lb. Wherever design data of existing bridges may be available it should be used to determine the load a bridge can carry.

8. States should also be requested to give top priority to the work of strengthening weak bridges and to earmark upto 10 per cent of their allocations on roads from the Central Road Fund.

9. To facilitate the employment of heavy trucks, with truck-trailer combinations were feasible, adequate maintenance and upgrading of the road structure wherever necessary should be provided generally on the routes selected for such traffic and particularly on their weak section.

10. States should be asked to take action under the new Motor Vehicles Act to put goods transport by road on an organised basis with particular reference to the following :

    (a) Permits for road traffic should be given more freely.
    (b) Provision of receiving centres and storage facilities.
    (c) Licensing of booking agents.
    (d) Insurance for goods carried.

11. There are a number of kutcha roads in the country on which demand for passenger transport from villagers has been increasing. The main difficulty in meeting it is that there is no authority at present in many States to look after these roads and to maintain them. States should take steps to provide the necessary

authorities for these roads. This also applies to roads built under Community Development and National Extension Service Projects.

12. The Consulting Engineer (Road Development) may be requested for a report on the progress of a wide-tyred bullock-cart wheel in and around Delhi since 1950/51 to-date.

Further, it was decided that, in order it may be possible to implement the above mentioned recommendations, the Central and State Governments should be requested to allocate more money for roads; particularly they should be requested to give priority to the improvement of existing roads to enable them to carry heavier loads. Suggestions should be made for raising more funds for road development.

8. The Council unanimously decided to enrol ECAFE as an Honorary Associate Member of the Indian Roads Congress. As the present rules do no provide for the enrolment of Honorary Associate members, it was decided that the question of amending rules may be taken up at a later date.

9. The Council decided that the Bridges Committee should be asked to release for printing Section II of the Standard Specifications and Code of Practice for Road Bridges in India as early as possible.

Minutes of the Business Meeting of the

INDIAN ROADS CONGRESS

held at New Delhi on the 8th January 1958

The Twenty-second Annual General Meeting of Members was held at New Delhi on Wednesday, the 8th January 1958 at 10-30 A.M. In all 284 Members and 18 Invitees (names and particulars at pages 643-650) attended the Session.

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

The minutes of the last Business Meeting held at Shillong on the 15th May 1957, as printed at pages 545 to 588 of the Journal of the Indian Roads Congress, Volume XXI-part 4, December 1957 were confirmed.

3. Audit Report.

(i) The Audit Report for the period 1st October 1956 to the 30th September 1957, pages 651-653, was recorded.

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

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

The Report of the Council (pages 655-681) was taken as read and approved.

5. Resolutions of thanks.

The following resolutions were passed :

(i) The Indian Roads Congress thank the Government of India in the Ministry of Transport and Communications for their kind invitation to hold the Twenty-second Session of the Indian Roads Congress in New Delhi and for the very excellent arrangements made in connection therewith.

(ii) The Indian Roads Congress thank Dr. Rajendra Prasad, President of India for kindly inaugurating the Twenty-second Session of the Congress and for his very instructive and inspiring Address on that occasion and also for his permission to print his Address.

(iii) The Indian Roods Congress thank Shri Raj Bahadur, Minister of Shipping, Govt. of India, for kindly declaring open the Technical Exhibition organized by the Indian Roads Congress and for his encouraging speech made on that occasion and for his permission to print the speech.

(iv) The Indian Roads Congress thank Shri Jawaharlal Nehru, Prime Minister, for his good wishes to the Congress.

(v) The Indian Roads Congress thank the Governor of Uttar Pradesh for his kind message to the members of the Indian Roads Congress.

(vi) The Indian Roads Congress thank Shri K. C. Reddy, Minister for Works, Housing and Supply, Government of India, for his encouraging message to the members of the Indian Roads Congress.

(vii) The Indian Roads Congress thank Sir Kenneth Mitchell, Shri J. B. Vesugar and Shri G. M. McKelvie, Past Presidents of the Indian Roads Congress, for their good wishes for a very successful Session.

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

(ix) The Indian Roads Congress thank the ECAFE for their message of good wishes, and to Shri M. S. Ahmad, Chief of Transport Division, ECAFE, and Shri K. N. Chiengmai and Shri George Reme for attending the Session.

(x) The Indian Roads Congress thank Shri J. M. Rijhwani, Chief Engineer, C.P.W.D., Shri T. B. Bhonsale and Shri V. Kandaswamy, Superintending Engineers, C.P.W.D., Shri Harbans Swaroop, (Local Organizing Secretary, Indian Roads Congress), Executive Engineer, and other officers and staff of the Central Public Works Department for the excellent arrangements made by them for the Session and for the convenience of the delegates.

(xi) The Indian Roads Congress thank Triveni Kala Sangam for kindly arranging a Cultural Show for the delegates.

(xii) The Indian Roads Congress thank the Ministry of Works, Housing and Supply, Government of India, for kindly placing the Vigyan Bhavan at the disposal of the Congress for holding the meetings and Government Quarters at Pandara Road for use of the delegates and for kindly allowing the holding of a technical exhibition at the Exhibition grounds.

(xiii) The Indian Roads Congress thank Sri Lal Bahadur Shastri, Minister of Transport and Communications, Government of India, for kindly inviting the delegates of the Congress to an 'At Home'.

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

(xv) 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.

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

(xvii) The Indian Roads Congress thank the State Bank of India, Railway authorities, Indian Airlines, Air India International, Post and Telegraph authorities for kindly opening their branch offices in Vigyan Bhavan for the convenience of the delegates.

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

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

Messrs. C. J. Fielder, Kishore Lal, Goverdhan Lal and S. C. Nayak were appointed scrutineers for the election to the Council under Rule 9-j of the Rules and Regulations of the Indian Roads Congress.

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

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

F. P. Antia, Dr.
M. P. Apte
C. J. Fielder
E. A. Nadirshah
L. R. Patel
Sujan Singh

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

L. C. Verman, Dr.

9-h. Representative of District Board Engineers.

Nilkanth Sinha

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

K. Sinha

9-j. Representatives elected by the General Body.

S. N. Gupta
R. K. N. Iyengar, Dr.
S. N. Sinha
P. Sirajuddin

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

	Name of participating Administration	Name of Representative
9-a.	Andhra	N. Durrani
	Assam	K. Barua
	Bihar	B. Prasad
	Bombay	Chief Engineer, Roads and Buildings.
	Madras	Chief Engineer (Highways).
	Madhya Pradesh	H. R. Gupta
	Orissa	B. S. Jootla
	Uttar Pradesh	M. S. Bisht
	Punjab	D. C. Sharma

Name of participating Administration	Name of Representative
West Bengal	R. C. Roy
Mysore	G. S. Ganapathy
Rajasthan	Kishore Lal
Kerala	V. V. Gopalakrishna Iyer
Jammu & Kashmir	D. N. Gupta
Himachal Pradesh	J. Mukand
9-b. Engineer-in-Chief, Army Headquarters	Brig. S. K. Bose
9-c. Central P.W.D.	J. M. Rijhwani
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	
K. K. Nambiar	

LIST OF MEMBERS WHO ATTENDED THE TWENTY-SECOND SESSION OF THE INDIAN ROADS CONGRESS HELD AT NEW DELHI IN JANUARY, 1958

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, Department of Transport, (Roads Wing)	...	36
	(b) Ministry of Works, Housing & Supply	...	2
	(c) Central Water & Power Commission	...	2
	(d) Central Board of Irrigation and Power	...	1
	(e) Central Public Works Department	...	14
	(f) Central Road Research Institute	...	19
	(g) Engineer-in-Chief's Branch	...	6
	(h) Railway Board	...	1
	(i) Hindustan Steel Limited	...	1
2.	**Assam**	...	8
3.	**Andhra Pradesh**	...	10
4.	**Bombay**	...	39
5.	**Bihar**	...	18
6.	**Delhi**	...	28
7.	**Kerala**	...	2
8.	**Kashmir**	...	1
9.	**Madras**	...	16
10.	**Madhya Pradesh**	...	7
11.	**Mysore**	...	9
12.	**Orissa**	...	3
13.	**Punjab**	...	15
14.	**Rajasthan**	...	9
15.	**Uttar Pradesh**	...	28
16.	**West Bengal**	...	22
17.	**Sikkim**	...	1
18.	**E. C. A. F. E.**	...	3
19.	**Pakistan**	...	1
	Total	...	302

LIST OF DELEGATES WHO ATTENDED THE 22nd SESSION OF THE INDIAN ROADS CONGRESS HELD AT NEW DELHI FROM THE 4th TO THE 8th JANUARY, 1958.

S. No.	Roll No.	Name
		1. GOVERNMENT OF INDIA
		(a) Ministry of Transport & Communications, Deptt. of Transport, (Roads Wing).
1.	266	Bhagat, D. G.
2.	783	Bhargava, T. N.
3.	322	Bazaz, S. L.
4.	1446	Bhalla, R. S.
5.	1892	Chandiramani, K. M.
6.	758	D'Costa, A. J.
7.	1078	Gursahani, R. L.
8.	1387	Grover, D. T.
9.	2188	Gajria, H. B.
10.	*Invitee*	Ghosh, N. C.
11.	879	Goverdhan Lal
12.	785	Hardyal
13.	*Invitee*	Harbans Singh
14.	—	Hedge, G. M.
15.	—	Kadiyali, L. R.
16.	1880	Kathuria, S. L.
17.	747	Lal, M. B.
18.	705	Mirchandani, N. D.
19.	1146	Menon, M. D.
20.	1274	Murthi, B. S. N.
21.	1878	Navaney, M. K.
22.	950	Nagarsheth, M. P.
23.	*Invitee*	Narayanan, C. V.
24.	790	Oza, M. G.
25.	885	Poonen, P. C.
26.	2020	Rao, B. Balwant
27.	752	Ramaswamy, N. S.
28.	724	Rajagopalan, S. K.
29.	723	Subrahmanyam, J.
30.	191	Sinha, H. P.
31.	1280	Sadarangani, T. G.
32.	1210	Subbiah, C. P.
33.	637	Surya, N. S.
34.	1532	Sehra, P. T.
35.	918	Trehan, J. M.
36.	1879	Venkatesulu, G.
		(b) Ministry of Works, Housing & Supply
37.	658	Bhatia, M. S.
38.	2063	Selvam, L. G.
		(c) Central Water & Power Commission
39.	708	Gidwani, M. M.
40.	78	Khatri, K. C.

S. No.	Roll No.	Name
		(d) Central Board of Irrigation and Power
41.	*Invitee*	Baleshwar Nath
		(e) Central Public Works Department
42.	977	Bahl, D. R.
43.	934	Chatterjee, P. L.
44.	2366	Dutt, D.
45.	2367	Harish Chandra
46.	2387	Harbans Swaroop
47.	2090	Jain, R. C.
48.	2375	Jain, S. C.
49.	2210	Keswani, J. W.
50.	915	Mittal, O. P.
51.	559	Rijhwani, J. M.
52.	1221	Rao, A. L. K.
53.	965	Rajagopalan, K. G.
54.	439	Saigal, Balbir Singh
55.	2384	Sadarangani, N. R.
		(f) Central Road Research Institute
56.	*Invitee*	Agarwal, H. R.
57.	*Invitee*	Chadda, L. R.
58.	2339	Dhir, M. P.
59.	1914	Gokhale, Y. C.
60.	833	Iyengar, R. K. N.
61.	*Invitee*	Krishnamachari, R.
62.	1857	Khanna, T. S.
63.	277	Mehra, S. R.
64.	1907	Mazumdar, B. C.
65.	2202	Natarajan, T. K.
66.	*Invitee*	Nair, K. P.
67.	*Invitee*	Nanda, R. L.
68.	2349	Puri, M. L.
69.	1913	Rao, N. Mohan
70.	1311	Subbaraju, Bh.
71.	2183	Swami, S. A.
72.	1345	Swaminathan, C. G.
73.	1720	Sankaran, K. S.
74.	847	Uppal, H. L.
		(g) Engineer-in-Chief's Branch
75.	1905	Arjan Singh, Col.
76.	2171	Avtar Singh, Lt.
77.	1818	Bose, Brig. S. K.
78.	*Invitee*	Deb, A. K.
79.	2344	Ramakrishna, Capt. L. V.
80.	1511	Radhey Shiam
		(h) Railway Board
81.	43-Associate	Kumar, S. L.
		(i) Hindustan Steel Limited
82.	2052	Guha, S. K.

S. No.	Roll No.	Name
		2. ASSAM
83.	889	Barua, Major K.
84.	2227	Choudhury, S. C.
85.	2342	Dutta, R. K.
86.	2163	Kataki, D. K.
87.	1968	Kharkongor, F.
88.	55-Associate	Rajkhowa, P.—Rep. : M/s. Assam Oil Co., Ltd., **Digboi.**
89.	1961	Sharma, G. C.
90.	1960	Serajul Islam
		3. ANDHRA PRADESH
91.	246	Durrani, N.
92.	2383	Krishnamurty, K.
93.	1082	Padmanabham, Y.
94.	1980	Prasad, J. V.
95.	1945	Rao, K. V.
96.	757	Rao, R. Rama Mohan
97.	1265	Rao, K. Rama Mohan
98.	233	Rao, H. R. Sayoji
99.	2380	Sarma, C. V. B.
100.	2110	Saxena, K. R.
		4. BOMBAY
101.	60-Associate	Amin, Dinkar T.—Representing Pashabhai Patel & Co., Ltd., **Bombay.**
102.	1522	Apte, M. P.
103.	383	Batlivala, H. S.
104.	1882	Bhosale, B. Y.
105.	1050	Bhambhani, B. I.
106.	214	Bhatt, U. J.
107.	2385	Chaphalkar, V. P.
108.	1322	Desai, C. N.
109.	614	Dhingra, A. D.
110.	1739	Desai, I. C.
111.	1336	Daftary, N. D.
112.	1942	Ghosh, D. K.
113.	663	Gupchup, N. S.
114.	2360	Gurnani, J. S.
115.	2205	Harris, C. D.
116.	1129	Iyengar, C. L. N.
117.	1474	Jagus, P. J.
118.	2033	Jayawant, M. B.
119.	1450	Joglekar, K. V.
120.	315	Joshi, S. B.
121.	374	Lakdawala, R. M.
122.	2382	Mistry, J. F.
123.	1946	Mascarenhas, W. X.
124.	1621	Mehta, Y. K.
125.	23	Nadirshah, E. A.
126.	2361	Noble, M. K.
127.	1528	Patkar, B. B.
128.	1780	Pimple, J. S.

S. No.	Roll No.	Name.
129.	1869	Padwal, M. J.
130.	2381	Panthaky, B. K.
131.	1008	Raghavan, P.
132.	1944	Raju, V.
133.	2379	Sarwate, M. C.
134.	1148	Shivdasani, P. D.
135.	2353	Sarkar, B. B.
136.	1432	Sujan Singh
137.	1501	Taylor, N. H.
138.	2351	Thakur, D. S.
139.	1600	Vibhakar, P. K.
		5. BIHAR
140.	1637	Amanullah, N.
141.	602	Dubey, B. P.
142.	1962	Lal, G. P.
143.	434	Misra, C. P.
144.	2007	Nath, S.
145.	1626	Prasad, S. N.
146.	733	Prasad, B.
147.	1992	Sinha, D. K.
148.	2071	Sinha, S. B. P.
149.	1902	Sinha, S. P.
150.	871	Sinha, S. N.
151.	706	Sinha, P. P.
152.	1291	Sinha, Nilkanth
153.	2329	Sinha, D. B.
154.	1331	Sen, S. K.
155.	1978	Sinha, B. K.
156.	2363	Varma, D. N.
157.	1827	Varma, R. P.
		6. DELHI
158.	69-Associate	Abrol, R. C.—Representing M/s. R. C. Abrol & Co., (P) Ltd., **New Delhi.**
159.	42	Brij Mohan Lal
160.	53	Bishamber Dyal
161.	484	Bhupendra Nath
162.	399	Bahl, M. L.
163.	1619	Bhandari, V. D.
164.	1888	Chakraverty, N.
165.	2208	Dawar, A. R.
166.	1837	Fondekar, P. B.
167.	1910	Green, John A
168.	946	Goel, R. R.
169.	1756	Jain, Prem Chand
170.	52	Jagdish Prasad
171.	1536	Jain, C. B.
172.	2067	Jali, L. M.
173.	56-Associate	Kaura, M. R.—Representing M/s. William Jacks, **New Delhi.**
174.	72	Khanna, I. N.
175.	1134	Khanna, P. N.
176.	2230	Madhavan, T. P.

S. No.	Roll No.	Name.
177.	1009	Mohindra, O. P.
178.	1183	Nazareth, C. V.
179.	1776	Prinja, K. C.
180.	356	Sandhawalia, N. S.
181.	23-Associate	Sud, M. R.—Representing M/s. Willcox (Buckwell-India) Ltd., **New Delhi.**
182.	40-Associate	Shahani, T. C.—Representing M/s. Standard Vacuum Oil Co., **New Delhi.**
183.	*Invitee*	Sehan, Surjan, S.
184.	491	Varma, P. L.
185.	58-Associate	Varman, Dr. L. C.—Representing Indian Standards Institution, **New Delhi.**
		7. KERALA
186.	1599	Ayyar, V. V. Gopalakrishna
187.	2377	Thomas, P. P.
		8. KASHMIR
188.	1624	Gupta, D. N.
		9. MADRAS
189.	2335	Ayyaswamy, G.
190.	694	Devarajan, K. S.
191.	2387	George Jacob, G.
192.	2022	Kohli, D. R.
193.	2037	Karnik, A. V.
194.	2371	Muthukalyani, T. C.
195.	671	Meeran, M.
196.	660	Nayak, S. C.
197.	2347	Palanivelu, G.
198.	2346	Rao, V. N. Ramdoss
199.	219	Sirajuddin, P.
200.	1775	Selvam, T. T.
201.	680	Sivaprakasam, P. S.
202.	2364	Sethuramiah, T.
203.	630	Thadaney, K. V.
204.	1178	Veeraraghavan, T. M.
		10. MADHYA PRADESH
205.	1547	Agarwal, G. D.
206.	2365	Balu, S.
207.	1575	Ghatpande, G. S.
208.	1643	Gupta, H. R.
209.	2299	Karnik, S. G.
210.	2286	Wasan, O. P.
211.	578	Yadav, H. J.
		11. MYSORE
212.	2362	Bellubi, P. R.
213.	1641	Ganapathy, G. S.
214.	2050	Iyengar, C. K. Rangaraja
215.	2352	Kenbhave, Basavana
216.	1668	Manchigiah, M. H.

S. No.	Roll No.	Name.
217.	2356	Murthy, N. Madhava
218.	2354	Rai, B. Sudhakar
219.	2355	Rudraiah, M. C.
220.	2348	Venkataramaiah, B.
		12. ORISSA
221.	285	Das, P. C.
222.	304	Jootla, B. S.
223.	2204	Mukherjee, P. K.
		13. PUNJAB
224.	892	Basant Singh
225.	2108	Dharm Pal
226.	457	Dogra, R. N.
227.	1242	Gurcharan Singh
228.	1615	Hukam Singh
229.	2143	Kohli, J. P.
230.	446	Khanna, G. C.
231.	2176	Mintzer, Olin, W.
232.	1948	Marya, R. K. S.
233.	729	Mohindra, S. K.
234.	1135	Singh, R. C.
235.	504	Sharma, D. C.
236.	1970	Sehgal, O. S.
237.	*Invitee*	Uppal, I. S.
238.	2132	Virdi, S. S.
		14. RAJASTHAN
239.	2218	Bhargava, S. P.
240.	2209	Bhim Singh
241.	1751	Calla, V. N.
242.	940	Desai, C. B.
243.	331	Kishore Lal
244.	864	Mathur, C. B. L.
245.	1764	Malhotra, Jag Mohan
246.	2211	Sexena, S. K.
247.	1955	Vyas, S. S.
		15. UTTAR PRADESH
248.	2388	Agarwal, Srinath Prasad
249.	877	Banerji, P. K.
250.	1524	Bishnoi, A. S.
251.	205	Bisht, M. S.
252.	213	Bagchi, C. C.
253.	—	Dinesh Mohan
254.	222	Fateh Chand
255.	1543	Gahlowt, R. S.
256.	1923	Gauba, J. C.
257.	1588	Gupta, L. N.
258.	2376	Jagmohan Lal
259.	2206	Jain, Rajendra
260.	284	Lakshman Swarup
261.	1176	Mahabir Prasad
262.	1973	Mathur, J. S.

S. No.	Roll No.	Name.
263.	302	Mirza, M. A.
264.	2350	Mangal, R. C.
265.	999	Misra, K. N.
266.	2374	Ojha, S. K.
267.	2370	Roy, P. N.
268.	1423	Srivastava, A. K.
269.	490	Shoba Ram
270.	960	Sinha, K.
271.	2372	Seth, M. M. Das
272.	1889	Satish Prasad
273.	115	Sharma, H. S.
274.	2373	Tayal, J. C.
275.	2378	Vaswani, N. K.
		16. WEST BENGAL
276.	910	Banerjee, S. R.
277.	962	Banerjee, J. K.
278.	41-Associate	De, K. C.—Representing M/s. Bengal Chemical, Calcutta.
279.	2359	De, Nirmal Chandra
280.	2250	De, P. L.
281.	231	Fielder, C. J.
282.	936	Gupta, S. N.
283.	808	Ghosh, S. K.
284.	2368	Gupta, Ashoke Sen
285.	2369	Iyya, K. C.
286.	1566	Laha, S. K.
287.	38-Associate	Mathur, U.—Representing M/s. Marshall Sons & Co. (India) Ltd., Calcutta.
288.	67-Associate	Mahadevan, M. R.—Representing M/s. United Provinces Commercial Corporation, Calcutta.
289.	488	Nagarkar, D. B.
290.	21-Associate	Patel, L. R.—Representing M/s. William Jacks & Co., Calcutta.
291.	1544	Ray, S. N.
292.	1785	Shah, Z. S.
293.	1010	Sengupta, K. C.
294.	2358	Sarkar, A. K.
295.	1231	Sudhamoy Pal
296.	2357	Verma, Hari Sankar
297.	65-Associate	Wahi, K. M.—Representing M/s. Agrind Fabricating Ltd., Calcutta.
		17. SIKKIM
298.	707	Jali, F. C.
		18. E. C. A. F. E.
299.	*Invitee*	Ahmad, M. S.
300.	*Invitee*	Chiengmai, K. N.
301.	*Invitee*	George Reme
		19. PAKISTAN
302.	1549	Doctor, P. K.

BALANCE SHEET AS AT 30TH SEPTEMBER, 1957.
(Excluding Transport-Communications Monthly Review).

LIABILITIES		Rs nP.	Rs nP.
SUNDRY LIABILITIES			
Creditors for Expenses	20 00		
Income-tax payable on salaries	21 00		
Shri McKelvie's Silver Salver Fund	120 84		
Advance for Publications	82 73		244 57
Subscriptions received in Advance from :			
Ordinary Members :			
1957—58	796 13		
1958—59	114 00	910 13	
Associate Members :			
1957—58 ...		100 00	1,010 13
MITCHELL MEDAL FUND (Invested as per contra) ...		2,154 25	
As per last Balance Sheet ...		48 00	
Add : Interest realised ...		2,202 25	
		0 63	2,201 62
Less : Bank Charges ...			
BUILDING, MUSEUM & TECHNICAL FUND		1,56,210 75	
Balance as per last Balance Sheet ...		1,119 00	
Add : Amount of Life Membership ...		6,101 34	
Interest on Investments ...			
Appropriated from Income & Expenditure Account ...		5,379 65	1,68,810 74
RESERVE FOR BAD & DOUBTFUL DEBTS			10,000 00
DUE TO INDIAN NATIONAL GROUP OF I.A.B.S.E.		1,670 00	
Less : Expenses during the year ...		40 76	1,629 24
PROVIDENT FUND DEPOSITS			32,702 44
PROVIDENT FUND INTEREST DISTRIBUTABLE			
Balance as per last Balance Sheet ...		452 77	
Add : Interest earned ...		772 87	
		1,225 64	
Less : Distributed ...		746 94	478 70
AMOUNT HELD IN SUSPENSE (pending adjustment)			422 76
CHEQUES ISSUED BUT NOT ENCASHED			893 25
DUE TO T. C. M. R.			6,889 50
INCOME & EXPENDITURE ACCOUNT			
Balance as per last Balance Sheet ...		1,24,618 49	
Add : Balance being Excess of Income over Expenditure as per annexed Income & Expenditure Account ...		29,505 16	
		1,54,123 65	
Less: Appropriated to Building, Museum & Technical Fund ...		5,379 65	1,48,744 00
Total ...			3,74,026 95

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

AUDITORS' REPORT.

We have audited the Balance Sheet of the INDIAN ROADS CONGRESS (excluding Transport-Communications Monthly Review) as at 30th September, 1957, 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.,**
Chartered Accountants.

41-L, Connaught Circus.
New Delhi.
Dated, this 25th day of November 1957.

ASSETS		Rs nP.	Rs nP.
EQUIPMENT			
Balance as per last Balance Sheet ...		7,456 92	
Additions during the year ...		407 64	
		7,864 56	
Less : Depreciation written off ...		871 59	6,992 97
LIBRARY BOOKS			
Balance as per last Balance Sheet ...		2,211 00	
Additions during the year ...		282 13	
		2,493 13	
Less : Depreciation written off ...		249 31	2,243 82
DRAWING MATERIALS			
Balance as per last Balance Sheet ...		19 87	
Less : Depreciation written off ...		1 50	18 37
INVESTMENTS			
Rs 6,000/- 5 years Post Office Certificates ...		6,000 00	
Rs 54,000/- 12 years National Savings Certificates ...		54,000 00	
Rs 74,600/- 10 years Treasury Savings Deposit Certificates ...		74,600 00	
Rs 21,200/- 3% Loan 1963-65 ...		20,271 62	
Rs 11,100/- 3½% National Plan Loan 1964 ...		10,984 12	
Rs 3,000/-3½% National Plan Bonds 1967 ...		2,955 00	1,68,810 74
INTEREST ACCRUED ON INVESTMENTS			13,946 34
PROVIDENT FUND			
12 years National Savings Certificates ...		25,700 00	
Interest accrued thereon to 30th Sept., 1957 ...		2,636 25	
Balance with State Bank of India ...		589 89	
Loans Advanced ...		3,694 00	32,620 14
MITCHELL MEDAL FUND			
Rs 1,600/- 3% Loan 1963-65 ...		1,652 93	
Interest accrued thereon ...		16 00	
Balance with State Bank of India ...		532 69	2,201 62
STOCK-IN-HAND			
(Certified as to quantities & values by the Secretary)			
Journals ...		53,449 77	
Paper ...		5,676 90	59,126 67
SUNDRY DEBTORS			
Subscriptions in arrears from :			
Ordinary Members ...		12,528 35	
Associate Members ...		600 00	
Outstandings - Publications ...		1,040 18	
Subsidies Receivable (includes Rs 15,000/- arrears) ...		47,000 00	
ADVERTISEMENTS			
Considered good	2,355 00		
Considered doubtful	360 75	2,715 75	
SESSION EXPENSES RECOVERABLE			
Transport Charges (of which Rs 50/- considered doubtful)	630 00		
Delegation Fees	6,120 00	6,750 00	70,634 28
ADVANCES			
Deputy Controller, Stationery & Printing, Calcutta ...		1,572 62	
Staff (against Cycle Purchases) ...		347 74	
Government of India, Ministry of Transport (Roads Wing)-Establishment of Bullock Cart Committee) ...		72 31	
Bhoop Ram (Daftry) against refund of Ticket (pending with the Railway Authorities) ...		57 25	
Indian National Society of Soil Mechanics & Engineering ...		233 74	2,283 66
CASH & BANK BALANCES			
With State Bank of India ...		5,179 68	
Cheques pending realisation ...		9,986 91	
Stamps in hand ...		1 75	15,1[illegible]
Total ...			3,74,0[illegible]

INDIAN ROADS CONGRESS

Transport-Communications Monthly Review

INCOME & EXPENDITURE ACCOUNT FOR THE YEAR ENDED 30TH SEPTEMBER, 1957.

EXPENDITURE		Rs nP.	INCOME		Rs nP.
To Paper Consumed	...	4,131 56	By Sales & Subscriptions of the Journal	...	3,825 97
,, Printing Charges (including Rs 606/- paid as proportionate salary to Representative at Madras and other incidentals)	...	6,792 50	,, Advertisements	...	9,609 00
,, Postage	...	1,568 60	*Note*:—Subscriptions for unexpired period have not been adjusted in the accounts.		
,, Telephone & Miscellaneous Expenses	...	194 27			
,, Bank Charges	...	94 35			
,, Balance being Excess of Income over Expenditure carried to Balance Sheet	...	653 69			
	Total ...	13,434 97		Total ...	13,434 97

BALANCE SHEET AS AT 30TH SEPTEMBER, 1957.

LIABILITIES		Rs nP.	Rs nP.	ASSETS		Rs nP.	Rs nP.
SUNDRY CREDITORS				**BOOK DEBTS**			
For Goods	...		1,011 30	For Advertisement (of which Rs 222-06 nP are considered doubtful)	...	3,761 56	
				For Sale of Journal	...	33 60	3,795 16
SURPLUS ACCOUNT				**DUE FROM GENERAL ACCOUNT**	...		6,889 50
Balance as per last Balance Sheet	...	11,470 55		**STOCK IN HAND** (Certified as to quantities & values by the Secretary)	...		2,449 91
Add: Balance being excess of Income over Expenditure as per annexed Income & Expenditure Account	...	653 69	12,124 24	**STAMP IN HAND**	...		0 97
Total	...		13,135 54	Total	...		13,135 54

(Sd.) A. J. D'COSTA,
23—11—1957
Secretary.

We have audited the Balance Sheet of the INDIAN ROADS CONGRESS (Transport-Communications Monthly Review) as at 30th September, 1957, above set forth, along with the Income & Expenditure Account for the year ended upon that date and have obtained all the information and explanations we have required.

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

41-L, Connaught Circus,
New Delhi.
Dated, this 25th day of November 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 GENERAL BODY OF MEMBERS FOR THE PERIOD 1ST JANUARY TO THE 31ST DECEMBER 1957

[The report covers the period from the 1st January to the 31st December 1957, though a few matters referred to in it are carried beyond the latter date for convenience and completeness of record].

1. GENERAL

The Twenty-first Session of the Indian Roads Congress was held at Shillong in May 1957 when 272 members and 10 invitees attended the Session. The 10 Papers published in the Journal of the Indian Roads Congress Volume XXI-parts 1 to 4 were read and discussed. Fourteen Committees were reconstituted to deal with various engineering and administrative problems. Three new Committees, one to consider the Prevention of Ribbon Development, the other to deal with Community Projects Road Maintenance and the third to deal with Traffic Engineering were appointed. The Executive Committee held one meeting at New Delhi on the 30th November 1957.

2. ADMINISTRATION

Shri M. S. Bisht, Chief Engineer, P.W.D., Uttar Pradesh was elected President at the Shillong Session. Shri H. P. Sinha, Consulting Engineer to the Government of India (Road Development) continued to function as Honorary Treasurer. Shri Goverdhan Lal, Additional Consulting Engineer to the Govt. of India (Roads) continued to work as Honorary Deputy Treasurer. The Executive Committee at their meeting held on the 30th November 1957 elected Shri D. G. Bhagat, Deputy Consulting Engineer (Roads) as Honorary Deputy Treasurer.

Shri J. Subrahmanyam continued as Honorary Secretary till the 16th May, 1957 when Shri A. J. D'Costa was elected as Honorary Secretary.

3. OFFICE

The office continued to function in New Delhi. It disposed of 9,600 receipts and issued 22,000 letters during the period under report.

The staff worked satisfactorily.

4. MEMBERSHIP

(1) The number of members on the rolls on the 30th September 1957 was 1593 (1556 ordinary and 37 associates). During the year there were 153 new admissions and 54 removals from the rolls. The removals were the result of resignations 26 ; deaths 8 ; non-payment of arrears of subscription 20.

(2) **Life membership** : During the Congress year, 1st October 1956 to the 30th September 1957, 9 members were enrolled as life members. The number of life members on the 30th September 1957, was 142. 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 :

L. N. S. Bibhuty

G. S. Gnana Prakasam

G. P. Sengupta

J. S. Narasimham

S. M. Madbhavi

6. BUDGET

The budget for the year 1957-58 and the "Actuals" for 1956-57 were approved by the Executive Committee at their meeting held on the 30th November 1957. The estimates have been placed before the Council at their 50th meeting. The actuals for 1956-57 show a surplus of Rs 4,131 against an estimated deficit of Rs 15,732.

The total contribution received from the Government of India and State Govts. during the year ending the 30th September 1957 amounted to Rs 40,500. 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 11,500 have been received after the 30th September, 1957.

Part 'A' States were approached in 1949 to sanction annual contribution for five years at ½ per cent of their share from the Central Road Fund or a fixed sum on that basis subject to a

minimum of Rs 2,000. Part 'B' States were also making contributions to the Congress. The question of approaching the States for fresh sanctions as a result of the reorganisation of States, is being examined and they will be addressed shortly.

The arrears of subscriptions at the beginning of the Congress year 1956-57 amounted to Rs 10,117/62 which were due from 203 members. The names of 20 members, who had failed to pay their subscription, were removed from the rolls. Consequently, a sum of Rs 2,025 standing as arrears against these members was written off by the Executive Committee during the year 1956-57.

A sum of Rs 2,485 was realised from 63 members during 1956-57.

After adding the arrears for 1956-57, the total as arrears on the 1st October 1957 stood at Rs 13,128/35 due from 290 members. Efforts are being made to realise the arrears.

7. AUDIT

At the Twenty-first Session at Shillong it was decided to appoint M/s Walker, Chandiok and Co., Chartered Accountants and Auditors, Delhi, to audit the accounts of the Congress for 1956-57. The report was examined by the Executive Committee on the 30th November, 1957. It was also placed before the Council at their 50th meeting on the 4th January, 1958.

8. PUBLICATIONS

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

The balance of the publications on the 30th September, 1957 was as under :

Name of Proceedings	*Volume*	*Balance*
I. R. C. Proceedings	I to VII-parts 1 & 3	Sold out
Do.	VII-part 2	46
Do.	VIII	Sold out
Do.	IX-part 4	118
Do.	IX (Bound)	73
Do.	X-parts 1 to 3	Sold out
Do.	X-part 4	217
Do.	X (Bound)	Sold out
Do.	XI-parts 1 & 2	20
Do.	XI-parts 3 & 4	24
Do.	XI-part 4	156

Name of Proceedings	*Volume*	*Balance*
I. R. C. Proceedings	XII-part 1	6
Do.	XII-part 2	404
Do.	XII-part 3	385
Do.	XII-part 4	445
Do.	XII-part 5	419
Do.	XII-parts 1 to 3 (Bound)	323
Do.	XII-parts 4 & 5 (Bound)	138
Do.	XIII-part 1	274
Do.	XIII-part 2	360
Do.	XIII-part 3	711
Do.	XIII-part 4	Sold out
Do.	XIII-parts 1 & 2 (Bound)	501
Do,	XIII-parts 3 & 4 (Bound)	72
Do.	XIV-part 1	283
Do.	XIV-part 2	372
Do.	XIV-part 3	284
Do.	XIV-part 4	409
Do.	XIV-parts 1 to 4 (Bound)	444
Do.	XV-part 1	713
Do.	XV-part 2	323
Do.	XV-part 3	327
Do.	XV-part 4	394
Do.	XV-parts 1 to 4 (Bound)	479
Do.	XVI-part 1	Sold out
Do.	XVI-part 2	98
Do.	XVI-part 3	115
Do.	XVI-part 4	146
Do.	XVI-parts 1 to 4 (Bound)	553
Do.	XVII-part 1	48
Do.	XVII-part 2	124
Do.	XVII-part 3	Sold out
Do.	XVII-part 4	Sold out
Do.	XVII-parts 1 to 4 (Bound)	640
Do.	XVIII-part 1	Sold out
Do.	XVIII-part 2	6
Do.	XVIII-part 3	28
Do.	XVIII-part 4	122
Do.	XVIII-parts 1 to 4 (Bound)	370
Do.	XIX-part 1	Sold out
Do.	XIX-part 2	20

Name of Proceedings	*Volume*	*Balance*
I.R.C. Proceedings	XIX-part 3	Sold out
Do.	XIX-part 4	45
Do.	XIX-parts 1 to 4 (Bound)	657
Do.	XX-part 1	31
Do.	XX-part 2	22
Do.	XX-part 3	64
Do.	XX-part 4	162
Do.	XXI-part 1	220
Do.	XXI-part 2	383
Do.	XXI-part 3	380
Road Research Bulletin No. 1		102
Road Research Bulletin No. 2		122
Road Research Bulletin No. 3		843
Nagpur Report		915
Paper on "Water-Bound Macadam"		Sold out
Type Designs for Boundary and Furlong Stones		3580
Route-Marker Signs for National Highways		2906
Dimensions and Weights of Road-Design Vehicles		1369
Type Designs for Highway Milestones		1785
Recommended Practice for the Location and Layout of Roadside Motor-Fuel Filling Stations		414
Standard Specifications and Code of Practice for Road Bridges - Section I - General Features and Design		2925
Paper No. 167 - "Design of Small Bridges and Culverts"		22
Lecture on Statistics and Road Research by Prof. K. B. Madhava		16

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

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

On a reciprocal basis, copies of the publications continued to be supplied to several technical institutions in India, the United States of America, the United Kingdom, Australia, Switzerland, Germany, Japan, New Zealand, U.S.S.R., etc. Copies were also sent to the offices of the United Nations Organization in

the Far East. Recently some more Institutions have agreed for the exchange of their literature with our Journals. A list of the periodicals which are being received in the I. R. C. library is given in the Appendix.

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

The members of 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 310 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 June 1957 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) Sign boards at bus stops on National Highways.
(2) Painting of Mile Posts, Caution Boards, Gang Beat Boards.
(3) I.R.C. Standard Specifications & Code of Practice for Road Bridges in India.
(4) Design of Bridges & Culverts.
(5) Specifications for the Rocker Bearings for R. C. C. Bridges
(6) Carrying Capacity of Bridges & Cross Drainage Works.
(7) Specifications for Steel Bridges.
(8) Stone Masonry Arches for Submersible Bridges.

(9) Steel Bearings for Bridges.
(10) Adoption of Metric System in the Classification of Roads and Bridges.
(11) Caution Signs.
(12) Traffic Lines.
(13) Black and White Markings.
(14) Type Designs for Highway Mile-Stones.
(15) Location & Siting of Petrol Pumps.
(16) Rolled Concrete Construction.
(17) Soil Stabilized Roads.
(18) Basis of Road Development Plans.

10. LIBRARY

A large number of technical journals of Institutions in India and abroad were received in exchange for the Indian Roads Congress publications. Some new books and standards of the British, Swiss, German, and the Indian Standards Institution were added to the Library of the Congress. Members can borrow books from the libraries of the Congress, and the Consulting Engineer (Road Development) by writing to the Secretary, Indian Roads Congress. The rules regarding the loan of books are published in Volume XXII-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.

95 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 1,600. Members have to be urged to make more use of these libraries. Photostat copies of any article can be supplied on payment.

11. MEDALS AND PRIZES

The Executive Committee, in their meeting during the Session at Shillong, noted that the Papers Committee had commended the following Paper:

Paper No. 180—"Stabilized Soil Construction in the Formation of Tuticorin—Tiruchendur Road" by E. C. Chandrasekharan and T. S. Chandrasekhar.

12. 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 and Communications. As soon as compilation is complete, the question of its publication will be taken up.

13. MEMBERSHIP OF SOCIETIES

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

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

Shri Goverdhan Lal was nominated in place of Shri H. P. Sinha as the representative of the Indian Roads Congress on the Engineering Division Council of the Indian Standards Institution as the latter was not in a position to continue to represent the I. R. C.

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 ,,	— ,, M. S. Bhatia

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
EDC :— 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) 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 continues to represent the Indian Roads Congress on this Panel.

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

The following represent the Indian Roads Congress :

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

Shri D. G. Bhagat—(Alternative representative)

Scientific Advisory Committee—Shri Goverdhan Lal.

Road Research Committee —Shri J. M. Trehan.

14. TECHNICAL ACTIVITIES

(1) Specifications and Standards Committee

The Committee held meetings on the 15th May 1957. The following subjects were discussed.

(i) Method of Numbering Brigdes and Culverts.

(ii) Specifications for borrow pits.

(iii) Scheme for detailed study of the benefits of road communications in under-developed regions.

(iv) Relaxations in Recommended Practice for the Design for Location and Layout of Motor-Fuel Filling Stations.

(v) Form for recording test values of stone metals.

(vi) Type Designs for Village and place name Signs.

(vii) Tolerances for Indian Roads Congress Standard sizes of Road Stones.

The Committee approved the Standards given at items (i) and (ii) above. These will be published shortly.

Under item (iii), the scheme for a detailed study of the benefits of Road Communications in under-developed Regions, was discussed. It is intended to study the case of the Ramnad-Mandapam Road (N.H. No. 49) which has been recently opened to traffic. It was also understood that a road near Amritsar had been selected for the purpose. The Committee felt that the studies both at Amritsar and at Ramanathapuram should be carried out in close collaboration. A small Subcommittee was set up to go into the details of the Experiments at both the places, to make suggestions and to co-ordinate the work.

Item (iv)—The Committee approved the following amendments to the Recommended Practice for Location & Layout of Roadside Motor-Fuel Filling Stations.

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

Items (v) & (vi)—The Committee approved the form for recording test values of stone metal and Type Designs for village or place name sign. The question of their publication is now under consideration.

Item (vii)—The Committee decided to recommend the tentative adoption of the British Standard on the Definitions of the normal sizes for road aggregates and on tolerances as well as the method for determining the Flakiness index (B. S. 63: 1951). The Committee further recommended that co-ordinated research

should be carried out at the C.R.R.I. and some other road research laboratries before any modifications in the tentatively adopted standards are suggested.

As desired by the Committee, the recommendations were placed before the Council at their 50th meeting held on the 4th January, 1958.

The question of standardising the Affinity Test was entrusted to a subcommittee and the report is awaited.

A specification for $\frac{3}{4}$-in. light chipping tar carpet is under consideration.

The Committee at their meeting in January 1956 discussed the Paper on "The Influence of a Superimposed Layer in Increasing the Load Bearing Capacity of a Rigid Pavement" by Brig. S. K. Bose. The Research Organization Committee 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) investigation regarding temperature stresses in rigid pavements under Indian conditions, and (c) development of heat resisting bituminous pavements. The research will be carried out at the C. R. R. I. The Highways Research Station, Madras, also agreed to conduct research on item (b) above. The results may be awaited.

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. A report of investigation by C.R.R.I. has already been received. The report of Punjab P.W.D. is awaited. The information will enable the I.R.C. to issue a standard for the Design and Layout of Cycle Tracks.

The Standard of Road - Rail Level Crossings were revised in light of the comments of the Committee and have since been forwarded to the Roads Wing of the Ministry of Transport and Communications with a request to finalise them in consultation with the Railway Board.

Some members of the Committee had 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) Standard Form for Recording Traffic Census.

(iii) 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. The views of the Committee are awaited. The Committee held meetings in May and August 1957. Joint meetings of Prestressed Concrete Subcommittee of the I.S.I. and Bridges Committee of the I.R.C. were also held in May and June 1957 to consider the criteria for Prestressed Concrete Bridges.

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) Test Track Committee

The Committee held its meeting on the 11th May, 1957. The following subjects were discussed :

(i) Specifications for the 11th series of tests at the Road Test Track.

(ii) Scheme for constructing a new oval test track at Thakurpukur near Calcutta 4 miles south of the existing test track and of constructing a straight test track on Diamond Harbour Road at Palam.

(iii) Suggestions for future tests. While discussing this subject, the Committee decided as under :

(a) to keep in view the suggestion that instead of using cement for cement-soil bases, brick aggregates might be tried.

(b) Specifications about the use of brick metal in soil mortar used in Punjab should be tested on the test track at Calcutta to see how far they could be used successfully on field experiments in wet areas. It was also considered that similar specifications should be tried on some of the West Bengal roads to see how they behave under actual road conditions.

The 11th series of tests at the Road Test Track will have the following specifications :

There will be 5 test Sections, 4 in the two straight portions and one in the curved portion of the Test Track. Each test section will have the same length.

1. The sub-base in all the test sections will consist of 5 in. thick soil-sand stabilized course.

2. The base course will consist of :

1st Section :

(i) 4 in. thick sand-soil-cement (7 per cent cement approximately) stabilised course.

(ii) Grafting with 10/12 cu. ft. of 1½ in. Gauge Pakur stone metal per 100 sq. ft.

(iii) Priming coat with a suitable Primer.

(iv) 1 in. precoated asphalt carpet with 9 cu. ft. of chips and a seal coat.

2nd Section :

(i) 4 in. thick sand-soil stabilized course mixed with 35 per cent brick ballast of 1 in. gauge.

(ii) Grafting with 7 cu. ft. of 1 in. gauge Pakur stone metal 100 sq. ft.

(iii) & (iv) Same as above.

3rd Section :

(i) The specifications should be the same as for the second section but without stone or brick metal grafting and instead of two-coat surface dressing, the black topped surface should be the same viz., one inch premixed asphalt chipping carpet over a coat of a suitable primer as provided in the first section. It was further decided that the top surface of the two curved portions shall also be covered with

one inch premixed asphalt chipping carpet, over a suitable primer to have uniformity and facility of construction.

4th Section:

(i) 4 in. thick sand-moorum stabilized course.

(ii) Grafting with 7 cu. ft. of 1 in. gauge Pakur stone metal per 100 sq. ft.

(iii) & (iv) Same as those in 1st Section.

5th Section:

(i) 4 in. thick sand-soil-cement stabilised course.

(ii) 3 in. (loose) stone metal W.B.M. course, (curved portion).

(iii) 2 coats of surface dressing to serve as control section.

Tests on Surface Dressing laid on the Delhi-Mathura Road near the Central Road Research Institute, Okhla, (Delhi) had been under study for about 4½ years. A detailed report presenting the details of various specifications together with their cost analysis and service performance received from C.R.R.I. has been referred to the Test Track Committee for their consideration.

(4) Research Organisation Committee

The Committee held a meeting on the 11th May 1957.

It was decided that to facilitate exchange of views and closer contacts with the working of the Research Institutions, it should hold at least one meeting in a year at a place other than Delhi and the place of the Session.

As decided by the Committee, the note on "Calcium Chloride and Sodium Chloride in Soil Stabilization" along with the comments of Members has been published in Volume XXII-3 of the I.R.C. Journal.

The Committee decided that the notes received with the object to decide their fitness for publication in the Journal of the I.R.C. should, in future, be referred to a few referees out of the panel according to the subjects of the research work in question.

The Committee discussed in detail its duties and functions and recorded as under:

To study highway research done in the country and to decide on which subjects research should be carried out and where; to keep an eye on the results of research and on their application and implementation; to consider the general report on highway research along with the discussion thereon at the sessions of the Indian Roads Congress and to take steps for organising further research where necessary.

The Committee also discussed the methods of design of airfield pavements and runways. The representative of E-in-C was requested to formulate specific problems for study by the Committee. The problems are awaited.

While discussing a note on sand bituminous stabilisation for road construction, the Committee at their meeting on the 11th January, 1956 felt 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 carriageway 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 I.R.C. regarding the earmarking at least 1 per cent of the Central Road Fund allocation of each State for equipment and maintenance of road research and testing laboratories in the State has already been considered by the Govt. of India and the State Govts. have been urged to give the matter their careful consideration.

As desired by the Committee, the Chief Engineers of State P. W. Ds. were requested to send annual reports of their road research stations to the Secretary, Indian Roads Congress as early as possible after the close of the year ending the 31st March 1957. The annual reports were studied and a general report has been published in Volume XXII-3 of the I. R. C. Journal for discussion at the Session of the Congress at New Delhi. This is the second research report. The first report on road research published in Volume XXI-3 of the I. R. C. Journal was discussed at Shillong in May, 1957.

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 progress may be awaited. The methods for strengthening concrete pavements and their resistance to abrasion is already under investigation at the Central Road Research Institute.

The specification for the development of heat-resisting bituminous pavements were obtained from the manufacturers of tar and bitumen and passed on to the Central Road Research Institute for further action.

As decided by the Committee at their meeting held on the 14th May, 1955, more information had 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 Committee will be sent to research laboratories after priorities are fixed.

(5) Soil Research Committee

The Committee held a meeting on the 13th May, 1957. The following subjects were discussed.

The Committee discussed a note entitled "A Suggested Classification of Black Cotton Soils of India" by C.R.R.I. The Committee decided that the proposed classification for black cotton soils in India should be adopted provisionally for the construction of pavements and that, based on practical experience, the Road Research Laboratories should suggest modifications by the next meeting of the Committee. The suggestions received from the Road Research Laboratories will be placed before the Committee.

The Committee noted that the subject entitled "Degree of Pulverisation of Black Cotton Soil for Cement-Soil Stabilization" was under investigation at the C.R.R.I. Further progress may be awaited.

The Committee noted that the specifications and practices for stabilized soil base-courses and wearing courses received from various State P. W. Ds. had been passed on to the C.R.R.I. for study and drafting out specifications for adoption in various States. A draft note on the subject was circulated to Members of the Committee with the request to send in their comments on it within three months.

The Committee noted that there was a feeling that although considerable progress had been made in the knowledge about soils and the possibility of their uses in developing low

cost all-weather roads, under suitable conditions, sufficient use was not being made of that knowledge. Certain suggestions were considered. It was agreed that these should be circulated to the members of the Committee for their written comments.

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

The Committee discussed a note on "Soil Classifications for India" by Dr. H. L. Uppal and Shri Bhatia. Members were requested to send in their written comments. It was agreed that the C.R.R.I. would take into consideration the comments of various members, as well as the work done by the Committee previously, and prepare an authoritative note for circulation to members. The record of the studies made in the I. R. C. on the classification of soils for road purposes had already been passed on to the Central Road Research Institute.

With a view to evolve a method of design for thickness of flexible pavements under Indian conditions, a programme for study has been drawn up and the actual investigation is expected to be commenced shortly at the Central Road Research Institute.

As recommended by the Committee, 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 Departments of States for field trials and to various road research stations for trial and comments. This subject was also discussed at the research committee meeting of the Central Board of Irrigation & Power held at Mysore in July 1957 and the specifications were finally approved. As a result of research work in various laboratories, it is more or less established that cement soil can be used for construction of river banks during floods as an emergency measure. It needs further to be established that cement-soil should also be used as a permanent material of construction and in the last meeting of the Soil Mechanics & Foundation Engineering Research Committee of C.S.I.R. a scheme on the subject was approved.

As decided by the Committee, the Central Road Research Institute has been requested to study the economy of the use of Seaman Pulvimixer by conducting full-scale experiments.

As decided by the Committee, the subject of fixation of optimum size of particles of black cotton soil for stabilizing it with cement for sub-grades has been referred to the Central Road Research Institute for study and further action.

The Committee also discussed a report of the work done during 1955-56 in the Roads & Buildings Research Institute, West Bengal.

(6) Education Committee

The Committee held its meeting on the 11th May, 1957.

Following up the reply from the All-India Council of Technical Education stating that the universities could not switch over to the I.R.C. Education Committee's syllabus for Highway Engineering taking up 60 hours of study in the Bachelor's Degree course, an inquiry was made to find out how many hours of study were devoted for this subject at present in the different institutions. Their replies indicate that 3 out of the 4 institutions have already more than 60 hours' duration for Highway Engineering in the curriculum of their degree course in Civil Engineering. It is now proposed to recommend the substitution of the existing syllabii with syllabii prepared by the Committee pointing out advantages of an uniform training method in all the colleges.

2. A draft syllabus of study prepared by Shri K.K. Nambiar for Diploma Courses in Highway Engineering for including in the diploma courses for overseers and supervisors is under circulation amongst the members of the Committee and will be finalised after discussion during the Committee meeting.

3. A syllabus for the M.Sc. degree examination in Highway Engineering at Punjab College of Engineering, Chandigarh, who have curtailed the period of study, from their original plan of 16 months to one year, is under circulation at their request amongst the members of the Committee for comments. This syllabus and the one adopted by the Roorkee University this year, will be studied by the Committee at their next meeting. It is intended to draft a standard syllabus for post-graduate course in Highway Engineering.

4. The Committee noted that Refresher Courses for Highway Engineers working in Highway Departments were being conducted at Roorkee and were proposed to be conducted at Madras and also at Chandigarh. The Committee had requested the Chief Engineers' meeting last year to endorse to the various State Governments the need for a liberal participation of Engineers in Refresher Courses.

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

(7) Provincialization of Local Bodies Engineering Services Committee.

The Committee held a meeting on the 13th May 1957.

The Committee noted that the Ministry of Transport and Communications, Roads Wing had addressed the State Governments on the subject of the provincialization of engineering services of Local Bodies. The Government of India have expressed 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.

The Committee requested that in view of the fact that some of the State Govts. are actually considering provincialization of the Engineering services of local bodies, the Council of the I.R.C. should recommend to State Govts. that the engineering services of Local Bodies be placed at par with the other engineering services of the State by placing such personnel under a State P.W.D. Chief Engineer in a common Cadre.

The Council at their 49th meeting held on 16th May, 1957 expressed the view that the State Govts. themselves were likely to take into consideration the length of services 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 State Chief Engineers.

The Committee expressed the opinion that factual data relating to works carried out by the different Local Board Engineers in various States, and particulars relating to the road works such as budget, milage, etc., is of great importance. The Committee felt that in addition to the questionnaire issued by the Ministry of Transport relating to rural roads, it was necessary to have detailed information relating to the service conditions of the Local Bodies Engineers in the various States. They, therefore, requested that the Indian Roads Congress pursue the matter and obtain from the various State Governments their annual reports relating to the administration of works carried out by the Local Board Engineering personnel.

(8) Manufacture of Road Making Machinery and Mechanization Committee.

The Committee held a meeting on the 12th May, 1957.

The Manufacture of Road Making Machinery and Mechanization Committee at its meeting noted the manufacturing programme of the three units which have been established in India for the manufacture of steam and diesel road rollers. One unit has already started producing road rollers and the other two units are expected to bring their road rollers in the market shortly.

The Committee also noted the progress made so far in regard to the indigenous development of stone crushers/granulators industry in India.

Another important subject examined by the Committee was to investigate the suitable equipment to handle supplies of Bitumen in bulk. The advantages claimed are the saving in costs, frequent and quick deliveries of hot bitumen in bulk.

The Committee also expressed the view that the present methods of laying asphaltic carpet should as far as possible be replaced by mechanical methods on account of its advantage of quality control resulting in longer life for the road and the service value. The Committee passed a resolution in which it has been urged that all the State Governments and the Central Government should use as far as practicable complete asphalt surfacing plant from Crusher to Finisher depending on the work to be undertaken.

(9) 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 experiments 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 Session held at Nagpur in January 1956. It was also circulated widely among technical experts for comments.

Necessary modifications in the design of the experiments were made in the light of the comments and discussions 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. The 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 at its meeting held on the 14th May, 1957 considered an interim report containing the results of the analysis of the data received. The Committee recommended that the experiment should continue for a period of 2 to 3 years more, the scope of the experiment being broadened by the inclusion of earth roads and that the expert advice of Oil Companies should be obtained by the Bombay State Road Transport Corporation regarding the condition of engine oil after different milages are covered.

The Bombay State Transport Corporation have agreed to continue the experiment till the end of March, 1959, while a reply from U. P. is still awaited in this direction. The U. P. State Transport have intimated their inability to extend the experi-

ment on unmetalled roads while necessary action is being taken by the Bombay S. T. C. to include the earth road surface in the experiment. The Bombay State Transport Corporation have further asked for the expert advice of the four leading oil companies of Bombay as to the condition of engine oil after different milages.

The Committee have further received daily data for 9 months from U. P. and for 10 months from Bombay in addition to the daily data for 12 months from U. P. and monthly data for 6 months from Bombay already received earlier. The analysis of the combined data is under progress.

(10) Cement Concrete Road Surfacing Committee

A meeting of the Committee was held at Shillong on the 14th May, 1957.

The finalised answers of the Panel Discussion prepared by the Committee were considered along with the comments made by some Council Members and required amendments were circulated for comments by the members. Now these answers are being endorsed by the Committee for purposes of publication.

A form of questionnaire for condition survey of concrete roads in India was circulated with a view that collection of information of some typical lengths would help appraising the adequacy or otherwise of the present standards of design and construction for modern traffic. Comments from the members will be discussed at the next meeting of the Committee.

(11) Road Transport Development Committee

A meeting of the Committee was held at Shillong on the 14th May, 1957.

The Committee has prepared a report suggesting ways and means to increase the road transport capacity both on a long-range basis and implementation of the Second Five-Year Plan. The report was considered by the Council at their 49th meeting on the 16th May, 1957. As decided by the Council this report was examined by the Executive Committee at their meeting held on the 30th November, 1957.

(12) Stabilized Soil Roads Committee

The Committee has been constituted to inspect the Stabilised Soil Roads already laid in the Punjab and other places and to give an assessment of the usefulness of the technique on the basis

of service value given by these roads in relation to the first cost and subsequent maintenance, and in the background of prevailing traffic, climatic and subgrade moisture conditions.

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

15. MISCELLANEOUS

(1) PAPERS

8 Papers were received during the year. 11 were already in hand. Out of these 19 Papers, 7 were accepted for publication, 4 were returned for revision, one was accepted as a note, 2 were rejected, and 5 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 are requested to constantly bear in mind that the knowledge they have acquired must be passed on to their fellow-Members and that a record must be kept for the benefit of posterity in the Journals of the Congress or the Transport-Communications Monthly Review.

The Council should also suggest to Members, especially the senior Members, that they should encourage the taking of notes and photographs during the progress of important works with the object of writing Papers for the Journal of the Congress and for contributing articles to the Transport-Communications Monthly Review.

(2) TEST VALUES OF ROAD STONES

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

(3) POINTS ARISING OUT OF PRESIDENTIAL ADDRESS—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

draft memorandum on the following subjects should be prepared for consideration by the Council.

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

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

(4) INDIAN 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 and Communications, Roads Wing and the Indian Roads Congress for some years. The aim of such a group is 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. Accordingly, a Committee consisting of representatives of the Govt. of India, Ministry of Transport and Communications, Railway Board, E-in-C, C. W. & P. C., C.P.W. D., Business interests, was constituted to draft a constitution of the Indian National Group of the IABSE. The Committee at its meeting held on the 13th May, 1957 finalised the constitution. It was later considered and adopted by the General Body of persons interested in this Group at their meeting held on the 15th May, 1957. The formation of the Indian National Group has been brought to the notice of Central and State Governments and other organisations interested in it. The Constitution of the Group has been published in Transport-Communications Monthly Review for September, 1957 and in Volume XXI-part 4 of the Journal of the Indian Roads Congress.

(5) PANEL DISCUSSION ON SURFACE DRESSING

A questionnaire on Surface Dressing was discussed during the 19th and 20th Sessions of the Indian Roads Congress held in June, 1955 and January, 1956 respectively. The discussions and written replies were studied by the Central Road Research Institute and note on the subject has been received for discussion by the Specifications and Standards 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 Engineer.
7. British Road Federation (Bulletin).
8. Bulletin Technique De la Suissee Romande (in French).
9. Bulletin of the Central Building Research Institute, (India).
10. Bulletin of the Institution of Engineers (India).
11. Bulletin of the Permanent International Association of Road Congresses.
12. Bulletin of International Association for Bridge & Structural Engineering.
13. Burmah Shell News.
14. Central Board of Irrigation and Power Abstracts.
15. Commonwealth Today.
16. Concrete Quarterly.
17. Contractors Record and Municipal Engineering, U.K.
18. Cement (in Dutch).
19. De Ingenieur in Indonesia (in Dutch).
20. De I'nstitut 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, Bangalore.
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.
75. The News in Engineering (at the Ohio State University).
76. Research & Industry.
77. LE Strade (Italy).
78. Chartered Civil Engineer (Bulletin of the I.C.I., U.K.)
79. Journal of the National Buildings Organisation.
80. Documentare Technica.
81. International Road Safety & Traffic Review.
82. Geophysical Digest.
83. La Technique Rottiere.
84. African Roads & Transport.
85. Traffic Engineering (U.K.)
86. Road Safety in India.

Minutes of the 51st Council Meeting of the

INDIAN ROADS CONGRESS

held at New Delhi on the 8th January, 1958.

The Council met with Shri M. S. Bisht in the Chair.

Present

M. P. Apte
J. K. Banerjee
S. K. Bose, Brig.
N. D. Daftary
N. Durrani
C. J. Fielder
H. R. Gupta
S. N. Gupta
V. V. Gopalakrishna Ayyar
R. K. N. Iyengar, Dr.
B. S. Jootla
Kishore Lal
W. X. Mascarenhas
S. R. Mehra
E. A. Nadirshah
S. C. Nayak
B. Prasad
K. Sinha
S. N. Sinha
D. C. Sharma
G. C. Sharma
N. Sinha
H. P. Sinha
P. Sirajuddin
Sujan Singh

P. L. Varma

A. J. D' Costa—Secretary.

The following co-opted Members attended :

M. S. Ahmad
Goverdhan Lal
Hardayal
P. D. Shivdasani

The following attended by invitation :

R. S. Bhalla
U. J. Bhatt
R. N. Dogra
G. C. Khanna
S. K. Ghosh
Hukam Singh

A. D. Dhingra

Harbans Swaroop

1. Co-optations 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 50th Council Meeting.

The Minutes of the 50th Council Meeting held at New Delhi on the 4th January, 1958 were confirmed.

3. Office Bearers.

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

President	—W. X. Mascarenhas
Vice-Presidents	—J. M. Rijhwani D. C. Sharma Sujan Singh
Honorary Secretary	—A. J. D'Costa

At this stage, the newly elected President, Shri W. X. Mascarenhas took the Chair.

4. Venue of the next Session.

The Council accepted with thanks the kind invitation of the Government of Andhra to hold the next Session of the Indian Roads Congress at Hyderabad in December, 1958 or early January, 1959. The Executive Committee was authorised to fix the dates and programme of the Session.

5. Committees.

The Convenors of Committees were appointed as under :

(1)	Specifications and Standards Committee	Goverdhan Lal
(2)	Bridges Committee	S. L. Bazaz
(3)	Test Track Committee	R. C. Roy
(4)	Research Organization Committee	H. P. Sinha
(5)	Soil Research Committee	Director, CRRI
(6)	Education Committee	E. A. Nadirshah
(7)	Provincialization of Local Bodies Engineering Services Committee	Fateh Chand
(8)	Papers Committee	H. P. Sinha
(9)	Manufacture of Road Making Machinery & Mechanization Committee	R. S. Bhalla
(10)	Organization Committee	H. P. Sinha
(11)	Road Operation Cost Committee	N. D. Daftary
(12)	Local Committee of the Test Track Committee to supervise Delhi-Mathura Road Tests	Director, CRRI
(13)	Cement Concrete Road Surfacing Commmittee	E. A. Nadirshah

(14)	Road Transport Development Committee	Dr. F. P. Antia
(15)	Traffic Engineering Committee	D. G. Bhagat
(16)	Prevention of Ribbon Development Committee	H. P. Sinha
(17)	Community Projects Road Maintenance Committee	K. K. Nambiar

6. **Action on points arising out of Presidential Addresses.**

Various suggestions were made in order to ensure that the recommendations made in the Presidential Addresses are given due consideration by the Central and State Governments. Some of the points brought out were:

(i) The Council should meet more frequently.

(ii) The suggestions made in the speeches should be referred to the existing Committees if they fall under their purview; otherwise, new Committees may be appointed in order that they could examine the suggestions in detail for further course of action.

(iii) The possibility of discussing road problems with the Chief Ministers and P. W. D. Ministers and even arranging a Conference of P. W. D. Ministers in order to put before them forcefully the views of the Congress should be examined.

(iv) The work of publicity should be carried on throughout the year.

(v) The Secretariat of the Indian Roads Congress should be strengthened in order to cope with the increased activities of the Congress.

7. The Council decided that the Technical Secretary to be appointed by the Indian Roads Congress should be either a Senior Executive Engineer or a Superintending Engineer. The Chief Engineers of States should be requested to suggest the names of officers whom they consider suitable for this post.

8. The Council passed a vote of thanks for the excellent work done by the Executive Committee and the Secretariat of the Congress during the year.

Discussion on Paper No. 199 *

"Construction of A Bridge Across Pennar River At Nellore"

By

J. V. PRASAD

Sunday, 5th January, 1958.

Shri B. Prasad (Chairman) introduced Shri J. V. Prasad (Author) and called upon him to introduce his Paper.

Shri J. V. Prasad said that the Paper described the general features of the bridge and gave details of its construction. Difficulties encountered during the construction had also been enumerated. The bridge was tested before it was opened to traffic. The behaviour of the superstructure was very interesting and the conclusions arrived at were embodied in the Paper.

Shri S. Pal wanted to know the reasons for the following deviations from the Indian Roads Congress Bridge Code.

(i) Roadway was 22 ft instead of 24 ft for N. H. bridges catering for double lane traffic.

(ii) Clear headroom provided above H. F. L. was 4.12 ft against 5 ft minimum as per requirements of the Indian Roads Congress Bridge Code for a discharge of over 1,00,000 cusecs.

He also wanted to know whether the river was tidal at the bridge site, which was only 15 miles from the sea.

Further, he desired that tests results of laterite rock which served as foundation might be stated, if available, to compare with pressure on foundation allowed in the design. Also, the minimum thickness of such rock stratum as was considered safe for bridge foundation might be mentioned.

The south abutment was very high, about 41.5 ft from foundation to road level. He wanted to know if it would not have been more economical to adopt R. C. counterfort type abutment and tied-back return walls or, in the alternative, to

* Published at pages 19-73 of the Journal of the Indian Roads Congress, Vol. XXII-Part I, November, 1957.

add one more smaller shore span and adopt open-type abutment with no return-walls, allowing the earth to spill through and round the abutments?

He requested the Author to state if any special anti-corrosive measures had been taken to prevent rusting of the M. S. plates of the bearings.

Sliding plate bearings were usually recommended for comparatively small spans and in cases where the intensity of pressure did not exceed 400 lb per sq. in. of sliding surface. He wanted to know the capacity of the bearing in this case. The sliding surface was only 21 in. by 4 in. or 84 sq. in. and the safe load at the rate of 400 lb per sq. in. worked out to only 15 tons per bearing. If the design load coming on a bearing was higher than 15 tons, which was most probably the case, it would be worthwhile to know how the bearings were behaving at present.

There were only four cross-beams per span, two at the ends and two at the third points. As these were, for all practical purposes, pure and simple stiffeners he would like to know if it would not have been better to leave a gap between the cross-beams and the deck-slab so that the deck-slab remained uniform all through the span. The stiffeners could easily be made deeper for greater rigidity.

The Author might enlighten whether the contractors had supplied their own equipment. If any departmental work was done, it might be interesting to compare finished item rates with those quoted by contractors assuming that the departmental work was done by daily or monthly paid labour.

The speaker desired to know if for day-to-day observations of the longitudinal centre line of the pier wells in deep water, any special contrivance was adopted for the reference line on the spot, as the temporary islands would get disturbed with the progress of well sinking.

Pier No. 21 was resting on well foundation at R. L. 11.80 but the adjacent pier No. 22 which was only 70 ft away had open foundation with major portion of the foundation at R. L.+27.00 and only a small portion at R. L.+16·00. How was it ascertained that this sudden change in the type and depth of foundation was quite safe to be adopted in a major bridge with a design discharge of over 6,00,000 cusecs?

It might be explained if the cutting edge angle 6 in. × 6 in. × 1½ in. was intact in all the wells during sinking. In West Bengal, from bitter experience of the cutting edge angle getting

badly twisted and consequently spalling off the embedding concrete from the R. C. curb, these angles were now being generally fitted with the vertical leg pointing upwards i.e., the cutting edge of the well became somewhat blunt but there arose no trouble during actual sinking on account of loosening and twisting of the angle.

It might be explained how the passages where sand blowings occurred were detected and packed with empty gunny bags and steel wedges. It appeared that the passages were not closed up after sand blowing had ceased.

He also enquired whether the central well was sunk first and then the two outer wells, or they were all sunk simultaneously. As distance pieces could be inserted only at the top of the steining but not at any depth below the water level, the speaker wanted to know how the bottom portions of the outer wells could be prevented from coming closer to the central well.

The maximum tilt or shift that had occurred in any well might be stated. It would be interesting to know how often the wells were dewatered. The maximum tilt and shift which was allowed to remain might also be mentioned.

He enquired whether any well was tested under load and if so, whether it had been tested before plugging or after plugging and in what manner. It might also be made clear whether the accepted rate of Rs 135 per rft. was for each separate well or for three wells together. It had been stated that the actual cost of sinking in sand was about Rs 50 per rft. Assuming Rs 6 per diving hour, it might be explained whether the well could be sunk by 1 ft in sand in 8 diving hours.

Referring to bottom plug, the speaker stated that dewatering after one week appeared too risky. The Author might state whether he had found any leakage through the plugs. If so, whether this was measured. The maximum head of water acting on the plug, when completely dewatered, might also be stated.

Reasons for unsatisfactory plugs, if known, might be stated. The small springs at the bottom of wells could pierce through the concrete whatever be the method adopted for laying it. If there was any advantage in using the steel box it might be explained.

To prevent the porosity of the freshly laid concrete caused by the action of small springs, he wanted to know whether it would not have been better to fully refill the plug pockets with water immediately after the concreting of the plug was completed.

Positions and sizes of cracks might be explained. It was presumed that 1 : 3 : 6 concrete was used for extra plug laid on detection of cracks in the steining after normal plugging and dewatering. This might be confirmed.

Provision of sufficiently deep haunches say 12 in. × 12 in. would probably have prevented the cracks at the curbs.

He wanted to know whether the Author would advocate the system of sand filling in layers with watering and ramming where the depth of well was quite appreciable say above 50 ft or 60 ft. In this connection he would also like to know the magnitude of the hydrostatic pressure at the base of the well plug during the fully dewatered stage of a very deep well.

It appeared that all the capping slabs were cast above low water level (about R.L. 28.00). How could all the capping slabs of wells be concreted only in the driest part of the year ? The margin above the low water level might be given. It required clarification whether this was one of the reasons why it took five years to complete the bridge.

For ease of sinking and for eliminating tilts and shifts, he wanted to know whether a composite well would not have been better than a set of three or even two independent wells ? The concreting of the capping slabs then became easy by erecting a light cofferdam built on the periphery of the well itself. He requested the Author to enlighten whether in any other bridges in his state composite type of wells with double or triple pockets had been adopted and, if so, the relative merits and demerits as regards cost and practical execution might be given.

He also wanted to know whether it was for any practical convenience that pier shutters had to remain for the complete height of the piers. These could have been easily utilised for concreting other piers after sinking of wells within three days or so.

The consolidation of concrete by iron rods might be explained and it should be stated whether the cement concrete was done in a similar manner as lime concrete. Also, it might be mentioned whether vibrators did not suffice for 1 : 3 : 6 concrete.

What was meant by mass concrete in cement mortar 1 : 3 might be elucidated.

Referring to superstructure, he stated that there were four R. C. Tee beams 21 in. × 89½ in. (overall) for 71 ft spans and 20 in. × 71 in. (overall) for 61 ft spans. It appeared that considerable economy could have been made by making the rib of T-beams I-shaped.

Referring to scour meters he stated that if the pipes were filled up with silt previously these might not be cleared even during heavy scours. Then the probe rod might not work. Also, if the probe rod got down into a scour hole it might afterwards be filled with silt and as such it might be difficult to pull it up to the normal position later on.

He wanted to know the time-gap allowed between the earth filling at the back of the abutment and the concreting of the approach slab. The present condition of the 6 in. thick slab might be given and it might be stated if any allowance was made for sinkage after a lapse of time of that end of the slab which was removed from the bridge.

Shri N. C. De enquired why a unit of three wells for pier foundations was considered more advantageous than a single well of bigger size. Usually a single well could be sunk more quickly than a unit of three and tilts and shifts could be rectified with less difficulty.

On page 36 of the Paper, tilts and shifts occurring in wells had not been mentioned. In actual practice tilts and shifts, however small, must be present. So he wanted to know the maximum tilts and shifts developed during the course of sinking and how far they were rectified and how much was allowed to remain. He also wanted to know whether any of the residual shifts required slight adjustment in span lengths.

From Fig. 8, page 33, it was observed that the edges of the wearing course at the expansion gap were not given any protection. Actually, after some time, the so called " resilient filler " would be depressed and the wheels were likely to damage the edge lines by hitting directly on them. So he wanted to know the precautions which were taken to prevent this.

In para 7. 3. 16, page 38, it had been stated that some well steinings had developed cracks in the corners. The bending moment due to the horizontal pressure developed on dewatering subjected the outer face of steining at the corners to tension. It might be that the concrete failed under this tension and the cracks thus developed on the outer face appeared in the inner face. He wanted to know if the maximum tension thus developed, was actually calculated and found to be within allowable limit.

Shri M. D. Seth asked if the helmeted sinkers remained inside the well while sand blowing took place, to determine and seal the passages of sand blow. Usually the sand blowing was so sudden and in such large quantities as to result in a watery

grave of the workers inside the well. How was this guarded against ?

He also wanted to know the process adopted for giving a blast of gelignite and whether the charge was suspended in the dredge hole and blasted or whether the gelignite charges were put in the holes drilled in the wells of the dredge hole. He requested the Author to give the details of the precautions taken to prevent damage to the steining during blasting.

The Author had mentioned that the outer wells had a tendency to draw towards the central well. Nothing had been said about the tendency of the wells to tilt and shift in other directions. He wanted to know if this tendency was absent altogether or it could be fully controlled. If so, what method proved most efficacious and what was the maximum tilt and shift observed in the wells.

He also wanted to know the safe limit for tilts in the wells adopted in this case.

The actual cost for sinking the wells in clayey soils had been reported to be as much as Rs 400 per cu. ft. He wanted to know if this figure represented the average cost of sinking through clayey strata or it represented the average when dewatering was not possible or the absolute maximum in any particular reach of clayey soil.

He also wanted to know the average cost of sinking per rft. through clayey soil in this bridge.

The Author had mentioned that the wells in most of the cases were found to be watertight. What were the measures adopted in cases where the wells were not found watertight ? He also desired to know if the steining of the wells showed complete watertightness on dewatering. If not, the measures adopted might be stated. The Author had mentioned that the causes of the cracks in the steining could not be ascertained. Could they not be due to jumping and falling of the wells during blasting by gelignite ?

Two beams had been reported to be concreted in one day. He requested the Author to mention the place and nature of construction joints in the cross beams. He also requested him to state whether they were stepped sloping or vertical joints and whether the smooth surface at the joints was scarified before laying the next stage of concreting. Also it should be stated if the concrete was laid in layers or in one lift upto the bottom of the fillet. The factors taken into consideration for deciding the system of concreting should also be mentioned.

The interval between the concreting of deck slabs and beam ribs also needed mentioning.

Shri K. C. Sen Gupta requested the Author to give the following information :

(i) The guiding factors for cutting into 2 ft depth of laterite rock in open foundations.

(ii) Fig. 5—Well No. 17 : The reasons of piercing through the 9 ft of soft rock and not less.

(iii) Plate II : The reasons for not tapering the bed block for piers for 71 ft 0 in. spans at the ends whereas in 61 ft 0 in. spans they were tapered.

(iv) The material used for resilient filler in the gap of expansion joints (on copper sheets).

(v) Tell-tale blocks : Whether the resistance to abrasion was the same as of the wearing course ? How the top was made to be in line with the camber given to the surface ? Their positions in respect to the width of the roadway and the intervals at which they were placed ?

He also wanted to know what was actually meant by " Variation in top of the wells was also made in the plugging ".

He felt that hand railing panels could have been cast more conveniently by placing the mould horizontally.

He was also of the view that the vertical grating should have been lowered a bit below the surface of wearing course for preventing stagnation of water.

Shri M. P. Apte stated that, in his opinion, an ideal site for this bridge was upstream of the railway bridge, between the railway bridge and the anicut. There appeared to be a belief among railway engineers that new bridges should not be allowed to be constructed on the upstream side of their existing bridges. On account of their insistence, many excellent sites were often forbidden. 'Pennar' bridge appeared to be one such example. The site to the upstream of the railway bridge had a well defined narrow course between the railway bridge and the anicut. Moreover, location of the bridge to the upstream of the railway bridge would have saved reconstruction of about two miles of approach roads. Two railway level crossings, which would always be a source of nuisance and delay to the heavy vehicular traffic on this important National Highway would have been

avoided. When a road bridge was safe 300 feet downstream of the railway bridge, it was not understood why the safety of the railway bridge was in danger due to the construction of a road bridge, say, about 400 feet upstream of the railway bridge.

The railway bridge had a linear waterway of 2210 feet. It was interesting to note that this conforms to I. R. C. formula for linear waterway, i. e., $2.67\sqrt{Q}$. He was, therefore, interested in knowing the scour depth calculated for the railway bridge to see if it also conforms to the I. R. C. practice.

To avoid cross currents and development of eddies etc., at the instance of the railway authorities, the same number and size of spans as of the railway bridge were adopted for the road bridge. There was a distance of 300 feet between the railway bridge and the road bridge. A little change in the spans, therefore, in his opinion, would not affect the current of a big river. The spans of the railway bridge were designed for different loadings, different construction materials and under different working conditions. It was, therefore, evident that adoption of the same spans for this road bridge was not at all an economical proposal. It would be better if, for future designs, advice was sought from the Hydro-dynamic Research Stations about the minimum distance from an old bridge beyond which spans of a new bridge might not strictly follow the spans of the old bridge.

Even assuming that cross currents and eddies would have developed if piers for the road bridge had not been in line with the piers of the railway bridge, it would have been possible to drop alternate piers by increasing the spans to 142 feet and 122 feet instead of 71 feet and 61 feet as provided. The fact that there was a difference of more than 70 feet between the bottom of the foundation and the top of the pier warranted the use of longer spans for this bridge for effecting economy. In his opinion, a bow string girder or a balanced cantilever design with double the spans would have been cheaper than the T-beam design with shorter spans as adopted by the Author.

The strata met with in the foundations had been described as black clay, yellow clay, green clay, etc. A more scientific classification according to the principles of soil mechanics would be more useful for comparing the different types of strata.

He requested the Author to enlighten on the scour depth as calculated in the design. According to the I. R. C. Bridge Code, the scour depth worked out to about 81 feet at the noses of the piers and the grip to be provided should therefore be 27 ft as per Clause 110 (e) (i). The foundations resting on clay should have gone much deeper than R. L.—12 as provided. This point required clarification.

For 77 feet spans, plate bearings had been adopted. The actual expansion in this length of concrete due to a temperature variation of $\pm 30°F$ worked out to about 0.328 in. In his opinion, for this length of the bridge, plate bearings were not suitable. Concrete bridges of 77 feet spans were quite heavy. The frictional forces operating through the plates would be quite large, particularly when, with age, the plates would have a tendency to rust and stick more. There was also a danger of corrosion in the presence of moisture from electrolytic action between the copper and steel plates. A roller bearing was, therefore, advisable and particularly it was essential on the abutments. There had been cases where the abutments had been pulled towards the river bed, due to the defective functioning of such plate bearings. The plate bearings as provided on 'Pennar' bridge would not allow for any rotational movement caused at the bearings due to the deflection of the span at the centre on account of the live and dead leads. This difficulty could have been solved by the introduction of a lead plate in between the two copper plates. The lead plate was easily compressed on one side when the span deflected and was recommended by many Authors. He would also like to add that to avoid corrosion and electrolytic action between the copper and steel plates, stainless steel plates could be used, if the cost of securing such plates was not prohibitive.

It appeared that, to effect economy, the roller bearings were changed to plate bearings at a later stage, perhaps after the piers were started. The coefficient of sliding bearings was 0.15, which was nearly five times that of the roller bearings originally provided. With a maximum dead and live load reaction of about 260 tons, there would be a longitudinal force of 39 tons. The bending moments on piers and wells upto scour depth due to all longitudinal forces were so high that it was doubtful if any check was at all made for the stresses in the piers and wells due to these longitudinal forces added with wind and water loads.

On page 36, para 7.3.3, it was stated that upto 15 ft depth sinking was done under water by divers without any equipment. How long did the divers stay under water without any equipment and how much sand did they excavate at a time? Also, it should be stated whether that did not cause undue strain on their lungs.

It was mentioned in para 7.5.7, on page 40 that the railing was done with cement conorete 1 : 2 : 4 with 3/4 in. granite jelly. The material "granite jelly" might be defined.

In para 7.3.8, page 37, it was stated that there was a tendency for the outer two wells to draw closer towards the centre well because the space between the wells was not uniform, i.e. 3 ft at the top and 2 ft at the bottom. He did not agree with

this. Actually the wells were too near each other and therefore the soil between them was bound to be loose. The wells would, therefore, draw nearer even if this distance was uniform.

In para 7.3.16, on page 38, mention was made about the cracks developed in the steining. The reason for this appeared to be the excessive stress developed in the walls of the square wells on account of the heavy bending stresses due to the pressure of the saturated soil and water when the well was dewatered.

On page 48, para 9.4, it was mentioned that machinery and materials worth about Rs 2 lakhs were either submerged or washed away due to the heavy unexpected flood. He requested the Author to clarify whether all this machinery and material belonged to the piece workers or the Government and whether Government compensated for these losses as the work was said to have been carried out departmentally through piece workers.

The results of the test loading were really very instructive and interesting. The conclusions arrived at the Pennar Bridge could be verified by other authorities in their constructions. Some work in this respect could also be entrusted to the research laboratories, so that future designs of four beam bridges could be made on a more scientific basis.

Shri Fateh Chand enquired as to why the waterway of the railway bridge, close by, was adopted for the road bridge.

About foundation, he wanted to know if 4 ft depth of plugging was tried and whether it was not found to be sufficient.

In most cases in certain State P.W.D. a reinforced concrete capping was provided as there was unequal settlement over the well steining and concrete plugging over sand. Any special reasons for not providing it in this important bridge might be stated.

Piers and also abutments were made in 1:3:6 cement concrete. Substantial savings in cost could have been made by using brick in 1:5 cement mortar and thereby a large quantity of cement could have been saved. He wanted to know what kind of coarse aggregate (laterite or granite) had been used in mass concrete and reinforced concrete work of substructure and superstructure respectively.

Foot-paths had been made 9 in. higher than the roadway against the usual height of 7½ in. This might be clarified.

It should be stated if the wing walls were made separate from the abutments to allow for unequal settlement of abutment masonry resting on well foundations and of wing wall masonry on less stable foundations, or both were made simultaneously.

In the latter case, whether any crack was noticed at the joint as was usual. He also wanted to know if the wearing surface was laid along with the decking or separately. In the former case, a thickness of 2 inches instead of 3 inches should have sufficed. 1:2:4 ratio was found to be generally strong enough in most cases. Any special reasons for using $1:1\frac{1}{2}:3$ mix should be stated. The cross slope given from the centre of the roadway to the kerbs should be mentioned. At what points and distances were tell-tale blocks provided?

Rushing out of sand from below the well kerb in dewatering appeared to be the cause of cracks in well steining. All wells did not develop such cracks because only in a few cases the velocity of water and spring were powerful enough to scour sand from below the kerb, which did not happen in all cases. Dewatering was not usually required for filling sand nor was it necessary according to the theory or practice of ramming sand in layers of 2 ft or 1 ft.

The Author was requested to say whether the iron bars could not be hooked or tied with a lap of 40 times diameter to obtain the necessary bond instead of welding, as was done in most cases to increase the length.

Filling-up of iron grating with dust could be avoided by fixing the gratings vertically or by continuing the slope of bottom of sprout at 45 degrees below the horizontal grating.

Reinforced approach slabs did not appear to be absolutely necessary and most of the bridges in India were doing well without relieving the abutments of the live load, which these slabs were meant to provide. Abutments, were strong enough to take such loads.

Only one or two marble tablets at the left end of one abutment on each side with a few particulars only such as datas and depth of foundations etc. should have sufficed, instead of 8 with pedestals.

Sri A. S. Bishnoi stated that the Author had mentioned, under plugging, that a steel box with shutter at bottom was used. It was presumed that it was open on the top. The steel box should have a top cover to prevent floating of mortar. Since the wells were inspected after dewatering he would like to know if any layer of cement was found over the top of the plugging.

The Author had mentioned that the use of 'tremmie' was abandoned in favour of the steel box. He felt that the plugging with tremmie was not found to be satisfactory because it was done in the dewatered well. He wanted to know whether the

tremmie was used with water in the well or not. Generally the tremmie gave better results, if properly used, than the steel box as there was much less disturbance of water in the former case.

The next point was about the sand plug. He wondered whether the care and extra expenditure in sand plugging was justified.

Theoretically, there was no harm if no sand was filled in the well and it was filled with water instead, because the sand did not help in transmitting the load in any way. The capping slab on top of the well rested on the steining and transmitted loads directly to it.

As far as he knew, 70 ft span was the limit for using plate bearings. The mild steel plates would get rusted in due course of time and would offer great friction to the movement of the span. He found that a copper plate had been given between the two mild steel plates. He would like to know if this copper plate had been fixed to one of the plates or not. This fixing was considered necessary as the copper plate was likely to move with the top plate when the span shortened and might not go back when the span resumed its length. The repetition of this process would cause progressive motion of the copper plate which might result in its being completely thrown out.

Shri N. S. Gupchup said that it had been stated that the object of the test was to subject the various members of the structure to the designed stresses, and that since there was no direct method of measuring stresses, they could be checked by measurement of strain, by observing deflections at critical points. It had to be remembered that deflection at a point was a cumulative effect of the loading on the entire span and depended on the manner of the distribution of the loading, physical properties of the beam and Young's Modulus of concrete, and it was not synonymous with strain.

During the test, uniformly distributed load was applied to beams to produce the designed bending moment in them and the corresponding deflections were noted. It was mentioned in para 11.5.1, that when all the four beams of the span were fully loaded, the deflection recorded was only 62 per cent of the calculated value. This statement was likely to create an impression that the stresses under the fully-loaded condition were also proportionately less than the designed stresses, which was not the case. The reason for the apparent difference in the two deflections was obviously due to the difference in the value of 'E' adopted for computation and the actual value of 'E' of concrete at the time of the test.

It was also stated that under the fully loaded condition, no cracks were noticed. This phenomenon alone did not give any index of the magnitude of the stresses in the beams; it only indicated that the stresses in the soffit—even if tensile—were below the cracking limit of the behaviour of the beams.

The test had, however, helped to throw light on a very important aspect, viz. the distribution of the loading amongst the various beams of the span and emphasised that the distribution depended on the transverse eccentricity of the load. The usual assumption followed also in the design of this bridge whereby the load transferred to individual beams was assumed to be equal to the static reaction from the slabs was definitely fallacious and led to incorrect results.

With a symmetrical loading all the beams participate more or less equally in sharing the load; but conditions changed when the loading is eccentrically placed.

Courbon's Eccentric Factor attempts to estimate the longitudinal bending moments in the beams under conditions of eccentricity, but makes no allowance for transverse bending moment due to transverse stiffness and tortional rigidity of the structure. There was a general tendency to pay a greater attention to the longitudinal bending moments only and the effect of transverse and tortional stiffnesses was often ignored. The present trend was to take into account both these factors and make adequate provision for bending moment in the transverse direction. This resulted in a more balanced and a sounder structure providing at the same time an economical design on the whole.

Shri K. S. Devarajan* stated that the foundation levels of the wing walls and abutments were varying. So he requested the Author to clarify whether any vertical construction joints were provided at the junction of the wing walls and abutments or at change of levels.

Provision made for drainage in the abutments and wing walls might be mentioned.

As one looked towards the bridge from the downstream side, marks of water trickling were seen on the sides of the T-beams. Whether this was due to want of sufficient projection and slope of the drainage spots was a matter to be examined and necessary remedy provided.

Shri Devarajan wanted to know if all the wells were sunk truly vertical and whether there was any cant and shift, and, if

* This and subsequent comments were received in writing.

so, to what extent? The limitations adopted for the cant and shift might also be stated.

Bottom plugging of wells was stated to be of 6 ft depth. The operation of laying the plugging might be described, whether the concrete was pre-measured and the number of mixes regulated to give the exact depth of 6 ft, or whether the quantity calculated to give 6 ft depth was laid, in which case, there would be a bulkage of nearly 40 per cent, as concreting was done under water without tamping, which meant the plugging was done to a greater height. He would like the Authors to enlighten him on this point.

He desired to know whether the wells were absolutely watertight. For what duration was the observation of leakage made? As it was felt that it was impossible to get a watertight seal by the method adopted, it might be stated whether there was any sweating even when the well was completely dewatered.

Regarding sand plug, it is stated that 1 ft of sand was dumped, levelled and watered till the sand became completely wet. What was the indication that it had become completely wet? If it was that when water appeared at the surface, then it would not be possible to consolidate it appreciably further with iron rammers. For the capping slab, how was a hard base obtained for the capping slab at the portions between the wells? Was it laid simply on sand?

The necessity for a drip course in the bed blocks right through at the projections beyond the pier was not apparent.

For the reinforcement of the deck slab, for the end 2 ft of the span the spacing of main rods were to be half the normal spacing of main rods, but the drawing did not show as such. This would need clarification.

Details of constitution of the mix and position of the telltale blocks and also if they would not form a hindrance to traffic in due course might be stated.

Shri Ziauddin Ahmed stated that as the deck system consisted of main beams, cross beams and slab, integral with one another, the design method stated in para. 11.4.4 was irrational. This had been demonstrated by the Author's load test observations and his conclusion.

From para. 11.4.5, it appeared that the nature of the applied load was symmetrical about the bridge axis and the test results showed that the deflection in the inner beam was 10 per cent more than that in the outer one; i.e. 0.11 : 0.10. Therefore it might not be quite correct to conclude that " for all symmetrical

loading.....all beams carried practically equal loading". As all the beams were assumed to have equal stiffness as in para 11.5.5, symmetrically applied load should give equal deflection in each beam, if Courbon's theory of eccentricity is to hold good.

He agreed with the Author that Courbon's eccentric factor for the end beams was on the safe side. Courbon's method contains two assumptions, (i) the method is applicable when the ratio of length of breadth is at least 2, and (ii) due to transverse stiffness, the transverse deflection profile is a dead straight line. But as a matter of fact, inspite of the transverse stiffness, as the deck system was an elastic structure, Courbon's eccentric factor gave over-estimated values for the outer beams.

It would be appropriate to point out that another recent method, namely, the "Distribution Coefficient" method of structural analysis advanced by Morice & Little in the booklet, 'The analysis of light bridge decks subjected to abnormal loading' (1956), published by the Cement & Concrete Association, England, was a rational method for designing such a superstructure. A few of the assumptions in the 'Distribution Coefficient' method are noted below:

(a) The deck system consisting of main and cross beams with the deck slab, is an elastic structure.

(b) Flexural as well as torsional properties of all the components of the structure are taken into consideration.

(c) Due to live load placed symmetrically, all the beams do not carry exactly equal loads.

Shri J. V. Prasad (Author) in reply to the points raised by **Shri S. Pal** said that the cutting edges in some wells had gone out of position. This was observed when the wells were sunk in hard disintegrated rock. The cutting edges were fixed to the bond rods of the well curbs at the bottom. The bond rods got sheared and the cutting edges had gone out of position. But there was no difficulty in sinking the wells since the cutting edges could be dismantled into four parts and removed. The Author agreed with Shri S. Pal that by fixing the cutting edge with the vertical leg pointing upwards the tearing away of the cutting edge from the curbs could be prevented. He also said that this was being done for the bridges under construction.

Referring to the next point regarding sinking of wells the Author said that the three wells of a pier were sunk simultaneously. Tilts and cants were observed but maximum tilt observed

was never more than 3 inches. The wells were not test loaded but when the capping slab was laid levels were taken and checked after the construction of piers and again after the superstructure was completed. No settlement of wells was observed. The accepted rate of Rs. 135 per rft. was for a single well and not for all the three wells of a pier. The cost of sinking wells in sandy soil reported as Rs. 50 in para 7.3.12 was the average rate worked out for sinking the wells to about 20 feet in sandy soils. The first five feet could, however, be sunk at the rate of Rs. 10 to 12 per foot depth.

As regards the points raised relating to the plate bearings the Author said that the bearing stress in the contact plates would be 2295 lb per sq. in. and the bearing pressure on the concrete would be 605 lb per sq. in. These stresses were considered to be safe. He said that the bearings were behaving quite well.

Regarding the scour meter, the Author stated that he did not think that the pipes would get filled up with silt. Further, there was no need to pull up the probe rods to normal position. The scour meter was meant to show the maximum scour that takes place in any heavy flood.

Replying to **Shri N. C. De** the Author said that he did not think there would be any damage to the edges of the wearing coat at the expansion joints. If the resilient filler gets depressed the same could be filled up again upto road level.

As regards the comments of **Shri M. D. Seth** the Author pointed out that sand blow in wells occurred only during the dewatering of wells. No divers would be working in the wells at that time. The divers would be sent in only after the complete operation of pumping was over. As such the danger of watery grave due to the blow was not there.

Regarding the method adopted for the blast with gelignite the Author stated that it was enough if the gelignite was just dropped in the centre of the well. That would shake the water enabling the well to sink.

About the cost of sinking in clayey soils the Author said that Rs. 400 per rft. reported in para 7.3.12 was the maximum cost observed.

Referring to the explanation given for the cracks in wells the Author stated that he was of the opinion that the cracks were not due to the gelignite blast. The cracks were not observed in many wells where gelignite blast was given.

Regarding the construction joints during the concreting of the T-Beams, the Author said that vertical construction joints

were given at one fourth length of the span of cross beams. The vertical faces of the joints were scarified before laying the next stage of concreting. The interval between concreting of the deck slab and the ribs of T-Beams was one day. Concreting for the beams was done in layers and not in one lift upto the bottom of the fillets. The Author was of the opinion that laying the concrete in one lift was not practicable.

Replying to **Shri K. C. Sen Gupta,** the Author said that the foundations were taken 2 feet into laterite rock only to see that the foundations did not get exposed due to scouring.

As stated in para 7.5.2. it was proposed to use "N" type trusses made out of Callendar Hamilton Bridge parts for centering to augment the work during the flood season. To provide seating for these trusses the bed blocks were left flat at ends.

For the resilient filler, bitumen, sand, cement and saw dust were used.

Regarding the Tell-tale blocks these would have the same resistance to abrasion as the wearing coat since the proportion of the mix for both was the same. Further, the depth of wearing could be calculated only by the increase in dimensions of the block at top due to its wearing which was the same as of the wearing coat.

Replying to the querry about the variation in levels of the top of wells the Author explained that all the three wells of a pier could not be sunk exactly to the same level. So there would be slight difference in levels in the top of the wells after sinking. These variations had to be made up before casting the capping slabs. This was done in top plugging.

The hand railing panels could not be cast placing the mould horizontally since some parts of the panels had sloping shape.

The Author did not agree with **Shri M. P. Apte** that the upstream side of the bridge would have been an ideal site. He said that the P. W. D. Anicut situated at about 2 furlongs from the Railway Bridge was about 12 feet high and there would be about 20 to 30 feet drop of water during the floods. This might have caused heavy scours if the bridge had been built on the upstream side. Also, the construction of two miles long approaches would have been in any case inevitable to by-pass the congested towns of Kovur and Nellore on either side of the river. Also it would have necessitated construction of well foundation for all piers since laterite was not available on the upstream side of the bridge. Due to this, the cost of the bridge would have gone up considerably. The Author agreed that spans of 142 feet and 122 feet would have been more economical.

Regarding the longitudinal force on the piers due to expansion of the superstructure, the Author stated that since all the 8 movable bearings were fixed on one pier and all the 8 fixed bearings on the alternate pier the longitudinal forces due to expansion would be equal and opposite at each pier and so there was no need to design the piers for the stresses due to expansion.

The Author appreciated the suggestion made by Shri M. P. Apte to improve the plate bearings.

Replying to the querry on well sinking by divers without any equipment, the Author said that the diver was able to stay under water for 2 to 3 minutes. Each time the diver excavated about 3/4 cu. ft. of sand.

By granite jelly it was meant only granite metal. Granite metal below 1 in. size was generally described as granite jelly.

The Author did not agree with Shri M. P. Apte that cracks in wells were due to excessive stresses developed in the walls of the wells on account of heavy bending stresses due to pressure of saturated soil and water when the wells were dewatered. Dewatering was done for all the wells. But cracks were observed only in a few wells.

Replying to **Shri Fateh Chand** the Author stated that welding of reinforcement rods was cheaper than lapping. Also lapping required wider rib to accommodate the rods.

Replying to **Shri A. S. Bishnoi** the Author stated that the steel box used for the bottom plugging was provided with a tarpaulin cover on the top to prevent floating of mortar. About 2 in. to 4 in. thick layer of cement was seen in the dewatered wells over the bottom plugging.

About the plate bearings the Author said that the copper plates were bent downwards at the ends of the bottom contact plates. So there was no chance for the copper plates to move with the top plates of the plate bearings.

The Author agreed with **Shri N. S. Gupchup** that the difference in the value of "E" adopted for computation and the actual "E" of concrete at the time of concrete might be the cause for the recorded deflection of 62 per cent of the calculated value when all the four beams of the span were fully loaded.

In reply to **Shri K. S. Devarajan**, the Author stated that vertical construction joints were provided at the junction of wing walls with abutments for the northern side abutment since

the wing walls were concreted separately after the abutment was constructed. But in the case of the southern side abutment, concreting for the abutment and the wings was done at one time in a contineous process. As such no vertical construction joints were found necessary.

The proportion of the mix of the Tell-tale blocks was the same as that of the wearing coat. They would not cause hindrance to traffic since the Tell-tale blocks also would wear out along with the wearing coat.

The drip coarse was required only at the ends for the bed blocks but for the sake of uniformity the same was provided right through.

Weep holes were provided in the abutments and wings above the ordinary flood water level for drainage in the abutments and wings.

The quantity of concrete calculated to give 6 feet depth of bottom plugging was laid through the steel box. The Author confirmed that there would be 30 per cent to 40 per cent of bulkage. This would give greater depth of bottom plugging.

About leakage in wells the Author stated that few wells were found leaky when dewatering was done. For such wells the wells were again filled up with water and bottom plugging was done for one foot extra depth. This proved very successful.

Bricks were laid and plastered over with cement mortar in between wells for laying the capping slab. Oil was applied to the plastered surface to prevent the same sticking to the capping slab.

Holes were left in the concrete and all the drainage spouts were fixed at a latter date when all the spans of the superstructure were completed. During that period water was trickling through the holes. Shri K. S. Devarajan might have observed the marks on the beams due to this. After fixing the spouts no trickling of water was observed on the beams.

The Author thanked **Shri Ziauddin** Ahmed for the valuable information given by him relating to the "Distribution Coefficient" method of structural analysis.

Shri B. Prasad (Chairman) congratulated the Author for the interesting Paper. He also thanked the various speakers who took part in the discussion.

Discussion on Paper No. 200*

"Asphalt Paving Mixtures—Their Design and Composition"

By

NORMAN H. TAYLOR, M.SC. (Eng.), A. M. I. C. E.

Monday, 6th January 1958.

Shri N. H. Taylor in introducing the Paper said he had tried to approach the problem of bituminous paving mixtures from the view point of the man who was familiar with soils. By a bituminous paving mixture was meant a dense mixture which had a life of 15 or 20 years and sometimes very much more. There were few dense carpets in India; therefore, very few people in India were interested in dense carpets and consequently they were not studied, specified or laid.

In a country like India materials were changing very rapidly in nature and quality from place to place and it was most dangerous to take some of the formulae or recipes for asphalt mixtures developed in other countries and try to apply them to Indian conditions. Attempt had been made in this Paper to show how the best mix could be built from whatever materials were available. Some specifications, particularly the American one, give a grading curve of which examples were shown in this Paper. They would also suggest a range of bitumen proportions which would include the optimum bitumen proportion. Attempt had been made to show how an engineer with comparatively simple apparatus could ascertain how much bitumen he should use. Test results were given in the Paper both in the form of tables and diagrams but a comparison between any table and the corresponding diagram would show that the diagram enabled the engineer to visualize exactly what was taking place within the mixture with changing bitumen content. The intelligent application of the knowledge of climatic and traffic conditions would enable the engineer to choose the optimum bitumen content for the materials and grading covered by the chart or to discard the whole series if no suitable mixture was obtained. Shri Taylor hoped this logical approach to the problem would be found helpful.

Shri K. S. Sankaran said that the design of a dense graded asphalt mixture could be expressed in a nut-shell as follows: Use as much asphalt as possible provided it satisfied the stability requirements.

* Published at pages 135 to 194 of Vol. XXII-2 of the Journal of the Indian Roads Congress.

Some of the stability tests now available were rational in their approach but in the ultimate analysis they became empirical in nature. Also, correlation between laboratory data and field performance was necessary. A very simple unconfined compression test as suggested by Shri Swaminathan in his Paper presented at the Nagpur Session would suffice after establishing a correlation between laboratory tests and field performance as per Indian conditions.

The dense graded mixture was the highest type of asphaltic carpet but it was also more critical than an open graded mixture as far as asphalt content and gradation of aggregate was concerned and good control was required in its manufacture, placing and compaction. Again, a dense graded mix was more of a semi-rigid type. A more flexible premix with a proper seal coat based on practical experience would probably be more suitable for Indian conditions on account of the iron-tyred vehicles.

In Western countries it had been established beyond doubt that for the same traffic intensity and subgrade conditions the cost of dense graded asphalt mixture was of the same order as a concrete pavement. The choice of one pavement or the other depended upon other factors, among them the availability of materials, riding qualities of surface, etc.

In India, more of labour was used than machinery in the construction of concrete roads and therefore the construction of concrete roads would invariably be cheaper than that of a dense graded asphalt concrete under identical conditions. Hence cost would not be the deciding criteria in the choice between concrete and dense graded asphaltic pavements.

Shri S. A. Swami sought clarifications on the following points in the Paper:

The author had not specified any particular minimum values for the stability of the paving mixtures both for sheet asphalt and asphaltic concrete, in the Taylor's stability test. It would also be worthwhile to know how the Taylor's minimum stability values compare with the minimum values stipulated in Hubbard-Field, Hveem and Marshall's stability test for any one particular mix.

On page 168, under series F, it was seen that when 30/40 penetration bitumen was used in place of 60/70 "the exceptions are that swelling and water absorption in the leaner mixtures are

reduced when 30/40 grade of bitumen is used and that the stability and resistance to deformation are better maintained in the richer mixtures of F series ". Further on page 190, under 12.2(d), it was stated that " an alternative is to use a hard bitumen at these locations ". In a reference by Hews and Oglesby, it was given that the latest tendency in the U.S.A. is to use a softer grade of bitumen which resists the action of weathering better, resulting in less cracking. Though this was a highly controversial question, the Author might throw some light on this point.

It was interesting to note the effect of compaction on an asphalt paving mix, as given in page 185, under para 10.3, that the additional compactive effort (namely, 50 blows on each side) had increased, reduced and unchanged values of stability and resistance for lean, normal and rich mixtures respectively, this fact being also observed in series F. B. on page 168. While the behaviour of lean and rich mixtures under increased compaction is understandable, the reduction in stability and resistance in the normal mix seems contrary. The Author may please explain this phenomenon. Further, since compaction plays an important role in a dense mix, it was necessary to achieve in the laboratory the same or near about degree of compaction as that under the roller in the field for the same mix. Among the various methods resorted to for compacting the mix in the laboratory, it was claimed that the kneading compactor gives a comparable compaction to that under the roller. The Author might give his experience on this aspect, and if kneading compactor had been tried with the Taylor's stability apparatus, how it affected the stability values.

Finally, it might be asked that since the Taylor's stability sample is $1\frac{3}{4}$ inch thick, what is the limit to which it can successfully be used for mixes containing stones of maximum size above $\frac{3}{4}$ inch for thicker layers of asphaltic concrete.

Shri Basant Singh stated that the Author had brought out very valuable information in this Paper for the road engineer. He only wished to touch some points on the actual execution side of the work in the field based on his personal experience. He had found that after a time with the effect of traffic and the summer heat the bituminous surfaces in some cases developed waviness. Also during rolling it was found to be most difficult to avoid corrugations inspite of adopting cross and side rolling on wide roads. Even the tandem roller did not help very much. On the sloping portions the riding surface at some places became so skiddy that it caused serious accidents. In addition, there were unavoidable delays in the process of mixing and laying the sheets and carpets with the present available machinery.

To meet the needs of the Punjab, they had tried to evolve some other suitable specifications for their conditions and carried out experiments. Some of these are mentioned in the Punjab Engineering Congress Paper No. 246. These specifications were given further trials and the built-up spray grout specification was evolved. This built-up grout method was also successfully applied in the case of brick metal. Cores taken from the road showed very good results and in fact the roads where this specification had been used were still behaving well after a lapse of a good number of years.

The built-up grout specification according to him was the cheapest and quickest and till such time as foreign exchange was standing in the way of purchasing machinery like batching plant, mechanical mixers, spreaders etc., and until Indian made machinery was not available in the market, one had to depend on such a specification as was easily adaptable to Indian conditions and had been well tried and found to be more or less foolproof.

Shri C. G. Swaminathan observed that it was high time indeed that Indian engineers thought in terms of dense carpets which in the long run were more durable and more economical than the conventional open-graded pre-mix.

The Author had advocated his own stability test, known as Taylor's stability test, for the design. But opinions differed widely on the choice of the proper test for the design. Some preferred Hubbard-Field, some Marshall's and some other stability tests. All these were empirical tests and the choice was based on one's opinion and fancy. The triaxial test, if at all there was any, was the nearest approach to a rational method of design. Even there opinions were divided.

Since experience was the keystone for any empirical method of design, it was obvious that the stipulated stability values should have a definite bearing on actual field performance. The Author who had a considerable experience could tell what were the stability limits that he would suggest for different tonnages of traffic. These had not been mentioned in the paper.

In the Paper, both a stability requirement and a deformation resistance were stipulated. Stability value was taken as the load to give a deformation of 0·2 in. while resistance to deformation was taken as the increase in pressure required to cause a deformation of 0·01 in. It was doubtful whether both were necessary.

On page 173, the Author had said that for the series H-B, the stability values were similar to those of F-B, but the resis-

tance values were not. The Author had not given the reason for this. Perhaps this was due to the fact that whereas the resistance to deformation is indicative of the inherent resistance within the mixture, the stability value is indicative of the flow characteristic. But then with about 25 per cent of stone would the interlocking effect of the stones play their part?

From page 156, para 6.3, it was seen that there could be four different gradations. Were these four gradations (given in Fig. 6) for different traffic intensities, or were they based on actual gradations of the sands available in those States?

In the typical calculation given on page 157, the Author had calculated the percentage V.M.A. as = sum of air voids (12) and volume of bitumen (14). This may not tally always with the V.M.A. actually determined.

Again, in the calculations of air voids, apparent specific gravity had been used. Now-a-days, it was customary to base calculations either on bulk specific gravity or on bulk impregnated specific gravity—the latter being preferable as it takes into consideration the percentage of absorbed bitumen. It had been found that if the percentage of air voids in a mixture based on apparant specific gravity is about 5 per cent, and if absorption is ·5 per cent, the nett percentage of air voids based on bulk impregnated specific gravity would work out nearly to about 2 per cent. This meant that based on the apparent specific gravity the design was O.K. but based on the bulk impregnated specific gravity, it was not.

In addition to the percentage V.M.A., it was also customary, from the point of view of workability, to fix the percentage of voids filled with bitumen. For if the value of V.M.A. in a given graded mix was about 10 per cent, by allowing about 5 per cent, it may be possible to get the minimum requirement of air voids, but then the mix may not be workable.

In the Table on page 157, against serial No. 26, swelling was shown as 20-7. Could it not be expressed as a ratio such as 23/11? It was felt that the swelling induced in the sample as a result of vacuum of pressure was likely to be very severe.

On page 168 (para 7.7) and on page 185 (para 10.2), the Author had compared the effect of different degrees of compaction. It was well known that all types of stability tests were very much influenced by the compactive effort given to the test specimen. It had been claimed that for the Marshall stability test up to 75 blows may be necessary. The nearest to the field method of compaction that could be obtained so far in the laboratory was only with a kneading compactor. However, it had been noticed in almost all cases that higher the compactive effort the higher would be the stability. But on page 185, the Author had mentioned that with the normal mixture the stability is reduced. It was understandable in the case of the lean mixture that the stability is increased and also that in the rich mixture it is unchanged. But the reason for reduction in the case of the normal mixture was not clear.

On page 173, the Author had recommended the use of a hard grade such as 30/40 bitumen, especially at places where high stresses were liable to be developed. Would the same reason hold good for roads having predominantly bullock cart traffic which produces much greater stresses at the surface than even a heavy lorry?

On page 168, para 7.5, the Author had observed that with 30/40 bitumen swelling was very much reduced. Would the Author throw some light on the reasons for it?

While comparing graphs on pages 166 and 171, it was noticed that in the former all the lines become more or less tangential at about 0·2 in. deformation, whereas it is not so at 0·2 in. deformation with F 3, F 4 and F 5 on page 171. So it was felt that instead of stipulating the load at 0·2 in. deformation it may be taken to stipulate the stability at 0·1 in. load.

Shri M. B. Jayawant stated that most of the asphaltic concrete specifications mention the gradation of the aggregates and the asphalt contents by weight. This puts the entire specification on weight basis which does not always give the best results. He fully agreed with the Author that the asphaltic concrete design should be on the volume basis.

Dealing with the basic specifications for the asphaltic concrete mixtures, it was found that more due to tradition than data based on analysis, the practice had been to specify the use of filler in all the asphaltic concrete mixtures from 8 to 15 per cent. For many blends of aggregates, the addition of mineral filler was not always essential to give a satisfactory mix. The specifications should lay down the limits for voids in the mineral aggregates, which might be about 15 per cent, the final air voids in the compacted mix which might vary from 3 to 6 per cent, and the stability of the mix. These three conditions together with a relatively wide grading bands constitute the fundamental requirements of a good design. The cost of the asphaltic concrete rises because of narrow range of gradations as specified in this Paper. On the basis of the above conditions, the wider gradation could be used and the mix made much cheaper.

Another point the Author had not mentioned was the volume of asphalt absorbed in the aggregates while calculating the air voids. Unless this absorption factor was also considered, the volumetric approach of the asphaltic concrete design would not be complete. Moreover, since the values for voids in mineral aggregates and voids filled with asphalt in a compacted mix depend on the value selected for the specific gravity of the aggregate—whether bulk specific gravity, apparent specific gravity, or impregnated bulk specific gravity—and the consideration of the absorption factor, these were important factors which must be taken into account when designing the asphaltic concrete mix.

Dr. Bh. Subbaraju said that one of the most controversial points in the design of the dense carpet was how to assess correctly the void content in a compacted mixture, which was the main basis for the design of the dense carpet. In this there were different schools of thought. Some people adopted apparent specific gravity and some bulk specific gravity and still others bulk impregnated specific gravity. One view is that bitumen is not going to fill the voids in the aggregates and so bulk specific gravity should be taken. Those who adopt the apparent specific gravity think that the voids are going to be filled with bitumen. The point that is nearer to the reality, to his mind, was that if a method could be evolved by which the specific gravity could be found after mixing the bitumen then it is immaterial what percentage of pores in the aggregate are left out. A method evolved in this direction was presented in the Highway Research Board Proceedings, 1955. According to this method, the mix had to be prepared according to the design and then to be loosely spread on a table. The specific gravity of the mix as a whole was to be found out by adding 0.1 per cent of aerosol solution to distilled water and then following one of the usual methods for finding the specific gravity of any road stone. But the actual procedure which most of the organisations adopted was the individual gravity either based on apparent or bulk gravity and then finally arriving at the specific gravity of the mix. He thought the method suggested for directly finding the specific gravity of the mix by adding aerosol or any other agent which could reduce the surface tension was a very useful one.

The Author had stated on page 149 that for finding the specific gravity of the sample in case of a porous sample, the weighing must be quick. He felt that the procedure of coating the sample with wax in order to find out the specific gravity was very useful, especially in the above mentioned case. The only caution, if necessary, was that the specimen should be immersed at the correct temperature of the paraffin wax, i.e., between 52 to 54 deg. C. for coating with paraffin. When

it was intended to rip off the paraffin wax from the specimen, if it was immersed in a water bath at about 110 deg. F., it could be pealed off like the skin of an orange, and the same sample could be used again for any stability test that was contemplated.

Shri O.S. Sehgal wanted elucidation from the Author on a few points.

Referring to para 2.2 he said that in the case of water-bound macadam type of pavement, which was to be covered with a higher type of surfacing, one should not be discouraged because of the fact that there is a possibility of the water table rising to quite a high extent and the plastic material underneath getting back into plastic stage and thereby impairing the structural stability of the road. One should always try to choose the higher type of surfacing material and at the same time try to safeguard against the possibility of ingress of water from the bottom by providing a blanket course.

Referring to the literature available on the work done by Mr. Betson, he had worked out two examples and had tried to compare the specifications as given in BSS-594-1950. He had found that there was not much of discrepancy between the mixes, depending on the climatic conditions whether it was a dry stage, medium stage or a very wet stage. He felt Mr. Taylor's method was more of a trial and error basis where any gradation of aggregate that is available was just taken and mixed. But the alternate as he felt was that efforts should be made to confine the mixes nearest to the BSS-594. The specifications he had worked out required stone 65 per cent, bitumen 5.6 per cent and fines 29.4 per cent. If this was compared with the specification given in BSS-594, (Table 11, page 22), 65 per cent of stone, 5.2 to 6.2 per cent of bitumen and 28.8 to 29.8 per cent of fine aggregates were required and there was not much of a difference between the two.

Reference had been made as to the possibility of treating the bitumen filler base or the fine aggregate bitumen base as a mortar which would depend on the surface area. Shri Taylor had said that it had been proved that the surface area of the aggregate had no bearing on the amount of mortar that was required. He had mentioned on page 177 that "the omission of material intermediate between sand and stone was thought by many engineers to render the mixture less harsh and to assist compaction". He personally felt that there was a clear indication that the system of compaction had given better workability, thereby the extent of surface area had been decreased by the amount of area to be coated. Hence there was better compaction which was directly the consequence of better workability. He personally felt that

it was not correct to make a general statement of such a nature.

Shri G. C. Sharma* stated that in the synopsis the Author had stated that the design of paving mixture was based on the analogy of soil and cement mixture. Workability dictated the selection of the grade of asphalt to be utilised and the grade of asphalt in turn dictated the design procedure of the paving mixture. The same conception as for hot mix asphaltic concrete design could not be applied in the design of liquid paving mixture. So, he suggested that while designing paving mixture and its control, the subject might be divided into three parts, viz., (1) Design of liquid asphalt paving mixture, (2) Design of asphaltic concrete and (3) Field control of road mix and oil processed mixture. There was no test developed so far for determining the workability, but experience in mixing would enable to judge the harshness, stiffness or gumminess of the mixture. Harshness might be reduced by mixing a low percentage of coarse aggregate, stiffness by low percentage of sand and filler and gumminess by lowering the percentage of asphalt content and filler.

The criteria of design and control of Asphalt Paving Mixture as developed by the United States Army Engineers were: (1) Flow, (2) Percentage voids in total mix-compacted, (3) Stability, and (4) Percentage of voids filled with asphalt. The following were the limitations which give satisfactory asphaltic concrete mixture validated by the traffic behaviour which might be taken into consideration while designing paving mixtures in India. Their findings were :— Stability at 140° F at 500 lb minimum by Marshall Stability Test, flow value not more than 20, percentage of voids of the total mix 3 to 5, and the percentage of voids filled with asphalt 75 to 85. A mixture having flow value more than 20 proved to be unsatisfactory regardless of stability.

In para 4.5, the Author had laid more stress on the importance of water resistance. The degree of swelling was of great importance to judge the suitability of the mixture for resisting water effects. To determine this quality, the Public Roads Administration in U.S.A. had developed the "Immersion Compression Test" which evaluated the water resistance properties of complete mixtures as well as of the individual material contained in them. So, he suggested that this test should be tried which would supply more physical characteristics of the mixture and the results obtained correlated with other results.

In review of the test results, the Author had stated in para 12.2 (g) that the quantity of bitumen which can be used in an

* This and subsequent comments were received in writing.

asphaltic mixture is determined by the voids in the aggregates and has no relation to the surface area of the aggregate. One of the most important problems in design of paving mixture is the determination of actual amount of bitumen content for the mix. Out of the two main methods of determining the oil contents viz., (1) Void content and (2) Surface area, the surface area method developed by the California Highway Department gives very satisfactory results as regards stability, durability and economy. Shri Wagner of New Mexico University had analysed 40 samples taken from the road surfaces by extracting the oil content from them, worked out and compared the results on theoretical calculations of eight available methods viz., (A) by oil ratio from New Mexico formula, (B) by the modified New Mexico formula, (C) oil by Mckesson formula, (D) oil by Stanton formula, (E) Mean Wyoming formula, (F) minimum oil by surface area, (G) Mean oil by surface area, and (H) Maximum oil by surface area, and found that the surface area method developed by California Highway Department was the only method which satisfied all the above requirements along with the behaviour of the traffic.

The samples had been tested for stability with the Taylor Stability Machine. Of course, he did not know how it worked in comparison to the other tests. But it had been found that with the exception of triaxial, none of the tests measure any particular physical properties of the mix but rather a combination of all the properties including those peculiar to the testing device employed. Therefore, each of them required a long period of service correlation to establish a criteria for various pavements for which they were used. The triaxial test which measures the angle of internal friction and cohesion of the mixture was not gaining favour for bituminous works due to the large size of specimen required and time consuming operation. For this reason, Dr. Caleron of Mexico city had tried a method by getting the results from Unconfined Compression test and Normal Shear test and then plotting them as Mohr Circles. A Mohr envelope is then developed which gives the value of internal friction and cohesion.

Shri K. P. Nair stated that the hardness of a stone was seldom an imporant factor in the wearing properties of the finished surface. The soft aggregates were likely to get crushed under traffic, expose uncoated area surfaces, give an entry for water, cause stripping of the binder and result in the failure of the road.

In a premix, the bitumen film was comparatively thick, but the film in a dense asphalt paving mixture was thin and in the presence of water its adhesion to the mineral matter might break down and the mixture would then rapidly disintegrate. In a

dense carpet water would not accumulate as in an open graded premix, and the possibility of adhesion failure was more in an open graded premix. It is also said that the thinner the film the better the adhesion. Again the degree of compaction obtained should be comparable to that obtained with modern machinery on the roads. He wanted to know how that was checked.

Referring to the Fig. 18—Grading curve for a city in India, he wanted to know its basis. Referring to stability he stated that it might be high when the air voids were over 5 per cent (3 to 5 per cent was the limit as given in page 148). He wanted to know if there was any relation between per cent voids and stability.

Shri N. H. Taylor in his reply to the discussion stated that in his Paper he had tried to cover the fundamentals of the subject in such a way that directions for research could open up and that the researcher would tackle his problem well equipped.

Several speakers had questioned the method of stability testing used and suggested that simple unconfined compression tests or triaxial tests might be substituted. The reason for using the Taylor test in the research described was simply that he had been using that test for the past twenty-seven years and the machine was available. He preferred this method of testing to others because (a) the test piece was similar in thickness to that of the material laid on the road, (b) the test piece could be readily compacted, (c) the loading and its effect were measured and not the resistance of the sample to increasing deformation as was the case with the Marshall and the Hubbard-Field tests, (d) if the sample was confined in a ring, the results obtained could be compared with the results obtained on actual road surfaces, (e) as the deformation was measured from the commencement of the test, the effect of the repetition of low pressures could be studied. The test was, of course, empirical but so were the Brinell Hardness Test and the California Bearing Ratio Test—the latter test was similar to the Taylor Test.

Shri S. A. Swami had asked if a kneading type of compaction had ever been employed and with what results. When the test was originally devised, direct pressures to effect compaction were employed. It was found that 5,000 psi was required to approach the compaction obtained on the road by traffic. A kneading type of compactor was then introduced. This consisted of a falling weight having projections on its base. As it was given a turning impulse after each blow, the weight gave a pronounced kneading action and gave good results. Nevertheless, the machine was expensive both in first cost and in upkeep and the standard Proctor rammer, a tool available in most laboratories, gave equally good results. His experience was that 25 blows on each side of the specimen gave a compaction to the test piece similar to that given by modern finishing and compacting equipment on the road, while 50 blows on each side gave a compaction similar to that given by several years of traffic. The compaction was checked by comparing the specific gravity of the sample compacted in the laboratory with that of a sample cut from the road.

In para 10.3, he had mentioned that in the case of Series J & JB the stability and resistance of normal mixtures were reduced following an increase in compactive effort. This observation had caused comment from Shri S. A. Swami and from Shri Swaminathan, but it must not be read out of its context and applied to normal mixtures of that series and was not a generalization. Any normal mixture at the rich end of the limits would tend to lose stability and resistance to deformation if, on further compaction, the voids became reduced to a very low value. Many observers had noticed that mixtures which might have behaved perfectly for a year or so had become unstable after having been further compacted by traffic. In the series J and JB, the fine sand No. 2 was used and it was possible that the fine sand contributed to the lowering of the stability, as this effect was not evident in series K and KB where sand No. 2 was replaced by Sand No. 1.

Shri C. G. Swaminathan wondered whether both stability and resistance determinations were necessary. The pressure-deformation curves were shown in the Paper only for Series D and F. An examination of these curves in Figs. 10 and 13 would show that the stability and the resistance were not proportional and Shri Swaminathan had himself remarked that the resistance values for Series HB (stone filled sheet asphalt with heavy compaction) were higher than those for Series FB (sheet asphalt with heavy compaction). If an engineer was using that method of testing for routine work, he would judge the mixture from the shape of the curve as well as from the actual values. The resistance value was read off from the curve simply by applying a plastic indicator having the slopes of the various resistances marked on it.

Shri M. B. Jayawant had suggested that a mixture might have a high stability value and a low flow value and fail under traffic. The plotted curve would indicate immediately if the mixture is "short", i.e., has a high resistance accompanied by failure after a comparatively small deformation. The condition of the sample after testing was a further guide. A rich sample might be intact with an indentation in the centre, while a lean sample might be completely shattered.

Shri S. A. Swami and Shri C. G. Swaminathan had asked if stability limits could be suggested. He had found a 500 psi minimum stability and a resistance from 45 to 80, these values being measured at the maximum road temperature, satisfactory for most heavy traffic conditions. In urban districts, the bus-stops would usually be the portions of the surfacing most likely to suffer from deformation. He was sure that some interesting research could be carried out to ascertain the optimum characteristics of heavily loaded areas of asphalt paving. The shade of the pressure-deformation curve, of which examples were given in Figs. 10 and 13, showed that some deformation occurred even under low pressures and a repetition of comparatively low pressures might give a deformation beyond the acceptable limits.

Referring to the point of penetration of bitumen raised by M/s Swami and Swaminathan, the Author said that if experience in the U.S.A. had shown that softer bitumens were more durable than the harder bitumens formally used, it was unsafe to assume that very soft bitumens would be satisfactory in the tropics. In regions subjected to tropical rainfall, the use of a comparatively hard bitumen such as 60/70 or 30/40 was essential. The mixture had to have a reasonable stability at high surface temperatures such as 60°C and yet to prevent the absorption of water the voids had to be sufficiently low from the time the mixture was laid and it was not enough to know that the voids would reach the design figure after a year or so of traffic. As the voids in a mixture were lowered, the stability became increasingly dependent on the viscosity of the bitumen-filler mixture while the effect of grading and particle interlocking decreased.

No better example of the compaction difficulties which had to be faced when a high penetration bitumen was used could be given than the results quoted in the official report on the WASHO Road Test. This full scale road test on flexible pavements with controlled truck traffic was carried out in 1952 and 1953 by the Western Association of State Highway Officials in the State of Idaho. The bitumen content of the asphaltic concrete wearing course averaged 5.27 per cent and laboratory tests gave averages of 4.8 per cent voids, 975 lb Marshall stability and 0.07 in flow. The bitumen was soft, having a penetration of 120-150. Different weights of rollers ranging from 7 to 13 tons were tried to determine the best consolidation procedure. This consisted of an initial rolling with a 7-ton roller and a final rolling by a 9-ton roller about three hours later, after the temperature of the mixture had fallen to 100-125°F. Tests on cores cut from the test tracks before the asphalt was subject to traffic showed voids from 9-12 per cent, stabilities from 120-620 lb and flows from 0.28-0.66 in. Such mixtures would have no chance of survival under tropical conditions and his own experience indicated that the compaction difficulty experienced with this mixture was due to the high penetration of the bitumen which, even after cooling, had insufficient viscosity to retain the particles of the mixture in the compacted condition which followed the passage of the roller.

Shri Swaminathan, Shri Jayawant and Shri Subbaraju had raised questions on the subject of the absorption of bitumen by the aggregate. The limits of length set for the Paper precluded the publication of results on absorbent aggregates and on page 193 under the heading "Bitumen", he had drawn attention to this omission and made suggestions on how this problem might be solved. He was well aware that in the U.S.A. factors were used in an attempt to allow for the absorption of bitumen by various aggregates. An example was quoted to him quite recently of a test made in a laboratory with advanced ideas on a sample of a paving mixture from which surplus bitumen could be seen oozing from the surface. By the application of the appropriate absorption factors for the aggregate in the mixture, the laboratory was able to report that the mixture contained over 3 per cent of air voids and was quite satisfactory. The determinations made by the methods described in the Paper will only be true for freshly prepared mixtures but if the compacted test pieces were kept and were tested at intervals, both in their compacted condition and after being heated and broken down and recompacted, the effect of bitumen absorption, if any, would become obvious. For instance, if a sample was recompacted after allowing time for bitumen to become absorbed, the specific gravity of the sample would be found to be higher than that of the freshly mixed and compacted sample. A calculation of the voids on the basis of the known specific gravities of the ingredients would often show negative voids, an obviously impossible result. On the other hand, the water absorption test would show immediately that voids were present and would indicate whether they were excessive or not. He was sure that it was always dangerous to use absorption factors determined by some other engineer for some other aggregates and that the practical approach was to make tests on cured samples containing the aggregates to be used.

Shri M. B. Jayawant had suggested that specifications should be widened as a narrow range of gradation such as that specified in the Paper would result in an expensive mixture. As mentioned in his opening remarks, one of the objects of the Paper was to show how, having mastered the basic principles of design, the engineer could use the materials most readily available without depending on grading curves or formulae recommended by some other authority. Having decided what materials were to be used, the engineer would then have to specify a grading to ensure that the quantity of bitumen he specified remained the optimum quantity. He would not specify a grading before

ascertaining that materials were available with which that grading could be met.

Shri O. S. Sehgal had reacted in an entirely different way to the suggestions in the Paper. He said, "I feel Mr. Taylor's method is more on a trial and error basis where we just take any gradation of aggregate that is available and mix it." His reply to that was, let the errors be confined to the laboratory; in the ultimate paragraph of the Paper, he had suggested that errors should have no place in actual construction work.

Shri Sehgal had felt that the alternative to the method of design outlined in the Paper was to confine mixtures to the BSS-594. The mixtures covered by BSS-594 were based on no theory but the schedules included mixtures found by trial and error on the roads in the United Kingdom to be satisfactory. Not only did he fail to see why mixtures found to be satisfactory in the United Kingdom should necessarily be satisfactory elsewhere but he considered that even in the United Kingdom, the continued use of BSS-594 was due to the skill of the experienced contractors in deciding the exact proportions of materials to be used in the mixtures. Shri Sehgal had quoted a mixture from Table 11, page 22 of BSS-594 which specified 5.2 to 6.2 per cent of bitumen. Somewhere within that range of 1 per cent was the optimum bitumen content and whatever it might be, any variation more than 0.1 per cent on either side of it would affect the characteristics of the mixture. BSS-594 was silent on how the exact bitumen percentage should be determined and he maintained that this specification was useless except in the hands of experienced contractors and engineers. For the surfacing of runways in the United Kingdom and in the Colonies, the Air Ministry used void determinations with stability tests for designing the asphalt mixtures, having found that a logical approach to the design of asphalt surfacings was essential in view of the heavy loadings by modern aircraft.

Shri G. C. Sharma had made a plea for the use of the surface area method of determination of the optimum bitumen content. It was quite possible that the California Highway Department was right and the rest of the world was wrong. Until this had been proved, he could only suggest that the voids method was the more logical.

Shri K. P. Nair had asked for the basis of the grading curve suggested "for a city in India". The reference in the Paper indicated that it was taken from a publication issued by an oil company in India. It was a grading which had in practice proved to give satisfactory results and was simply given to illustrate the method of proportioning available materials to give a mixture of a specified grading.

Shri Jayawant was of the opinion that, more due to tradition than to data based on facts, it had been the practice to specify considerable quantities of filler in asphalt concrete mixtures. The reasons for the use of filler were given in para 3.2 and a comparison of the results obtained in Series C and D showed clearly the improved results which followed the use of a substantial quantity of filler in sheet asphalt mixtures. The use of filler had been found unnecessary in some States in the U.S.A. in asphalt concrete mixtures. Filler could be omitted in the following circumstances.

(a) When the grading of the aggregate was such that the voids in the compacted aggregate approached 15 per cent and the addition of filler would reduce the voids below 15 per cent,

and

The aggregate was limestone or similar stone which had a natural affinity for bitumen.

(b) When the rainfall was low and there was no risk of stripping of the aggregate following the absorption of water,

and

The traffic intensity was such that the use of filler to increase the stability and resistance to deformation of the mixture was not necessary.

Shri K. S. Sankaran had stated that it had been established beyond doubt in Western countries that the cost of dense graded asphalt mixtures was of the same order as a concrete pavement, while Shri Basant Singh had come to the conclusion following his very unfortunate experience with asphalt paving mixtures—which one may suspect were not correctly designed—that until Indian made machinery was available, built-up surface dressings would be quicker and cheaper than asphalt concrete. A discussion on relative costs would be out of place in this Paper but it must always be remembered when making comparisons between the costs of cement concrete and asphaltic concrete, that asphalt concrete mixtures could often be laid on existing roads, that they could be opened to traffic almost immediately after being laid, that at the end of their useful life they could either form the base for a further layer of asphalt concrete or could be taken up, reconditioned and relaid.

The Chairman in his concluding remarks stated that he felt that this Paper suggested the methods by which our mixes could be designed properly. He thanked the Author for his valuable contribution and the various speakers for participation in the discussion.

Discussion on Paper No. 201*

"Construction of Prestressed Concrete Superstructure for The Bridge over River Hindan at Ghaziabad"

By

A. S. BISHNOI & J. S. MATHUR

Monday, 6th January 1958.

Shri E. A. Nadirshah (Chairman) called upon the Authors to introduce their Paper.

Shri A. S. Bishnoi (Joint Author), while introducing the Paper, said that before the advent of fast motor traffic the bridges normally had a narrow roadway of 12 to 14 ft, which presented a bottleneck to the smooth and rapid flow of traffic on the main routes. These crossings were now to be improved either by rebuilding the whole structure or by widening the superstructure only where the substructure and the foundations were sound and safe for modern heavy traffic.

Hindan bridge in mile 11 of N. H. 24 had a roadway of 14 ft 6 in. only on an important road connecting U. P. and Delhi. Sufficiently long piers being available, it was decided to widen the superstructure and to keep the increase in foundation bearing pressure to a minimum, the lightest form of superstructure had to be selected. Obviously the choice was a prestressed concrete structure. The Freyssinet system of prestressing was adopted, the special feature being that in addition to longitudinal prestressing transverse prestressing of the slab was also done, which resulted in a saving of about 22 per cent in the use of concrete and about 60 per cent in mild steel. The roadway is 24 ft wide between thekerbs, and the wearing coat consists of 3 in. thick cement concrete.

To see if the bridge was safe for the design load, one span was loaded so as to give the maximum bending moment and the deflections were measured. These compared favourably well with the design assumptions. Full control on the quality of concrete was maintained and the mix actually used was better than that provided in the design. During construction, to avoid hold up in traffic, a temporary timber pile bridge was erected over a diversion and this worked very satisfactorily.

* Published at pages 197 to 259 of Vol. XXII-2 of the Journal of the Indian Roads Congress.

Shri Fateh Chand said that it was stated in the Paper that the foundations were 9 ft deep. But it was not known what was the scour depth, the maximum flood level and what the discharge should be and what it actually was. Further, 20 per cent increased load had been put on the foundations on the assumption that the factor of safety would cover it. This was wrong. This being a scientific problem, it should be based on definite calculations as the bridge had a two-lane carriageway and additional load would come over it.

Shri Fateh Chand was of the opinion that beams should be of uniform length and the reinforcement mentioned as 6 in. centre to centre of 3/8 in. bars should not have been fixed arbitrarily but based on definite calculations.

Regarding expansion joints, Shri Fateh Chand said that instead of steel angle irons and plates, some sort of bitumen or other resilient filler should have been used. Were there any special reasons for using steel?

Referring to the maximum size of coarse aggregate used, i.e., $\frac{3}{4}$ in., he wanted to know if greater size could not be used, especially in the decking slab where the reinforcement was 6 in. centre to centre.

Shri Fateh Chand further wanted to know whether in prestressed concrete the coarse aggregate gave the same quantity of ready-made concrete as in 1 : 2 : 4 cement concrete which gave 100 c. ft of concrete for 88 c. ft of coarse aggregate.

Regarding water-cement ratio of 0.4, he desired to know whether it took into account the amount of humidity in the atmosphere and the water content in the aggregate. If so, what were the conditions prevailing at the time of construction?

He asked if it was absolutely necessary to use reinforcement in the wearing course, or it could be avoided as the wearing course had been separated from the deck slab.

Regarding protection of guide bunds, Shri Fateh Chand pointed out that nothing appeared to have been done in this regard when he happened to pass over the bridge and he enquired if it was proposed to do grass-pitching or stone-pitching.

Shri Dinesh Mohan wished to comment only on two points, viz., the quality control of concrete and the design stresses used.

He remarked that the quality control had been not only good but excellent. The concrete was designed to an average

strength of 7,250 lb per sq. in., expecting that the minimum to be obtained at site would be 5,360 lb per sq. in., which was 0.74 of the average design strength. Actually, the average strength of the cubes was found to be 6,575 lb per sq. in., which gave a relation of minimum to average of 82 per cent. But according to the work done in England and at other places, the minimum strength that could be obtained for very good control with weigh batching, etc., was only 75 per cent of the average, while in this bridge a value of 82 per cent was obtained even with volume batching. He asked the Authors to express in greater detail the various controls used in the mixing of concrete.

Regarding stresses given in Table 2 of the Paper, while appreciating the advantages taken of the stresses induced by the applied dead load, he felt that the concrete strength had not been fully made use of. At transfer, the stress was 1,730 lb per sq. in. as against 1,900 lb per sq. in. (allowable temporarily) and still less under working load—being only 978 lb per sq. in. as against 1,600 lb per sq. in. permissible.

While watching the progress of a prestressed concrete bridge at Hardwar, he felt that there was considerable difficulty when the contractors wanted to vibrate the concrete in the web of the beam. It was also not possible to vibrate effectively with immersion vibrators. So, he wanted the Authors to explain whether they had used any special method to make sure that the concrete in the web was fully vibrated.

Shri Dinesh Mohan then suggested some precautions to be taken to obviate toppling of beams during construction as it resulted in unnecessary losses.

Shri D. K. Ghosh asked as to how the spacing of the cross beams in the span was determined. Was it done with due regard to the distribution of load or on assumption based on experience ?

He said that ultimate and working stresses of concrete seemed to be very low and wanted to know the reason for this low stress assumption. He felt that with a certain amount of quality control a concrete strength of much higher value, say, 6,500 lb per sq. in. could conveniently be adopted without any additional cost. Shri Ghosh further asked as to why 4 in. cubes were taken as the general convention in India was to use 12 in. cylinder or 6 in. cubes.

Referring to para 2.1.5, he enquired about the arrangements made to take the shear at the junction of the top flanges and the in-situ slab.

In para 3.3.1, the Authors had given mix of 1 : 1 : 2 : 8. Shri Ghosh felt that a much higher strength should be obtained with this mix. He also wanted to know as to why the water-cement ratio of 0.4 was not kept constant throughout the working period.

In para 4.3.2, the Authors had stated that 5 ft extra length of wires was kept for stressing purposes, and which was cut after stressing. This length worked out to about 6 per cent of the effective cable length. He wondered if these short pieces were utilized or were mere wastage.

Lastly, Shri Ghosh stated that no mention had been made in the Paper as to whether the bridge was constructed departmentally or through contractors.

Mon. H. Claudot was very much impressed with the vast progress made in India in prestressed concrete. He referred to pages 227 and 229 and thought that slight adjustment could be done regarding the measurement of the elongation of the cables. He was of the opinion that the best method of calculating these elongations, while prestressing, was to take the measurements at about 100 kg. per sq. cm. corresponding to 1,000 lb per sq. in., depending on the reading of the metre gauge.

Regarding bearings, Mon. Claudot stressed that rubber bearings should be used in bridge construction, as they would save a lot of money on rigid bridges. He cited the instances of the Coleroon bridge in Madras and several other bridges constructed in the territory of French Cameroons for the last 7 years without any trouble.

Dr. Bh. Subbaraju replying to Shri Fateh Chand who had put a question regarding the advisability of separating the wearing course from the deck slab said that it was not only a puzzle to them but it was a world puzzle. A lot of research had been going on in this respect. In the U.K., they were trying to separate the two. But in the United States, it was not laid separate. So it was not fully established which was nearer the reality. This problem cropped up after the second World War to find out which was the best of the two. A study was taken up to actually measure the stresses in both the cases, in one case separating the two layers by interposing some lubricating oil and in the other by a monolithic slab. It was found that the stresses transferred to the bottom slab, where the layers were insulated, were less when compared to those obtained in the absence of insulation layers. That meant that stress transfer was lowest in the case of insulation as most of the load was to be borne by the upper layers.

Shri M. M. Gidwani remarked that no details for checking up of foundations of existing sub-soil structure to take additional loading were given in the Paper and the entire matter had been disposed of in a few lines. Also, no waterway calculations were supplied. Further, it was not explained how it was worked out that the increase in bearing pressure on foundation would not be more than 20 per cent. Reliance on unknown factor of safety would, therefore, be presumptuous unless it was substantiated by detailed calculations. He then asked the Authors whether any test on the existing piers was done to see what was the settlement under the additional load imposed on them.

Regarding adequacy of waterway, Shri Gidwani said that the Hindan bridge had been outflanked in the past due to heavy flood discharge, thereby proving that the existing waterway was insufficient. Since the utility of the bridge had increased, he asked whether there was not a case for revision of the waterway to cope safely the floods of higher intensities.

Referring to Plate I where the depth of the foundation of piers was shown about 9 ft below the river bed, he asked whether any calculations on scour depth had been made to see that the foundations were secure.

Shri P. J. Jagus differed with Shri Dinesh Mohan regarding the quality control exercised on the job. On page 211, the Authors had given the volumetric proportion of coarse aggregates Nos. 1 and 2 size as 2.25 and 1.25, which added up to 3.5, and ultimately they arrived at a proportion of coarse aggregate to cement of 2.8. This did not take into consideration the shrinkage factor on account of mixing of the two aggregates. So the final proportion worked out by him was in the neighbourhood of 1 cement : 1 sand : 2.4 coarse aggregate, which gave a very rich mix. He felt that the economy of the mix on the job had been sacrificed in the interest of lack of control, apparently because the mix was too rich. Therefore no contractor would probably consider using as rich a mix as that if he wanted to make the tender a success, unless cement was supplied by the Government free of charge.

Shri Jagus continued that work on prestressed concrete bridges was normally done by weigh-batching. On this particular job it was done by volumetric batching, which showed that the control was very poor because the aggregates available from the quarry might or might not be within the specified limits.

Shri Jagus also felt that the separation of the wearing course from the decking slab was an important issue as separating the two would mean that it was expected the wearing course would take all the load on point supports. For instance, the top course

which was very thin, viz., 2 to 3 inches, would be out of contact with the base slab and the initial failure would start at corner cracking. Shri Jagus commended the use of reinforcement in the wearing coat as in India they could not think of adopting integral concrete on account of the problems of bullock cart traffic which caused rutting on the surfaces.

In reply to **Shri Fateh Chand** and other speakers regarding details of foundations, **Shri A. S. Bishnoi** (Joint Author) said that the Paper, as was clear from its title, dealt merely with the details of the superstructure, hence the question of waterway and foundations had not been given in detail. However, this information would be given in writing if the members so desired. He added that foundations were tested and calculations were made for the bearing pressure and they were found safe.

Regarding Sri Fateh Chand's comment that the end spans should have been kept the same as the intermediate span, the Author said that if they had shifted the bearings towards the front of the abutment, the eccentricity of load on the abutment would have increased which was not desirable.

The mild steel reinforcement in the deck slab was provided arbitrarily because theoretically no reinforcement is required.

In the expansion joints if steel angle iron and plates are not provided and the edges of concrete are left as such, there is a danger of breaking of the concrete slabs at the joints.

A size of aggregate thicker than $\frac{3}{4}$ in. could not be used as cover allowed over the reinforcement in the beams as well as deck slab was only 1 in.

The quantity of ballast required to produce 100 cu. ft. of concrete depended not on the fact whether it was reinforced concrete or prestressed concrete but on the mix. In our case as the mix was richer than 1 : 2 : 4 the quantity of coarse aggregate required was less than 88 cu. ft. per hundred cu. ft. of concrete as in 1 : 2 : 4.

The reinforcement in the wearing coat was essential as it had been separated from the deck slab and had to take care of local stresses.

As regards protection to the guide bunds, they did provide the stone pitching in front. Of course, this had not been done on the back side.

To the query raised by **Shri Dinesh Mohan** and some other speakers regarding quality control, the Author said that he had already explained the point in his opening remarks. Probably

they could economise by using leaner mixes and have the stresses corresponding to the design analysis.

As regards vibration, they had used external vibrators as mentioned in the Paper. Two electric vibrators were used externally and they gave very good concrete and no honey-combing, etc., was found.

As regards toppling of the beam, of course it was a mishap. The precautions taken by them had been described in the Paper.

In reply to **Shri D. K. Ghosh's** comment about the reasons for adopting lower stresses, the Author said that their field conditions and control were probably not as good and this fact had to be considered when doing concrete work with higher stresses. In this particular case, there was difference in the design mix and the design stresses in the mix actually used ; it appeared they had used a very rich mix. In other words, they exercised a better control than probably what was expected.

The spacing of cross beams was provided on the basis of experience but advantage of the cross beams was taken in the design of main beams as the distribution of load taken on various beams was based on the assumption that the cross beams were infinitely rigid compared to longitudinal beams. The shear at the junction of top flange and in situ slab was taken care of by the prestressing force.

Regarding 4 in. cubes, the Author said that Indian Standards Institute specifications provided for testing 4 in. cubes. No cylinder was used as was the practice in the U.S.A. and other places.

The water-cement ratio was 0.4, but it was slightly varied when the season was very hot and dry, and allowance was also made for moisture in the aggregates. The test results showed that the strength did not go down. Of course, cubes were tested whenever the ratio was varied as a guidance for future mixes.

The extra length of cable used was necessary as otherwise prestressing jacks could not be fixed to them. Five feet overall length was only 30 in. on either side of the beam.

The Author regretted the omission of mentioning the name of contractors, viz., M/s. Uttam Singh Duggal & Co. (Private) Ltd of New Delhi, who constructed the bridge.

Mon. Claudot's suggestion regarding rubber bearings was worth consideration. The Author said that it was for the Indian Roads Congress to recommend as to what type of bearings should be used. He thought the use of these bearings would definitely effect a saving in the cost of bridges.

Mon. Claudot had suggested that the elongation should be measured from an initial reading at about 100 Kg. per sq. cm. Actually we had measured it from an initial reading of 50 kg. per sq. cm. and allowance made for the same. In my opinion it does not make any difference.

In reply to **Shri P. J. Jagus,** the Author said that cement was issued departmentally to the contractor and its cost was recovered from them. It was not issued free of cost.

Regarding checking of the grading of the aggregates, the Author said that it was done before using it in the mix.

The Chairman, **Shri E. A. Nadirshah,** winding up the discussion remarked that the Paper under discussion was yet another interesting one in the series of Papers on prestressed concrete bridges published in the Journals of this Congress. Each of these brought forth more and more interesting and useful information both from design and practical points of view. He suggested that the Authors of future Papers might try and minimise pure repetition of information and devote more time and space to new points and factors that they came across with and suitably deal with them so as to make the Papers more instructive.

The most important point in this Paper was the distribution of live load taken on various beams based on the assumed indefinite rigidity of the cross beams which made the entire decking act as a monolithically rigid one. This certainly was a step forward in refinement of the design procedure in order to bring it in line with the actual conditions met with in practice and results of experiments.

The Chairman then drew the attention to the important provision of footpaths on either side of the carriageway on a bridge for the safety of the pedestrians. He strongly recommended the authorities to consider the question of providing at least 5 ft wide footpaths on either side of the carriageway as 24 ft width was good to take care of the two lanes of carriageway but did not leave enough room for the pedestrians.

Shri Nadirshah emphasised the importance of proper selection of construction materials and the need of scientific control on the manufacture of quality concrete in the field.

The Chairman thanked the Authors for their very interesting Paper and the various speakers who had taken part in the discussion.

Discussion on Paper No. 202*

"Experimental Soil Stabilized Road Construction in Black Cotton Soil Area"

By

J. F. MISTRY

Monday, 6th January 1958

Shri S. R. Mehra (Chairman) called upon Shri J. F. Mistry (Author) to introduce the paper for discussion.

Shri J. F. Mistry (Author) in introducing the Paper stated that in Bombay State, black cotton soil was found largely in Kaira, Baroda and Broach districts and the construction of roads in the usual conventional manner did not prove successful in these areas. Hence some scientific approach to construct successful and cheap roads was thought of.

The method of soil stabilization adopted in this case was mechanical stabilization. By studying the pressure bulbs under a concentrated load and also by studying the resistive strength of different soils by means of the "California Bearing Ratio" test, some graphs had been evolved and then the thickness of the total road pavement and that of the different layers therein were determined. The method of designing the road pavement was described in the Paper.

The main advantage in adopting the method of designing the pavement on "California Bearing Ratio" was that the design for the road pavement in different stretches of the route could be changed according to the availability of the local materials.

In this method of construction, the soling of bricks or of rubble had been omitted and the base course was designed in two layers viz., one of sandy soil and the other of a mixture of sandy soil and pure sand. The cost analysis for the soling was worked out and the percentage saving was 42.48 per cent per 100 sq. ft.

In working out the cost for the base course, the cost of depreciation or the rental charges for the machinery used had

* Published at pages 261 to 296 of Vol. XXII-2 of the Journal of the Indian Roads Congress, December, 1957.

not been taken into account because, when the works are carried out departmentally, such cost of depreciation is generally not accounted for in small works but only in big project works. However, he had worked out the total cost of depreciation for the machinery used and it reduced the nett saving in the base course from 42.48 per cent per 100 sq. ft. to 38.70 per cent per 100 sq. ft.

As regards the behaviour of the road he stated that the full traffic had not started coming on this road as it was an intermediate section of the State Highway but local traffic viz., bullock-carts and some heavy lorries used for the construction of the state highway were passing on this road. No uneven settlement was observed on the surfacing even after the monsoon season.

Shri N. Amanullah stated that it was a coincidence that the soil used was more or less clayey loam and not a typical black cotton soil. Also, sand and sandy soil was available in the vicinity where mechanical stabilization had been tried. This happy coincidence was not always possible and therefore the stabilization of black cotton soil by this method could not be universally adopted.

The first difficulty faced by engineers in stabilization of black cotton soil was regarding pulverisation and mixing of the soil with sand. Even if the sand was easily and economically available in the area, the above two factors made it uneconomical. That difficulty was experienced on Bihar-Ekargarh Sarai Road in the district of Patna. It had been planned to stabilize two miles of black cotton soil in the above road but the project had to be abandoned after doing only about three furlongs due to the fact that pulverisation of the soil and thorough mixing with sand was becoming extremely tedious and uneconomical. This was one of the reasons why mechanical stabilization was not recommended for very clayey soils by the research laboratories in the U.K. & U.S.A. The Paper was quite silent on the methods adopted for mixing sand with the black cotton soil.

Another difficulty in the application of mechanical stabilization was the differential settlement in the road. It had been observed by several workers that mixing the sand with the black cotton soil even by mechanical devices such as rotators etc., had not produced a very homogeneous material. There would always be pockets in the sub-grade of a clayey soil and with the movement of traffic, differential settlement might develop. Batson had recommended in his book an allowable differential settlement of only $\frac{1}{4}$ in. This led to the conclusion that even if the road was successfully completed with mechanical stabilization it would not be long before the differential settlement started

causing failures. That had actually been observed in the experimental strip of stabilized base course work done in the 63rd mile of Makameh-Dorabji Road, Bihar.

The attention of the Author may also be drawn to the fact that according to Winterkorn, the C. B. R. curves should not be applied for a soil which had a C. B. R. value of under 5 per cent and a swelling of over 3 per cent. As typical black cotton soils exceed both these limits, it was suggested that standard C. B. R. curves should not decide the thickness of the pavements in such cases. In his opinion, the triaxial test was more appropriate in these conditions.

Shri Dinesh Mohan observed that the Author had used mechanical stabilization, resorting to the C. B. R. method for determining the pavement thickness. He had tested the compacted samples for the C. B. R. value after soaking them for 4 days so as to produce a severe subgrade condition comparable to the one met with in the field during monsoons. It would be worthwhile to know the value of the moisture content on various layers of the sample after 4 days' soaking and the per cent saturation that it represented.

Opinion differed widely as to the wisdom of testing the sample for C. B. R. in the completely saturated state as it was unlikely that with the waterproofed wearing surface and proper drainage of the shoulders on either sides the completely saturated state would ever arise in actual practice. If this was true, unduly conservative designs had been made. But since the road had already been constructed with a total thickness of about 18 inches, it would be worthwhile to measure the actual moisture content in the covered subgrade just after the monsoons by making a few boreholes in the centre of the road. The mischief of the black cotton soil lies not so much in its clay content, but in the dominating clay mineral, viz., montmorillonite which makes it a highly expansive clay. It is the differential swelling and shrinkage which does the greatest injury to the road surface. The super-imposition of an impermeable blanket over the clay layer disturbs its natural equilibrium and while the clay layer close to the edges does not behave very different to the open ground, the layer at the centre, if covered during a dry period, gradually gains in moisture content till an equilibrium is reached. This gain in moisture introduces swelling and pressures of the magnitude of 2 tons per sq. ft. have been measured when black cotton soil swells from shrinkage limit to saturation. It would, therefore, pay to construct the road just after the monsoon when moisture content is at its maximum and the soil had least chance of subsequent expansion. The British Road Research Laboratory had done a useful work in predicting the equilibrium

moistures at various depths below a road surface based on the negative pressure concept but the values hold true for their own conditions of climate. If a reliable method could be discovered for our own soils also, it would be possible to put the design of bases for roads as also foundations for buildings in the black soil areas on a more rational basis.

Another method of stabilization which was well worth a trial was by the use of admixtures. Lime had a promise as had been shown by Mehra and Chadda[1] who recommended 10 per cent of hydrated lime for satisfactory stabilization. Grawger[2], on the basis of tests on samples of black cotton soil for Southern Rhodesia recommended 4 per cent of hydrated lime together with 2 to 3 per cent of wood tar for waterproofing. The problem of mixing the soil on the site would no doubt have to be solved but if an economical method was found there was little doubt that this would form the most satisfactory method of stabilizing black cotton soils for roads.

Shri C. D. Harris stated that he also did not think that the type of sub-grade was true black cotton soil. He was not familiar with conditions in India, but in Sudan they would expect the black cotton soil to have liquid limit around 70 and P. I. approaching 20 as compared to 40 and 20 in Baroda.

The Author super-imposed the first layer on the subgrade and limited his compaction effort to 90 per cent of Proctor which was the degree of compaction he had used in the C. B. R. test. Considerably improved densities could be attained with 12 and 16 passes of the roller. Perhaps the Author had been considering to establish fresh C. B. Rs. at these high densities, which might in turn have permitted his second layer of 3 inches. This in any event, must have been extremely difficult layer to put down from the construction point of view. Similarly, it was possible that the Author had decided that high clay content of the sub-grade precluded additional compaction effort. But additional C.B.R. tests in the laboratory might have shown whether it was worthwhile to try to obtain higher densities and improved C.B.Rs.

The Author had not mentioned how he had distributed the water through the additional layer—whether it was done by hand or by blade-graders. He presumed it was not done by spraying water

1. Mehra S. R. & Chadda L. R., 'Some Laboratory investigation for improving black cotton soil in road construction' Indian Roads Congress Road Research Bulletin No. 4, 1957.

2. Grawger G. D. 'The stabilization with lime and a local wood tar of a black cotton soil from Southern Rhodesia; Br. Road Research Laboratory Road Note : No. RN/1778/GDC Sept. 1952,

on the road and leaving it to soak in. The Author had taken considerable trouble on his sub-base layer. He was wondering whether he had tried to improve the water-bound macadam layer by substituting perhaps machanically stable layer. Also, he would like to know what binder was used in his water-bound macadam.

Regarding plant hire, he had a feeling that Rs 400 a month (presumably the work was done for a month only) was perhaps a little low. If the P.W.D. was hiring the plant from some one else, he would think it would be something like Rs 1,500.

Shri N. Mohan Rao stated that from an analysis of the Paper, it could be seen that the main recommendations suggested for arriving at a rational design of road bed in black cotton soil areas around Baroda were:

(1) That the existing crust of $9\frac{3}{4}$ in. over the black cotton soil sub-grade was insufficient to ensure necessary load dispersion and hence the overall thickness should be increased to 18 in. based on the C.B.R. method of design.

(2) That the brick soling was to be replaced by sandy soil and stabilised soil mixtures, presumably to cut down the cost as well as to improve load dispersion characteristics of the pavement.

Referring to the design, he stated that the traffic was only of the order of about 600 tons consisting of about 60 loaded vehicles and 150 bullock-carts. The Author had selected the C.B.R. design curve corresponding to 9000 lb wheel load for estimating the required thickness. Personally, he considered that these traffic conditions did not warrant the use of 9000 lb wheel load design curve and probably lesser thicknesses would suffice. These curves were evolved on an empirical basis depending on the experiences of the California State Highway Department. Each design curve is supposed to give the thickness requirement over a sub-grade of given strength for a definite range of volume and frequency of traffic. Hence the values of 9000 lb, 12000 lb etc., associated with C.B.R. design curves should be considered only as a rating given to different ranges of traffic prevalent or anticipated and not as an exact index of the maximum wheel load that could be supported by the pavement.

Referring to the work of the Road Research Laboratory, London whose design curves the Author had adopted, he stated that these were evolved on the basis of actual investigations on roads in England and the C.B.R. design curve of 9000 lb wheel load was recommended by the Road

Research Laboratory, London for use in the design of roads carrying traffic of 1500–4000 tons per day with 150–450 load vehicles plying in a day. That was why, he considered that for the traffic figures given in the Paper, the thickness based on 9000 lb wheel load design curve was on the high side unless any other considerations apart from traffic, such as bad drainage, field difficulties in achieving good and uniform compaction etc., had weighed upon in the selection of that design curve thus ensuring a greater factor of safety.

Regarding the method adopted for rolling and compacting black cotton soil sub-grade, the Author had mentioned that the rolling was attempted at optimum moisture of 17.6 per cent to achieve a density equivalent to 90 per cent of Proctor's density, though finally a moisture of 10 per cent was adopted to give the same density. In this connection, he would like to point out that considerations of optimum moisture and maximum density were not very relevant for the case of expansive soils like black cotton soils unless these values were linked up with the expansive characteristics of the soil, since from the point of soil expansion each material was supposed to have a state of equilibrium regarding density and moisture for a given condition of confinement. At a given density, maximum expansion occurred when the voids were approximately full of water. To ensure that no shrinkage should occur in this case, drying of this layer should be prevented.

Basically the problem of design of road beds in black cotton soil areas, should be dealt with keeping two considerations in view:

(1) Designing the thickness of the crust to ensure safe stresses on the sub-grade, which the Author had already tackled in his Paper; and,

(2) Designing that the crust is safe against swelling and shrinkage which is inherent in black cotton soils.

Swelling pressures were often detrimental to the stability of the pavement and might eventually cause its failure even though the thickness may be sufficient not to overstress the pavement. With the present knowledge, it could be said that the second problem could be tackled either by inactivating the black soil by some chemical treatment or by adjusting the density of moisture and confined pressure in such a way as to eliminate this problem of expansion swelling. In the absence of exact data on equilibrium density and moisture for no swell state, it might be a better solution to roll the sub-grade at the natural moisture if it was feasible on the field.

Regarding the design densities adopted for sandy soils, it was not known why the density was fixed at so low a value as 102.6 lb per cu. ft. when the field density was as high as 110 to 113 lb per cu. ft. Results of rolling showed that it was possible to get dry density of 122.7 per cu. ft. with 12 passes. It would have been desirable to lay the sandy soil at this density, which might have resulted in considerable increase of its C.B.R. value, thus giving scope for reduction in the thickness of stabilized soil and metal by increasing further the thickness of locally available sandy soil.

He was of the opinion that, with heavy compacting machinery easily available in the market, it was no longer justified to stick on to the old practice of designing densities in the low order of 90 per cent of Proctor's density. With this very background, the laboratory compaction test was modified abroad some years back with a view to give higher compaction.

Lastly, it would have been better, had the Author adopted for the design moisture for rolling, that moisture which was optimum for the plant under use rather than the value obtained in the laboratory. Proctor compaction test as the optimum moisture for any soil depended primarily on the compactive effort.

Dr. Bh. Subbaraju stated that the volumetric swelling of the soil given was not more than 0.3 per cent. He doubted whether it could be called black cotton soil, and whether it could be included in C.H. group with liquid limit greater than 50 and high P.I. The soil content of the sub-grade material had not more than 23 P.I. and the swelling percentage was not more than 0.32. He would like to know from the Author (i) how he had classified his soil, whether by triangular specification or otherwise and (ii) how he had classified his clay loam and whether his soil came under that group.

From the soil swelling characteristics given in the Paper he wondered how the cracking could go up to 10 ft depth.

The table which gave the number of passes versus the densities obtained revealed that the first layer had given very attractive densities. So, when such wonderful soil was available as given in Survey No. 274, it was not clear why the Author should have gone in for admixture of sand for the second layer. In the beginning of the Paper it was said that the mixture of 1 : 4 (sandy soil to pure sand) was used and that gave a C.B.R. value of more than 20. If so, why a mixture of 1 : 2 was adopted. He wanted to know whether the borrow material obtained from the survey, was more costly than the admixture used.

Shri P. L. DE stated that it was not clear how the Author had classified the sub-grade as black cotton soil. The P.I. and the classification of the soil were quite different from black cotton soil; the sand content was high, the clay content was rather low. Sandy soil which had been used seemed to be quite suitable by itself for stabilization. It gave high density and the gradations were also quite suitable for stabilization. It was not clear why further admixture of sand was necessary. Sand had been mixed up to 200 per cent which he did not think was necessary for such types of sandy soils.

In Table 1. the optimum moisture content for sample 996 was shown as 10.2. It was not clear how it differed so much from other samples given in the same Table, whose other properties were the same.

In para 4.8 it was mentioned that rolling of second layer had been done with 20 passes of roller. The number of passes seemed to be too high. Generally after 8 or 10 passes, the density does not increase much.

The cost had been shown as Rs 9.69 per 100 sq. ft. for a 12-inch thick base course. He did not know how such a low value could be obtained.

Shri A. K. Deb stated that it seemed it was high time now that a suitable terminology was evolved to name the different soils in India. Any soil which looked black in colour might not necessarily be black cotton soil. The Author had not given any soil profile of the area. When he had got such good clay loam he would have probably encountered better material (granular) not at very great depth from the surface which could have been made use of by making quarries at the site itself.

On page 286 of the Paper, the Author had mentioned that 20 passes were required to compact the second layer of 3 in. design soil mix by a 8-ton roller. He certainly did not get good results because cracking and caking were bound to appear with so many passes and with such a heavy roller. If a pneumatic roller and less number of passes had been used that would have given satisfactory results.

Shri M. M. Gidwani stated that one of the speakers had sought confirmation regarding the depth (10 ft) to which cracks had extended in black cotton soil as referred to in para 1.1 at page 262 of the Journal. From his experience of works in river valley projects in black cotton soil area in Surat District, which was very contiguous to Baroda District, he could confirm that such cracks had extended to depths of even 10 ft. It all depended on what was the depth of overlying black cotton soil strata.

The rate analysis given in the Paper would not be complete unless it was fully known what was the life span of the road and what would be the annual cost of repairs. In the present stage, the Paper was only of the nature of description of an experiment, on which conclusions were yet to be drawn. In order that the Paper might be ultimately useful to the engineers in field, what was required at the moment was observation on the behaviour of the road for some time. After a lapse of time a supplementary Paper on the subject supported by realistic cost analysis might be published by the Indian Roads Congress.

Dr. H. L. Uppal stated that reference had been drawn to the C. B. R. curves for adopting them in black cotton soil areas. It was clearly indicated in the work done in the U. S. A. that though the C. B. R. curves were not meant for very expansive type of soils, and the percentage expansion for which the test was prohibited was about 10 to 12 per cent. He did not think that the soil dealt with by the Author was as highly expansive as that.

The other difficulty about treatment of black cotton soil was the pulverization and the mixing of admixture with the black cotton soil. The author had not gone into that aspect in detail which was really very important when dealing with black cotton soil. The work recently carried out in the Central Road Research Institute has shown that an addition of 5 per cent lime to black cotton soil cuts down the plasticity index considerably. To see the efficacy of laboratory results in actual field practice an experimental length was laid at Bhopal. It was observed that like all other soils black cotton soil can also be conveniently pulverised at a particular moisture which ranges between 20-25 per cent. The treatment with lime considerably improved the soil by raising its C. B. R. from 2-25 per cent, thereby justifying that almost half the thickness of road pavement which is normally built up in stone, can be replaced by treated soil.

Another point that had been mentioned by one of the speakers was that it is very essential that before the thickness could be designed the highest moisture to which the subgrade is wetted should be determined. The work in England and other places has shown that their sub-grade which is generally very clayey in nature attains moisture which is very much below saturation. This moisture is called " Equilibrium Moisture Content " and is used for C. B. R. tests. This unfortunately is true for moderate climatic conditions and therefore cannot be applied to tropical countries.

With the object of determining the highest moisture attained by sub-grades, an all India survey was made in areas of different soil type and climatic conditions, the two main factors responsible for rise of water table. The preliminary investigations reveal that there are large areas where the sub-grade is below saturation, and therefore for purposes of pavement design the C. B. R. tests should be carried out at those particular degrees of saturation and not at complete saturated conditions as is the practice now.

Shri Fateh Chand observed that the proportion of 2 : 1 was used because 4 : 1 proportion was costly. He thought even a little difference in proportion should materially affect the quality of the work. It was preferable to obtain stability on correct mix and correct proportions even with a little extra cost. Compaction at optimum moisture was important. It was not the compaction of black cotton soil but the compaction of the stabilized base. Therefore, optimum moisture was as important as anything else.

The Author had adopted a thickness of $9\frac{3}{4}$ inches. He doubted, if it was even that. It could not be $9\frac{3}{4}$ inches because he had taken two layers of $4\frac{1}{2}$ inches, which meant it was only 9 inches. Similarly, the crust thickness of $5\frac{1}{2}$ inches given by him could also be less.

Shri K. R. Saxena * pointed out that reference to para 1.1 showed that the road had failed in miles 0/0 to 2/0 and 11/6 to 15/3 only, although the whole road passed through B. C. soil area. In view of this failure of local character, it would have been better to explore the sub-soil strata to know the depth of B. C. soil and the ground water table so as to take necessary precautions in the design. In fact a reference to table 5 showed that soil No. 997 of the existing sub-grade contained 15.92 per cent moisture which was very near to the optimum moisture content for that particular soil.

Reference to Table I showed that the existing soil of the sub-grade belonged to 'clay loam' type which falls in A-4 group of P. R. A. classification system. The gradation characteristics of the soil also indicated that sand content varied between 50 and 42 per cent and clay content between 22 to 16 per cent. The maximum liquid limit value was 43.50 per cent and maximum P. I. value was 23.20. Even the maximum dry density of the soil was 107.0 lb per cu. ft. The soil, therefore, could not be classified as B. C. soil, for which the values of L. L. and P. I. should have been of the order of 80 and 40 respectively, the Proctor density 80 to 85 lb per cu. ft., and clay content more than 35 per cent.

* This and subsequent comments were received in writing.

There was no necessity to mix sand to the so called 'sandy soils' classified as sand in Table 2 and containing sand 70 to 85 per cent, for stabilizing them. Various mixes of sandy soil and existing sub-grade soil should have been tried as one of these mixes might have given even higher values of C.B.R. than the one obtained for sand and sandy soil mixture of 4:1. Moreover, before fixing the proportion of sand and sandy soil the dust ratio and L. L. and P. I. of the mixture should have been determined so as to satisfy the minimum criteria laid down for use of stabilised soil in base and sub-base of roads.

Shri R. Krishnamachari observed that for determining the thickness required, C.B.R. tests had been conducted at 0.9 of Proctor density. In the field the densities had been quite high and it was erroneous to take 0.9 of Proctor density. If the C. B. R. test was done on the average value of field density, then a lesser thickness of pavement would have been enough and this would have been more economical.

On page 284, first line, it should be Figure 5 and not Figure 3. This graph shows that there was sharp rise in density from moisture contents of 12 to 16 per cent. He was not sure whether the Author was correct to take the value of 10 per cent as moisture content for compaction purposes.

The Plasticity Index of the different mixes had not been mentioned. For selection of mix for the various courses, apart from grading, the values of P. I. should also have been taken into account.

Sri E. T. Chandrasekharan hoped that with the successful undertaking of this experimental work, the remaining portions of the road from 2/0 to 15/7 of Baroda-Dabhoi Road would also be constructed of stabilised soil foundations and further useful data would be made available regarding the use of stabilized soil for road construction in black cotton soil areas.

The black cotton clay in the sub-grade of the road possessed rather medium plasticity with the plasticity index varying from 19 to 24. Consequently, that did not seem to be a typically high swelling and high shrinking soil that the term black cotton soil was normally associated with. However, the observations made on the experimental work would be of immense value for construction of roads in similar soil areas. The Author was requested to furnish particulars of water table and intensity of rainfall in the areas.

From the cross-section of the experimental stabilised road given in Fig. 3, it was observed that the wearing surface was 12 feet wide and the stabilised soil layers of sandy soil and mixture of sand and sandy soil were 14 feet wide. That gave an offset of 1 foot of the stabilised soil layers beyond the edge of the wearing courses. The details of provisions for the berms on the sides were not shown in the figure. It was, however, presumed that for a road of State Highway standard with a black-topped wearing surface, special provisions for the berms would necessarily have to be made. In the Madras practice, the stabilised soil foundations were extended on to the sides by about 3 to 4 feet beyond the edge of the wearing surface so that this extended portion afforded additional stability to that immediately below the ends of the wearing surface. Also, this extension provided a stable foundation for the berms to be used by the crossing traffic. Construction experience in Madras State showed that the end portions of the stablised soil layer (about 2 to 3 feet wide) did not get as well compacted as those at the centre and this obviated the need for an increased width of the foundation courses. The Author was, therefore, requested to furnish details of observations, if any, on the relative compactibility of the stabilised soil layers at the centre and at the ends. It was, however, suggested that in conducting observation studies on the surface behaviour of the experimental road, special watch might be kept to note deficiencies at the ends of the wearing surfaces.

In para 2.2, page 267, of the Paper it was stated that a mix of sandy soil to pure sand of 1 : 4 gave a C.B.R. value higher than 20 and because of the availability of only a limited quantity of pure sand the actual proportion was changed to 1 : 2 for reasons of economy. Presumably, if additional quantities of pure sand were to be used this material would have to be imported from a longer distance. However, it seemed quite worthwhile to make a comparative study of the possibilities of obtaining a combination of sand-sandy soil with as high a C.B.R. value as possible so that the thickness of the more costly upper layers might be reduced to a minimum. As for example, on page 288, it was stated that the actual cost of the 12 inches of stabilised soil layer was only Rs 9.69 per 100 sq. feet while the cost of an extra $\frac{3}{4}$ inch thick metal used above the conventional thickness of $4\frac{1}{2}$ inches came to Rs 4.69. Obviously, if advantage was taken of the availability of the higher value of C.B.R. value for the stabilised sand-sandy soil mix, this extra thickness of metal could perhaps have been omitted. For instance, a C.B.R. value of 30 would warrant a thickness of $5\frac{1}{2}$ in. for the upper layers in which case the thickness of metal provided would get reduced to $4\frac{3}{4}$ in. Also, as a matter of general procedure, the more expansive a layer the lesser should be its thickness, provided this was consistent with consideration of availability of materials. A reduction in the thickness of the metal and an increase in the thickness of sand-sandy layer might be not only more economical but would have also facilitated a better compaction which was found wanting due to

the thickness being small (3 inches) as reported in Table 10 of the Paper. In his opinion, the minimum thickness of the sand-sandy soil should be at least 4½ inches (compacted).

Table 9 of the Paper showed that the sandy soil was capable of being compacted denser than the design value on a slight increase in the number of passes of the roller. In his opinion, the sandy layer with a higher density would show a higher value of C.B.R. and advantage could be taken of this feature to reduce the thickness of the other layers provided the extra cost involved for a greater compaction did not exceed the resultant savings.

In the method of construction described in the Paper, no mention was made as to how water was incorporated into the soils and whether any mixing was done. He requested the Author to give details of the actual procedure adopted.

In figure 3, mention was made of the provision of a metal layer of 5¼ inches thickness. It was not known whether this referred to water-bound macadam. If so, the actual procedure adopted in laying the water-bound macadam on the stabilised soil layers with observations on special difficulties, if any, experienced, might be stated.

The results of compaction for the sub-grade soil and the sandy soil layer showed that dry density equal to that of 95 to 100 per cent of Proctor's was obtained in most cases. In the case of the sandy soil-sand combination, however, the compaction was only 90 per cent Proctor's or even less in some cases, which had been attributed to the adoption of a thin layer of 3 inches as stated by the Author in Table 10. Analysing the general trend, however, it appeard more practicable and economical to have the design based on higher values of densities namely around 95 to 100 per cent Proctor's rather than limiting to 90 per cent Proctor's which, in his opinion, was rather low.

It was presumed that the cost given for the stabilised soil took into consideration the hire charges for the plant used. The hire charges for the various plant per day of 8 hours in vogue in the department might be furnished.

Shri J. F. Mistry (Author) in his replies to the various comments stated that the properties of the soil showed that the clay-percentage was not as high as many of the speakers had described. The clay-percentage was varying from 22 per cent to 25 per cent and hence from the triangular-classification the soil was classified as clay loam. Its California Bearing Ratio value was 3.50 which is very close to the lowest limits 2-3 of highly clayey black cotton soil. Secondly, the C.B.R. method of design was adopted only because of the very low expansive property of the soil, vide Table No. 5.

The water table was observed to fluctuate from top of the road in monsoon to a few feet below in summer and hence the C.B.R. test was performed under severe conditions after 4-days soaking in water and not at equilibrium moisture content as suggested by one of the speakers.

It was quite obvious that one would be easily attracted to the high densities of the first layer of sandy soil and would think of determining the C.B.R. value at higher density and providing it in a greater thickness, thus probably avoiding the second layer of mixture of sand and sandy soil. But this would have been a costlier process as, firstly, the first layer would have to be laid in three stages instead of two stages because of its greater thickness and, secondly, to get the higher density it would require rolling of at least 20 passes i.e., 2½ times more expensive than one layer, and the rolling on the third stage would have been extra in addition to the rolling on the first two stages. Thus it would have proved definitely costlier.

As regards adoption of 9,000 lb-wheel load-design-curve, he stated that the maximum lorry-weight in Bombay State was taken as 19,000 lb, and taking two-thirds of it as the reaction on the rear wheels, the wheel load comes to $(\frac{1}{2} \times 19{,}000 \times 2/3 = 6{,}333$ lb). Thus the design curve for light traffic with 7000 lb-wheel load could have been adopted, but to allow for an increase in the laden weight of lorries, the 9,000 lb-wheel load curve was adopted.

The second layer was mixture of sandy soil and sand laid in 3 in. thickness. According to the graphical solution, vide Fig. 2 on page 266, four parts of sand and one part of sandy soil should have been added for a very stable mix, but with this proportion of 4 : 1, three values of per cent passing were falling out of the standard specification-size-distribution—vide Table 4 on page 278. After various trials with a higher fraction of sand, it was observed that the per cent passing B.S. 200 sieve was getting reduced to below 10. It was quite necessary to keep the per cent passing B.S. 200 sieve within 10-25 per cent as it was this fraction only which acts as a binding material in the mixture. So with a lower fraction of pure sand, viz., 2 parts of sand and 1 part of sandy soil, the value of the per cent passing B.S. 200 sieve was brought within the specified limit. Also, this mixture (2 parts of sand : 1 part of sandy soil) gave a C.B.R. value of 20 which permitted laying of 3 in. thickness.

In reply to the speakers who were desirous to know how black cotton soil was pulverised for mixing purposes—he stated that B.C. soil was not at all used in the mixture. It was only the sub-grade which consisted of black-cotton soil which being very poor in bearing strength, a proper thickness of the road crust was provided so that the load was distributed on a larger area of the sub-grade, thus reducing the intensity of pressure.

As to the values of the moisture content on various layers of the sub-grade soil sample after 4-days soaking and the per cent saturation that it represented, he was sorry to say that this information was not collected during the tests.

Generally, when small works were carried out departmentally, depreciation and rental charges of the machinery were not taken into account in the cost of the work. However, the cost was worked out from schedule rates and it came to Rs 418.00 for base course only.

The suggestion made that the second layer should have been rolled with a pneumatic roller was a good one as it would have been possible to get a higher density without cracking.

Regarding the behaviour of the road under traffic and weather he would try to collect the necessary information and send it to the Secretary, Indian Roads Congress in due course.

Shri. S. R. Mehra (Chairman) in his concluding remarks stated that the laboratory work had far outpaced the field work and it was time that steps were taken to put in 5, 10 or 15 miles of road backed by proper laboratory testing and so on, so that results could be watched and the actual behaviour of the treated black cotton soil in the field could be known.

He appreciated that a young engineer had gone into the trouble of actually designing his pavement. At least four States in India had got full-fledged laboratories, but he was not aware if any State was designing its pavements with black cotton soil. Most of the time pavements which were far short of the requirements of traffic and sub-grade were laid, and the result was that the road suffered damage. Once a hard crust was put down on a sub-grade and it was covered with bitumen treatment as was done now-a-days, any damage or deformation became extremely expensive and difficult to rectify, except by doing patch work. And as the damage went on increasing, the patch work got heavier and created further deformations in the surface of the road. Shri Mehra, therefore, pleaded that those States at least which had laboratories should design their pavements with treated black cotton soil, and he was sure it would pay them handsome to do so. It only meant putting in certain amount of labour in the field. There had been a scheme circulated recently for testing and control laboratories costing about Rs 2 lakhs, and with Central aid it should be possible for all the States to establish such testing and control laboratories, which would in the course of time develop into full-fledged laboratories.

He thanked the various speakers for their comments and congratulated the Author for having taken the trouble to prepare a very useful Paper.

Discussion on Paper No. 203*

"Study and Investigation of Performance and Failure of Road Pavements in Uttar Pradesh"

By

H. G. VERMA AND D. C. CHATURVEDI

Monday, 6th January, 1958

Shri Hukam Singh (Chairman) asked Shri Mahabir Prasad, in the unavoidable absence of the Authors, to introduce the Paper.

Shri Mahabir Prasad read out the introductory remarks handed over to him by the Authors. He said that the presentation of the Paper was timely as at present arbitrary methods were being adopted for fixing the thickness of road pavement based on past experience. This resulted in uneconomical construction in some cases and in others the thickness of the pavement was insufficient, resulting in the failure of the pavement. It was for these reasons that the need for designing pavements on a scientific basis was being increasingly felt now. Road failures were not frequent. But whenever they occur, they provide an opportunity for studying the various factors responsible for failures and give a lot of information on the basis of which such failures can be prevented in future. In this Paper both types of pavements, viz., rigid and flexible, had been dealt with. The Authors had tried to examine how far the theory of pavement design developed by Westergaard was applicable to the thin bonded cement concrete slabs which had been tried in U.P. and had found that the theory might not be fully applicable to such slabs. For flexible pavements C.B.R. method was mostly adopted. On the basis of C.B.R. values of the subgrade, thickness of pavement was found from different graphs for various types of traffic loads and intensities. It was, however, very important that the C.B.R. value of soil should be determined under a condition critical to the design, i.e., under the conditions of density and moisture content which would provide the lowest strength which the soil was likely to have during the life of the road.

The investigations of failure described in this Paper pertained to two roads, viz., the G.T. Road between Ghaziabad and Bulandshahr and the Meerut-Baghpat Road. The portion of the

---

* Published at pages 347 to 393 of Vol. XXII-3 of the Journal of the Indian Roads Congress, December 1957.

G.T. Road under investigation had a rigid pavement consisting of 6 in.-4 in.-6 in. cement concrete slabs, while the other road had a flexible pavement of black top surface over water-bound macadam. After writing the present Paper, further investigations about conditions of subgrade on the G.T. Road were carried out in October 1957 immediately after rains. It was noticed that mile 843 which had been behaving satisfactorily till then had also settled and cracked at some places. The C.B.R. test carried out in the failed portion and another portion in the vicinity which was intact revealed that the C.B.R. in the former case was 3.3 and in the latter 6.6. The moisture at different depths in the former case was also higher than the latter. Recently they had also an opportunity of carrying out investigations into the probable causes of failure in mile 9 of Lucknow-Kanpur Road. In this mile two furlongs had been giving trouble and during 1956 the surface had disintegrated. Investigations carried out on the lines indicated in the Paper revealed that the thickness of crust in the failed portion, viz., furlong 2, was 7½ inches and in furlong 4, which was in good condition, it was 14 inches. This road carried very heavy traffic being an important National Highway and the thickness of the crust in furlong 2 was insufficient to withstand it. Moreover, the moisture content in October in the top subgrade was found to be more than the plastic limit and also the soil was not well compacted. These studies pointed out the necessity of compaction of subgrade soils. Use of stabilised soil in the subgrade and even soling could be economical in some cases and might be adopted.

The drainage under road pavement was another aspect which needed attention. Suitable specifications for this should be evolved for the benefit of field engineers. Taking the case of the Meerut–Baghpat Road itself, there was a heavy rainfall in that area in 1955. It was about 28 inches in three days. The area remained waterlogged for a pretty long time and as it was not well drained the road had failed.

Shri R. L. Nanda said that the C. B. R. values had been determined by the Authors on the natural moisture contents and thickness of pavements estimated on that basis when the water table in those sections was 4 ft to 5 ft 6 in. at the time of investigation. But in June 1956, vide Table 4, the water table in those sections varied from 1 ft 1 in. to 4 ft 1 in., which showed that the area was waterlogged. Therefore, it would be more rational to take soaked C. B. R. values rather than unsoaked values for the design of flexible pavements.

Shri Nanda referred to page 375 and Table 9 on page 376 of the Paper and said that the Authors had designed rigid pavements on the basis of C. B. R. values with 20 per cent reduction,

whereas the C. B. R. method was devised for the design of flexible pavements. It was not reasonable, he said, to accept this assumption without any experimental data. It was also borne out in Paper No. 20 of the Road Research Laboratory, England, that it was not desirable to place any reliance on assumptions unless further studies on the performance of existing concrete roads lead to new empirical C. B. R. curves for concrete roads.

Shri C. G. Swaminathan said that as long as their methods of design were empirical as the C. B. R. and the plate bearing tests, performance and failure of roads should be studied in detail and brought forward so that it might be possible to have some empirical procedures for the design of pavements.

He sought clarification from the Authors about the statement made in para. 3.1.1, page 354, that a flexible pavement was one having little or no inherent resistance to deformation under applied loads and wondered whether that was the correct definition of a flexible pavement. He thought that a flexible pavement was one based on its strength.

Referring to para. 3.2.1 on page 357, regarding wide distribution of wheel load pressures, he wondered whether there was any correct definition regarding distribution of a load. He thought that the so called method of distribution of a load or dispersion was dependent on the method of loading it. He wanted the Authors to throw some light on this point.

With reference to sub-para. 3 of para. 4.1.2, Shri Swaminathan asked how the energy stored in the subgrade by each passing wheel could be a destructive force. He was of the opinion that a road was no better than the amount of work put into it as greater the energy stored in the pavement as such the better it would be for the road itself.

He wondered how consolidation data could tell about the moisture content as had been stated by the Authors in para. 4.2.1 on page 360 that moisture content under an impervious pavement could be estimated for clay soils from the suction or consolidation characteristics of the soil.

Regarding the use of C. B. R. method for obtaining overall thickness of concrete and granular base, as stated in third para. on page 375, by allowing 20 per cent reduction for greater rigidity of concrete as compared to wholly flexible construction, Shri Swaminathan thought that the C. B. R. data could not be relied upon for concrete roads.

higher water table or water-logged conditions, and an uncompacted subgrade with ungraded soil, together with inadequate thickness of pavement in certain places. The use of ungraded soil from borrow pits should be discouraged and the soil blended to yield the required characteristics. This should not be difficult now that almost every State had a highway research laboratory.

Regarding the subgrade not properly compacted, Shri Swami said that it was a problem to be tackled at the time of formation of the road. Leaving the new formation during monsoon for traffic consolidation was not enough. It would do good to insist on a certain minimum density for the subgrade soil before a pavement was laid. Further, the thickness of the pavement also became less on a well compacted subgrade. He then cited an investigation conducted by the Central Road Research Institute on the G. T. Road, where it was observed that a pavement of about 7 in. thickness on well compacted subgrade withstood a traffic of about 3,000 tons per day much better than a 12 in. pavement on a relatively poorly compacted subgrade, other conditions being the same.

Shri Swami concluded that though the C. B. R. curves served the purpose for the present, it was widely felt that the interpretation of these curves for traffic consisting of iron tyred vehicles required modification.

Shri C. L. N. Iyengar commented that as far as rigid pavements were concerned, the Paper lacked considerable analysis in the sense that each type of failure, whether in respect of orientation or magnitude of the cracks, told a different story. Also, unless these observations were tied up with experimental findings about the failure of the subgrade, either near the corners or near the edges, and the stress transmission, the actual type of failure could not be made out. He felt that the report needed to be intensified before making good use of it.

Shri Iyengar agreed with Dr. Subbaraju that there was no point in treating a concrete slab when it had fragmented very largely, because once the fragmentation had taken place there was no interlock between the adjacent areas. Therefore, it was obvious that, if at all the benefit of the study should be made use of, reconstruction of the road should really be done at a stage when the initial signs of failure were noticed, and not when the entire fragmentation had taken place.

Shri Iyengar suggested that the question of blow-ups which was very peculiar to certain locations and not to the general type of failure in concrete pavements, should be separated from the main study.

Regarding the question of validity of Westergaard's formulae, Shri Iyengar observed that there had always been doubt about this except in the U.S.A. where it was accepted in entirety. After observing the trends of British investigators during the last few years, it was seen that opinion had completely changed from rejecting Westergaard's formula to totally accepting it, and now it was the nearest rational approach for designing concrete pavements.

Dr. H. L. Uppal was glad that attention of highway engineers had been drawn to the importance of the subgrade. So far the practice had been that pavements of different thicknesses were put on certain subgrade without knowing whether they were poor, lean or fat.

Regarding the reduction of 20 per cent allowed for greater rigidity of concrete, Dr. Uppal said that this had been taken for soil mechanics for road engineering. For cement-soil, which had only a flexural strength of 50 lb per sq. in., generally a reduction of 20 to 25 per cent was allowed. But cement concrete had much greater flexural strength, rather 10 times that, and should have been given more reduction in thickness.

Dr. Uppal said it appeared a very strange way of putting Proctor's density as 90 per cent or so, because a soil in the laboratory could not probably be compacted to more than 1.8 and, therefore, calling it 90 or 95 per cent in the field did not appear logical. It should be called by the specific gravity that was aimed at.

On page 388 it was stated that movement of the capillary moisture could be resisted by interposing a requisite thickness of low capillarity something like sand or gravel. Before such courses were laid in between the wearing course and the base course it was very essential that the capillary fringe of these materials should be very carefully measured, otherwise it was no use putting a sand layer of 2 to 3 in. and being satisfied that it was not likely to pass on moisture to the upper grade.

Dr. Uppal continued that it was a very wrong assumption that if the water table was kept at 4 ft depth it was probably safe. Recent work had shown that even when the area was very dry, there was always the possibility of the moisture getting accumulated under the sealed surface, because apart from capillary moisture the movement of moisture in the subgrade could also take place through the *vapour phase*.

Shri R. Krishnamachari* referred to para. 2.2.4 on page 351 where the Authors had mentioned Kelly's formulae for calcu-

* This comment was received in writing.

lating the total stresses in concrete pavements. He said that for calculating thermal stresses a temperature differential of 3° F. per inch had been assumed. This data was obtained from foreign countries and it was quite erroneous to assume the same for Indian conditions.

Regarding the non-failure of 4 in. slabs, as mentioned in para. 2.2.7 on page 352, Shri Krishnamachari thought the reason could be that the assumed maximum wheel load of 5,000 lb might not have been reached. He also felt that the assumed figure of 1,000 lb per sq. in. for K modulus of subgrade seemed to be on the low side. Plate bearing tests could have been carried out to determine the value of K.

In regard to laboratory C.B.R. tests on the subgrade samples in their natural moisture content, vide para. 5.2.5 on page 363, Shri Krishnamachari said that the test should have been done at a moisture content that would have been prevalent in the subgrade soon after the rains.

To support the statement on page 375 that the stability of affected subgrades was affected by the rise in moisture content over the plastic limit, the Authors should have determined the moisture content of the subgrade soon after the rains.

Referring to para. 5.2.8 on page 377, Shri Krishnamachari enquired how the thickness of 3 in. or ¾ in. was fixed for the overlays constructed over the disintegrated concrete pavements.

Shri Mahabir Prasad stated that detailed replies to the comments made by various speakers would be given by the Authors in writing.

Regarding the failure of the G.T. Road, he said that this road was constructed about 20 years back and since then the traffic had increased considerably and the water table had gone up. These two factors would probably provide a rational basis for the investigation of the failure of the cement concrete pavement.

Regarding Meerut-Baghpat Road, Shri Prasad said that the heavy precipitation in 1955 of about 28 inches in three days when the area was water-logged might have been the cause of failure of the road.

AUTHOR'S REPLY

The Authors were grateful to the various speakers who had taken part in the discussions on the Paper and were glad to observe that it had aroused considerable interest, particularly among those who were connected with investigations and problems of pavement design.

The discussions had indicated that some of the speakers did not agree to the lines on which some of studies or investigations had been carried out. The purpose of writing this Paper was to bring before the Engineers and Research Workers the results of detailed study on the performance and failures of road pavements and factors responsible for the success or failures of different types of pavements in order to ascertain what other Engineers or Research Workers were doing in similar cases so as to have the benefit of their experience in this field. This purpose has been served to a great extent.

Shri R. L. Nanda had stated that soaked C. B. R. value should have been taken instead of unsoaked value. Although it was possible that the ground might have been water-logged in some portions, yet it could happen that saturated condition below pavement was not created. Determination of C. B. R. value under soaked condition would have given very low value of C. B. R. and consequently higher thickness of pavement than was necessary. There were authorities* who did not recommend soaked C. B. R. values for this reason. It was stated that C. B. R. values determined in-situ (i.e. unsoaked) gave thickness in some agreement with the thickness found to be satisfactory. Another objection to the soaking procedure was that it produced a specimen with more sudden changes in density and moisture content within a small volume, owing to swelling and softening of the top ½ in. of the soil, than were likely to occur in practice.

Attempt was made to carry out investigations in these portions soon after rains as already stated in the introductory remarks so that C. B. R. test may be done in the worst condition of moisture but the results were not conclusive.

It was agreed however that if conditions were such as to create saturation of the subgrade, determination of the C. B. R. value under soaked condition would be desirable.

The Authors agreed with Shri Nanda that C. B. R. method was mainly devised for the design of flexible pavements but this method was adopted for rigid pavements on the basis of information given in "Soil Mechanics for Road Engineers" which says that overall thickness of concrete and granular base obtained by C. B. R. method may be conservative and a reduction of as much as 20 per cent is perhaps reasonable to allow for the greater rigidity of concrete as compared to wholly flexible construction.

* "Soil Machanics for Road Engineers" published by H. M. S. O., U. K. (Chapter on Pavement Design).

In the Technical Paper No. 20 of Road Research Laboratory, U. K., it was stated that too much reliance cannot be placed on the assumption that one inch of concrete is approximately equivalent to two inches of flexible construction.

It would have been useful to carry out plate bearing test to determine modulus of subgrade reaction but as no equipment was available this could not be done.

The Authors, however, agreed that further study of the performance of existing concrete roads was essential and it may lead to new empirical C. B. R. curves for concrete roads giving the variation of total thickness of construction with C. B. R. of the subgrade for different proportions of thickness of concrete to thickness of granular base. These curves would be useful for ensuring that subgrade is not overstressed but theories of stresses within concrete slab like those of Westergaard would still be required to check that concrete slab is not overstressed.

Shri C. G. Swaminathan had sought clarification regarding definition of flexible pavement given in para. 3.1.1. To Authors there appeared to be no anomaly in this definition. According to the publication referred to earlier a flexible pavement is able to resist only very small tensile stress and any change in the shape of the subgrade is followed by a corresponding change in the road surface. If flexible pavement has resistance to deformation, then it is not *flexible*.

Regarding method of distribution of load or dispersion, the Authors felt that the problem was still not completely solved. Methods had been evolved based partly on theory and partly on experience, as well as based wholly on mathematical analysis of the stresses and strains. However, there was no method of design yet devised which had a sound theoretical basis throughout. Research was in progress in foreign countries in this connection and we might in future be able to lay hands on a reliable method of design based on true analysis of stress distribution and soil strengh.

As regards sub-para. 3 of para. 4.1.2, the Authors would refer to Highway Research Board (U. S. A.) Bulletin No. 114 on "Pavement Deflections and Fatigue Failures" by F. N. Hveem. The Authors did not agree with the remark that the greater the energy stored in the pavement the better it would be for the road itself. Repetition of load, in the opinion of the Authors, was a destructive force and not a strengthening one.

Regarding estimation of moisture content under an impervious pavement for clay soils from the suction or consolidation

characteristics of the soil, the depth of the water table and the surcharge imposed by the pavement, the Authors would refer to Paper on "Calculation of the moisture distribution beneath structures" by D. Croney, W. A. Lewis & J. D. Coleman, published in the "Civil Engineering, London" 1950, 45 (524) 103.6 and to Road Research Technical Paper No. 20 on "Pavement Design".

Dr. Bh. Subbaraju had expressed doubts regarding specifications recommended for strengthening the failed concrete pavements. So far as specification No. 1 was concerned, viz. resurfacing with 3 in. coat of stone ballast, it was not understood how this top coat would fail when load came over it as the stresses would be distributed through this top coat and the concrete pavement would be serving as intercoat for which it had sufficient strength.

It had been stated that once unreinforced concrete was extensively cracked it became virtually a flexible type of construction. It was possible that by traffic moving over the cracked portion of the concrete road, the concrete pieces might have got interlocked. As such, the premix carpet laid over such a surface should behave quite satisfactorily. In fact, the reports so far received from site indicated that these experimental portions were standing quite satisfactorily.

Complete removal of slabs might have meant a huge expenditure. As stated in para. 5.2.8, such specifications were being adopted in several other miles of this road and behaviour of such lengths would be watched with interest.

At present the shoulders of roads were not being designed on any basis. On the roads which carry heavy traffic, the edges were liable to wither away and, therefore, an edging was provided in the form of strips of water-bound macadam at least 12 in. wide and $4\frac{1}{2}$ in. thick using stone, brick ballast or kankar. Brick edging was also sometimes provided. When the road was to be widened at a later date the edging was removed and the road extended by adopting the usual specifications.

As regards under-designing of extended portions, the Authors agreed with Dr. Raju. In the present case, a thickness of about 9 in. would be provided on extended portion and if the subgrade was compacted, this thickness should be sufficient to take the traffic.

Shri N. Mohan Rao had considered the approach to the problem not strictly scientific. These remarks were very vague, as the investigations of the failures of pavement had been

carried out on the basis of procedure recommended by the Road Research Laboratory of U.K.

The reasons for adopting the value of wheel load of 5,000 lb for calculating stresses in concrete pavement had already been given in para. 2.2.6. Curve D or E was adopted to find out the depth of crust on the basis of traffic intensity coming over the road. Curve D was for a traffic intensity of 150 to 450 vehicles per day exceeding 3 tons loaded weight and curve E for a traffic intensity of 450 to 1,500 vehicles per day. These curves were not based on wheel loads although earlier curves were based on different wheel loads indicating light to heavy traffic. Adopting a load of 9,000 lb for the concrete pavement would have resulted in very much higher stresses for which a thicker slab than indicated in para. 2.2.7 would have been necessary.

In Australia, a standard wheel load of 5,000 lb was adopted and C.B.R. curves were given for different numbers of thousand of repetitions of this load. For example, one 9,000 lb wheel load was considered as equivalent to 16 repetitions of the standard 5,000 lb load.

A value of 1,000 for 'K' the modulus of subgrade reaction had been assumed in the absence of any other reliable data available for a subgrade consisting of well compacted kankar or other material. It had already been stated in para. 2.2.8, that even this value might be higher in actual practice.

Similarly, there was no error in assuming a value of flexural strength of 650 lb in sq. which could be obtained under actual conditions. Thus, for 650 lb per in. sq. strength, the corresponding compressive strength would be about 4,615 lb per sq. inch which should not be difficult to obtain in the field.

It was not possible to cut concrete cubes of more than $2\frac{1}{2}$ in. in size out of concrete pieces obtained from the road. The Authors felt that it would not have made very much difference in the strength of the concrete cubes had these values been converted to those corresponding to standard cubes. Moreover, no data was available on this aspect. For arriving at the relationship of compressive strength = 7.1 × flexural strength, 6 in. concrete cubes and 6 in. square section beams were tested.

If 50 per cent reduction in thickness as calculated from C. B. R. curves was allowed, the thickness of pavement required would have been much less and no increase in thickness would have been necessary.

Regarding gradation limits fixed by the Bureau of Public Roads, U.S.A., the Authors understood that gradation limits had

been fixed for effective subgrade soils* which could also be applied for base course soils.

Shri C. C. Bagchi had referred to the possibilities of chemical reaction taking place which might have caused the blow-ups in concrete pavements. In this connection, petrographic study was carried out on the concrete specimens as stated in para. 5.2.7, and it was stated on page 377 that there was no deleterious mineral present in the coarse aggregates which could cause alkali-aggregate reaction.

Regarding width of cut through the pavement for purpose of study, the Road Research Laboratory, U.K. recommended a 3 ft wide cut but it had been possible to carry out tests with $2\frac{1}{2}$ ft wide cut. Such a wide cut was essential as it was required to take out samples from the subgrade for tests in the field as well as in the laboratory.

The Authors had not tried the different methods for checking the capillary rise of moisture and it was therefore difficult to give comparative costs of such methods. As they understood, different specifications were proposed to be tried on different roads in water-logged areas by the Government of India and it may then be possible to obtain data of comparative costs of such treatments.

The querry made by Shri Bagchi regarding Appendix 3 was not clear. The first coat of painting was done with $\frac{1}{4}$ in. to $\frac{3}{4}$ in. grit and tar No. II and the second coat of painting was done with 1/8 in. to 3/8 in. grit and mexphalt 80/100. These were the usual specifications followed by the U.P. P.W.D.

The Authors agreed with **Shri S. A. Swami** that ungraded soil should not be used but it should be blended to yield soil of required characteristics. So far as Uttar Pradesh was concerned, necessary instructions had already been issued by the Chief Engineer in this connection and the importance of subgrade compaction before laying pavement had been stressed. The Authors agreed with Shri Swami that investigations should be carried out regarding interpretation of C.B.R. curves for traffic consisting of iron tyred traffic and they hoped that the Central Road Research Institute would take up this problem sooner or later.

Regarding **Shri C. L. N. Iyengar's** comment, the question of blow-ups in concrete roads was mentioned in this study as it was considered that this aspect should also be looked into when the prevailing atmospheric conditions cause wide variations in

*Hyderabad Engineering Research Laboratory Annual Report (Technical) for 1950 (pages 70-71).

temperature leading to considerable expansion and contraction in concrete slabs.

Dr. H. L. Uppal had stated that as flexural strength of cement concrete was higher, a much higher reduction in thickness calculated from C.B.R. curves could be allowed. As already stated in para. 2.2.2, the reduction of 20 per cent was more or less arbitrary. It might be possible to increase this reduction but before this was done, further investigations were necessary.

As regards expressing compaction of subgrade soil as a percentage of Proctor's density, it had been seen that in a highway work, the degree of compaction of embankment usually varies from 90 to 100 per cent of the standard Proctor's density and if the field density is less than 90 per cent of Proctor's density the soil is generally considered not very well compacted. In U.S.A. Highway Engineer's Group Index method of designing pavements, the design curves were based on the assumptions that compaction of the subgrade was to be not less than 95 per cent of maximum dry density determined by the standard A.A.S.H.O. test (which was equivalent to the B. S. test), and compaction of sub-base and base not less than 100 per cent. It was, therefore, evident that there was nothing strange about expressing the degree of compaction in the above way. As regards keeping the formation level 4 ft above the water table, this had been suggested by the Road Research Laboratory, U.K. It was not based on any experience gained in this country. The Authors believed that investigations on this aspect for conditions prevailing in this country were already in progress at the Central Road Research Institute, New Delhi.

Shri R. Krishnamachari had stated that assumption of temperature differential of 3° F. per inch may not be applicable for Indian conditions. This may be correct but in the absence of any such data available for Indian conditions, this value was assumed for study. The Authors agreed with Shri Krishnamachari that the modulus of subgrade reaction might be higher than what was assumed. As regards wheel load of 5,000 lb it was known that for a 6 ton four-wheel-lorry, the maximum wheel load is 2 tons and hence it was reasonable to assume that this maximum wheel load was coming over our roads. The Authors agreed that C.B.R. tests should have been carried at the moisture content in the subgrade soon after rains. This was attempted but conclusive results could not be obtained.

Regarding basis for fixing the thickness of 3 in. and $\frac{3}{4}$ in. (vide para. 5.2.8), these were adopted from practical consideration as provision of lesser thicknesses than these would not have been possible. Economy was another consideration.

The Authors thanked Shri Mahabir Prasad for introducing the Paper on their behalf and all the members who had taken part in the discussion.

Shri Hukam Singh (Chairman) winding up the discussion said that there was no doubt that the thickness of the crust and the design of the subgrade should not be worked out from any empirical or rule-of-thumb formulæ but should be based on detailed study and scientific design, modified where necessary to suit local conditions. Considerations of capillary action of water and increase of moisture content were important as some portions of the G.T. Road seemed to have collapsed badly due to these causes. He also stressed the need for giving greater attention to the earthwork of the road. It must be properly compacted and blended to serve the required surface ; otherwise, the trouble could not be solved except by digging up the whole surface.

In the end, he thanked the Authors for their interesting Paper and the various speakers who had taken part in the discussion.

Discussion on Paper No. 204*

"Scientific Aspects of the Road Traffic Problem"

By

TEJBIR S. KHANNA

Tuesday, 7th January, 1958

Shri J. M. Rijhwani (Chairman) called upon Shri Tejbir S. Khanna (Author) to introduce his Paper.

Shri Tejbir S. Khanna in introducing the Paper said that increased number of road accidents and road congestion were often explained as a result of lack of proper enforcement. This analysis was as false as it was brisk. As a matter of fact there were several factors which made traffic conditions safe or unsafe. Some of these factors were (1) the type of vehicle, (2) the volumes of traffic including pedestrians, (3) geometric design of roads and intersections, (4) planning, control and regulation of traffic flow, (5) the behaviour of road users and (6) stray animals.

The object of the science of road traffic is to discover the laws which govern traffic—the relationship between speed, traffic flow, traffic density, road design, vehicle characteristics, accidents, driver characteristics and road users' behaviour. One of its main object is how to predict the effect of quantitative changes in any of these variables.

Regardless of what action was initiated to secure better roads, a planned and continuous effort was required to secure the best possible efficiency of roads as they existed at any one time. This could only be achieved by setting up Traffic Administration in every big city of the country and regional traffic administration units in each State.

The role of traffic administration in civil defence in developing a well conceived plan of traffic operation for any emergency is also important.

It was fortunate that in the field of traffic science expenditure could be supported in terms of savings which were effected. Although it was difficult to assign accurate monetary values, it was known that a reduction in accidents, a decrease in delay due

* Published at pages 395 to 423 of Vol. XXII-part 3 of the Journal of the Indian Roads Congress, December 1957.

to traffic congestion and other improvements which might come directly from a scientific approach to the traffic problem had values that could be greatly recognised by the public.

Money for Traffic Administration could be found partly from taxes on vehicles, petrol, etc. and partly from contribution by business interests in urban areas, commercial vehicle operators, local bodies and parking meters.

Towards the end Shri Khanna said that in an accident there is only one thing better than the presence of mind, i.e., the absence of body. Appealing to the house to work for that discussion was opened.

Shri Fateh Chand said that every $2\frac{1}{2}$ men owned a car in the U.S.A. while in India this number was much bigger, but the accidents were as many as 70 per 10,000 motor vehicles as against eight in the U.S.A. In other countries also the number of accidents was low. He felt there were five precautions to prevent accidents and he would call them 5 P's. viz., proper planning, public opinion, police, prosecution, and precaution. First of all we had to look to planning. We had to design our roads and signposts according to the needs of the traffic.

Congestion was one of the causes of accidents. During Christmas there were so many accidents in the U.S.A. Accidents caused by congestion could not be avoided even on well planned roads but the number of accidents could be reduced by proper planning which includes proper parking, notice boards, creating traffic sense in the public, etc. At present the bullock-cart would not care to get away from the road to provide way for motor vehicles.

Shri Fateh Chand referred to the District Traffic Committees which were functioning about 20 or 25 years back. Such Committees would frame bye-laws and suggest legislation. But legislation alone would not help unless it was supported by public opinion. Prosecution of people by levying small fines also had its effect. While taking traffic census on all important roads, causes of accidents should also be recorded so that precautions to avoid them in future could be taken.

Shri C. L. N. Iyengar stated that the problem as dealt with in the Paper applied to cities only. Traffic Engineering was applicable even to places having a few vehicles.

He considered that traffic engineering was basically related to highway improvement. Actually traffic planning was interposed between preliminary surveys and final surveys. If

complete data, viz., classification count, classification of traffic, volume, origin and destination of traffic, the desire of the traffic as to how fast they want to move were recorded properly for different locations, it would not be very difficult to comprehend the various implications of the problem. Actually, research workers in this field were trying every day to find new methods to express themselves so that the characteristics of different streets and different routes were put in much clearer form. Every journey was measured in terms of the quality of traffic transmission which was related directly to the journey speed, the number of speed variations during the journey and the frequency with which the speed variations were made, multiplied by some constants to allow for certain intangibles. Irritation to the road user was caused if the frequency of stops was too high.

There was always hesitation to believe in the application of this method where the traffic classification was very complex as in this country. In the U. K. and the U. S. A. there was the difference that the smaller types of vehicles such as motor-cycles and cycles were not as great in number as in Europe. Dr. M. E. Feuchtinger, a German authority on traffic engineering, had found out the equivalent for each type of vehicle in terms of average motor vehicles and that had enabled him to analyse the problem almost on the same lines as adopted in the U. S. A. Our approach should also be on similar lines so that it was possible to find equivalents of our slow moving vehicles.

Dealing with Engineer's responsibility to the road user, Shri Iyengar stated that the former could not achieve accident reduction in entirety. But he was responsible to the extent that the driver should be entirely relieved of his attention as for the soft spots on the road, the cross roads, etc., and was only allowed to concentrate his mind on complexities arising out of traffic hazards.

As far as rural roads were concerned he was of the view that traffic engineering should be the responsibility of the P. W. D., and as far as city roads were concerned, they should be the sole responsibility of the municipality. For example, in most of the cities in the U. S. A., police was a department of the municipality ; of course, that situation did not arise here. If at least the financial burden of traffic improvement was taken away from the police and given to the municipality, possibly it would be a more effective way of carrying out engineering improvements for traffic.

Shri A. Sen Gupta stated that planning of road junctions etc. had become no less important than the design of pavements.

He also felt that the Highway Engineer could deal both with the design of roads and planning the maximum efficiency for movement of traffic for which training in Traffic Engineering would be necessary.

He requested the Author to give in his replies some idea as to how he proposed to draw up the traffic flow sheets proposed in the last para. of page. 399.

The Author had rightly stressed the point of pedestrian study at page 401. In this connection, he pointed out that special walk signals had been installed in Calcutta with very good results.

He did not agree with the Author that the relationship between the distribution of parking space and the time required for a vehicle to be parked was connected with the road users' psychology.

He felt that an automatic flow of traffic would be more advisable than prohibitive measures. Therefore, it was necessary that improvements to existing roads, road crossings, parking places, etc. were carried out and planning of future roads was done with care.

He also stressed the necessity of public education. In this connection he cited the example of Calcutta where police vans at every crossing advised cars and pedestrians at rush hours. Children were helped to learn the A.B.C's of traffic regulations. He also stated that they had carried out a traffic survey in and around Calcutta.

While supporting the plea of the Author for research he stated that geometric planning of roads and road crossings was not being given the attention it deserved. He was of the view that there was a feeling of shyness about designing grade-separations which were omitted on the plea of heavy cost without ascertaining whether the cost might pay for itself. Recently, while designing a single-leaf fly-over at the crossing of N. H. 2 and 6 near Calcutta, they had difficulty in getting any Indian reference and had therefore to resort to American and German practices. Even then the available books did not furnish the sort of information sought for and so they had partly to rely on their own judgement. Publications of the A. A. S. H. O. and Dawson's books were no doubt of great help in this respect.

The feasibility of adapting Prof. Mayer's tables of friction values while designing curves and islands had to be investigated thoroughly and he felt that the choice of selecting 1.5 as the factor of safety had to be worked upon both in the office and in the field.

Shri Walter P. Hedden* stated that his observations were confined to Delhi region with brief visits to Bombay, Agra and Amritsar. Referring to Shri Khanna's Paper he said that the only sector not mentioned was that of the railroad level crossings where one often met with excessive delays and some potential hazards. He had personally encountered delays of 20 to 25 minutes at one crossing on the Agra-Delhi Road and had records indicating that such heavily travelled roads in Delhi as West Patel Nagar and Rohtak Road were closed for 30 to 45 per cent of the time during peak morning and afternoon road traffic periods. The traffic delay was serious to all except the cyclists who detoured the crossing gates at some hazard.

Since " fly-overs " were expensive the economic justification in establishing priority for financing them was another job for the traffic engineer. Where " fly-over " could not be justified because of lower traffic density, the road traffic engineer might co-operate with the railway engineer to devise a safe but speedier system of communication between the station master and the gateman to cut down excessive periods of gate closure.

He agreed with Shri Khanna that traffic engineerig units should be established in the bigger cities to undertake the functions he had outlined. The gathering and analysis of traffic, accident and pedestrian flow data ; the improvement of street patterns and intersections; matters of signs, lighting, traffic regulation and pedestrian as well as vehicle control, all required special training, knowledge and experience.

In big cities, however, he considered that the Traffic Engineer should be an important part of the municipal administration rather than that of the State, since he must act closely with the police and courts and the local law and the budget making bodies.

Vehicle inspection and licensing, which appeared in Shri Khanna's outline of functions, were traditionally associated with the State authorities and might well remain there.

The municipal traffic engineering department should be an action agency to carry out a programme and to demonstrate the resulting benefits, and not merely a research and advisory agency. Much of the detailed fact-gathering and research on traffic problems might be carried out by Universities or the Central Road Research Institute so that the municipal traffic engineering staff could be kept within modest bounds of budget.

* Shri Walter P. Hedden, Transport Consultant from New York (U. S. A.) was in Delhi on 3-month visit studying Indian Traffic in Transport Problem with the Ford Foundation.

In order to make progress in getting in motion a programme to handle the many facets of the big city traffic problems in India, the Indian Roads Congress, through an appropriate committee, might outline the structure, functioning, powers and duties, and the required personnel and budget of a Municipal Traffic Engineering Department and urge prompt action in establishing such Departments.

Shri V. S. Ahuja who had been connected with Road Safety as the Secretary of the Road Safety Advisory Committee, stated that laying of roads was a very important problem but his observations were that roads in Colonies like Sunder Nagar were not properly laid and their width was insufficient; the safety angle seemed to have been ignored altogether. Similarly there were other colonies where the width of the roads was not sufficient even for the present traffic; there was no provision for future traffic and there were no footpaths for pedestrians.

In Delhi there was another serious problem, viz , the problem of laying the traffic islands. We had been laying the traffic islands with a view to controlling traffic and breaking speeds. In Delhi the traffic islands and the police canopies were not lit at all with the result that the vehicles knocked against them. Even roads needed better lights.

The speaker then gave instances of various other roads in Delhi and stated that unless the local municipality had a fully trained traffic engineer and the work was done under their guidance, it was not possible to solve the traffic problems.

Cycle tracks were provided for segregation of traffic but as they were not properly laid and properly lit, cyclists avoided using them. There was no safety for the cyclist as he could be knocked off by a car suddenly emerging from a bungalow.

Referring to street lighting, Shri Ahuja stated that the height of lamp posts and the lamps being covered by tree branches was a serious problem in Delhi at least. He was of the view that where we insist on having nice foliage and trees for roads, the only answer was central street lighting.

Without proper traffic laws and their enforcement, road safety problems could not be handled properly. Disposal of traffic cases needed immediate review and emphasis ought to be laid on road safety aspect rather than merely on technical faults which were sometimes beyond the control of people.

Bodies like the Rotary Club and National Safety Association had been trying to help in solving these problems one way or the

other. Often the trouble had been the shortage of funds for their work. He felt that if these bodies were represented on the suggested traffic administrations, they could be of assistance in solving the traffic problems.

Shri P. K. Banerjee stated that traffic problems in India were peculiar to every city or town, depending upon the heterogenous mixed type of traffic; secondly, there were growing suburbs in almost all the towns resulting in flow of traffic from outside or adjoining areas into the town and vice versa. Segregation could be tried but before this was done, the Author might investigate the reaction of traffic to the enforcement of segregation.

Blind corners and indiscriminate over-taking of slow traffic by fast moving traffic, irrespective of the sight distance, were other problems to be tackled. In his opinion, it would be worthwhile trying to disallow overtaking on certain stretches of a road during certain rush hours. The selection of these points and operation during rush hours could only be established through trial and error.

The speaker pointed out that encroachment of road land should not be permitted. Even parking of vehicles on the road was a sort of encroachment and should be prohibited by law.

Huge advertisement boards and cinema posters also caused a great amount of distraction to the motorists. Steps should be taken to minimize this distraction on the road.

The speaker wished the Author to study the maximum period for which any traffic regulatory personnel should be posted. Regarding traffic administration, he was of the opinion that if it was to be handled by municipalities, the set of officers should be provided with proper magisterial powers or some sort of enforcement powers.

Referring to knocking off of policeman's canopies, he expressed the view that it was better to provide traffic islands.

Shri N. K. Vaswani observed that in Table on page 423, the Author had suggested two departments, viz., Highway Department or the P. W. D., and the Police Department. Each of these departments had been sub-divided into various sub-departments. In his opinion, the Vehicle Inspection organization should be placed under the Police Department and not under the Highway Department as it was a problem of determining the suitability of vehicles for road use.

WRITTEN COMMENTS

Shri Durga Dass (President, Provincial Motor Transport Union) stated that whereas Shri Khanna had elaborated on the width of the roads, the crossings and other connected points, he felt that equal if not greater attention should also be paid to the humans who drove vehicles on the roads.

The first point was about the issue of driving licences. His suggestion was that a thorough and rather strict test should be given by the issuing authority both on the road and with respect to theory, to be followed again by a probationary period of six months before a permanent licence was issued. It would be a good idea if the Government opened training centres where every candidate could undergo training in the rules of the road and how to behave on the road before a licence was actually issued.

Considering the illiteracy of most of the heavy vehicle drivers who come from villages, he suggested that some minimum standard of education should also be prescribed for issuing a licence.

Another point was regarding the slow-moving traffic which must be segregated from the fast-moving traffic. A survey should be made to apportion specific areas both for the slow-moving and fast-moving traffic.

On the main highways, bullock carts should not be allowed. Their function should be to bring the produce etc. upto the highway where it should be transhipped by fast-moving vehicles, serving only as a feeder service.

He felt that there were enough laws for controlling traffic but strict enforcement was necessary.

He also supported the idea that the public should be educated on proper uses of the road.

Shri C. B. Dube (Deputy Commissioner, Delhi) stated that he agreed with Shri Khanna that there was a definite need of specialised training for traffic police to handle both traffic and traffic offenders properly on the road. But the difficulty was that most of the police staff in the lower ranks were not educated and at times it might become difficult to impart to them the intended training. But certainly an effort along this line would be useful.

Consequently there should be a separate pool of traffic police as suggested by Shri Khanna. It would, however, be difficult to have separate pool of traffic police in small cities unless it was done on State level and traffic police was distributed to different cities in accordance with their need.

As far as road traffic laws were concerned there could hardly be any doubt that uniformity throughout the country was essential as stressed in the Paper. In the past 'keep to the left' was the law of the road but now the traffic conditions had changed considerably and several new regulations were necessary for controlling, parking, loading and unloading, one-way traffic, intersection traffic with light signals, etc. To meet all these new demands of traffic in urban areas an 'Urban Traffic Code' on an all-India basis should be framed.

He agreed with Shri Khanna that traffic courts should develop a psychological approach to traffic offenders. Traffic magistrates should train themselves for this approach specially as far as motorists were concerned. But *this comparatively lighter approach to cyclists and heavy vehicle-operators, who knowingly break traffic laws to their advantage, might not work satisfactorily.* Such offenders deserved strict punishment and probably that was the only thing that could keep them from breaking traffic laws.

Undoubtedly there was a need of setting up traffic administration for urban areas in India, as suggested in the Paper. But he was of the view that such administrations should be under the municipalities controlling urban areas. Speaking particularly of Delhi, he felt that 'Traffic Administration' should be under the Chief Commissioner.

As mentioned by Shri Khanna in his opening remarks, Traffic Administration certainly had even more important functions to perform during war-time for civil defence purposes.

Shri A. D. Pandit (Chief Commissioner, Delhi) while surveying the various useful points raised in Shri Khanna's Paper stated that a traffic Advisory Council suggested by the Author already existed in the shape of Traffic Advisory Committee at present, but it lacked the traffic engineer's bias as there was no traffic engineering wing in the Delhi Administration.

As regards the place of traffic unit in the Administration, he was of the view that for its effective working, it might be attached direct to the Administration in a big city and placed on the same level as the Engineer-in-charge of construction and the Transport Controller. The advice of the Traffic Engineer would then be available to all authorities who were responsible for the planning and construction of roads as well as the enforcement of traffic laws. Where there were differences of opinion between these parallel authorities, these differences would have to be resolved by the administration itself.

Shri Pandit felt that it would be desirable for the Ministry of Transport and Communications to advise all States to set up traffic engineering units initially in their large cities, so that adequate solutions of the traffic problem, which was likely to get more and more complicated with the rising standards of living of the people, could be found based on scientific studies. As cities continue to grow, there could be no final solution to the problem of traffic and only a *dynamic equilibrium between road capacities and volume of traffic* could be attained, but fresh thought would have to be given to the question continuously, which could only be done if research into the various aspects brought out by Shri Khanna in his Paper was instituted.

Shri B. L. Ghulati (Supdt. of Police, Traffic, Delhi) stated that Shri Khanna, in his Paper, had suggested a separate pool for traffic police. With a separate pool of traffic police and specialised training in this line, law enforcement efficiency would undoubtedly increase but this would also create certain administrative complications such as :

(a) When a certain police staff were permanently put on traffic duty they, especially the lower ranks, were likely to become corrupt. The corruption started in collaboration with drivers of commercial vehicles and other heavy vehicles. So it was better to keep changing the police staff on traffic and keep bringing in fresh blood.

(b) Traffic duty was comparatively hard and younger men preferably not above 40 were more suited for this job. If a separate pool of traffic police was created these men would have to be doing traffic duties till the retirement age (55).

(c) If traffic police were separated from the general pool, adequate trained staff required in very large numbers for handling the special events, e.g., Republic Day Celebrations, would not be available.

He agreed with the Author that there was certainly a need of uniform traffic laws and road rules. Besides the uniformity in traffic laws and rules there was also a need of bringing about uniformity in penalty standards in traffic courts. This would be well done by pre-determining the penalties for particular offences and limiting the discretion of traffic courts as far as possible. This was not a radical change as Sec. 123 of the M. V. Act does lay down such restriction on the powers of the court. Similar restrictions need also to be imposed for almost all other offences under the said Act.

He also agreed with Shri Khanna that for some offences, which were not major and which might be due to lack of knowledge of traffic rules, the offender should be given a choice of either attending a series of safety lectures or facing the trial.

He did not agree that "Vehicle Tax Collection" work should be done by the Traffic Police. This job, perhaps, could best be done by post offices in the absence of Motor Transport Department. Issuing of vehicle permits might also not be done by the traffic police but by the "Vehicle Administration" (as proposed in the Paper) instead.

It was a good idea to have a full time traffic safety organisation. This organisation should be attached to the Traffic police for routine work and for bigger functions like "Safety Weeks" etc. and *ad-hoc* body might be appointed for the job by the proposed traffic Advisory Council.

Shri S. B. Bapat (Joint Secretary, Ministry of Home Affairs, Government of India) stated that it was a good idea to set up Traffic Administration specially for urban areas but he did not agree with the Author that such Traffic Administration should work under the Highways Department or the P. W. D. It would be better if Traffic Administration functioned under 'Law and Order'. Speaking particularly of Delhi, Traffic Administration might best be placed under the Chief Commissioner. There was a snag in that also. All road repair, maintenance and improvement work was to be under the Municipal Corporation of Delhi. Approval of Traffic Administration would be necessary before execution of the plans for road improvement or any proposed changes in road or traffic conditions by the Corporation but it might not always be possible for the Corporation, due to financial or other reasons, to carry out road work desired by the Traffic Administration. In such cases the matter might be referred to the Ministry of Home Affairs, through the Chief Commissioner and the Corporation Commissioner, for final decision. In the States, Traffic Administration could function well under the Commissioner who controlled both law and order and the municipalities.

He agreed with the Author that besides police investigation of 'party-at-fault' there was certainly a need of scientific investigation and an up-to-date accident record keeping with a view to finding preventive measures. As a matter of fact accident investigation should be carried out jointly by the Traffic Police and the Traffic Administration both from legal and scientific points of view.

He supported the view-point of Shri Khanna that there should be a separate pool for traffic police in order to achieve

overall efficiency. However, he felt that whereas training in developing and keeping up good public relations was necessary to the police it was equally important to make efforts to improve public behaviour. At times one wonders if one's sympathies should not be with the police. Probably, Public Support Organisations could play an important part in improving public behaviour.

From his own experience, he had found that there were different traffic laws in Calcutta and Delhi. This was not desirable. Uniformity in traffic laws for the whole country was extremely important for obvious reasons.

Many court cases could not be given fair trials as witnesses did not like receiving summons or coming to the courts. To meet this snag, he would suggest that the statement of witnesses might be taken right on the spot before at least two reliable persons who might be present there. These reliable persons (M. P.s or gazetted officers) should sign on the statement and this might be taken as evidence for trial purposes.

Shri Bapat felt that it was not possible for the police to bring to book every offender. And, therefore, assistance of the public should be sought in the matter. A warning should be issued to the traffic offender when two reliable persons notified the police (by mail) about the traffic offence and after three such warnings the offender's explanation should be called as to why disciplinary action should not be taken against him.

Shri Tejbir S. Khanna in his replies to various comments stated that **Shri Fateh Chand** had mentioned that there should be district traffic committees. Such a traffic committee was already in existence in Delhi and it had members of all different interests. But according to his experience, these committees did not do much work. They were only advisory committees having no jurisdiction or authority to enforce anything. It was for the executive authority to accept or reject their recommendation.

Regarding causes of road accidents, he had already stated that there was need for scientific investigation. It was rather surprising that though the total number of deaths on account of road accidents was greater than the total number of deaths due to railway or aircraft accidents, yet no scientific investigation in case of road accidents was carried out.

Beginning with Delhi as a model city, the Author in collaboration with the police were starting scientific investigations of road accidents. The police had only confined themselves to finding out who was to blame for the accident. But the scienti-

fic investigation would go further than that ; it would tell us how the accident occurred and how it could have been avoided.

He agreed with **Shri Iyengar** that traffic administration was necessary even for thinly populated areas. As mentioned in the Paper, regional State units should have jurisdiction over all aspects of highways, both on the main as well as non-crowded highways.

To find the equivalent slow-moving vehicles, as referred to by Shri Iyengar, he stated that studies regarding the roadway capacity were being carried out in the C.R.R.I.

Regarding police financing the solving of traffic problem in Bombay, Shri Iyengar had said that if this burden was taken off, efficiency would improve. But in Delhi Shri Khanna mentioned, although the financial burden of putting up road signs and road markings, etc., fell on the municipality yet things were not satisfactory and took their own time.

As regards drawing of traffic flow maps, he stated that he would do it at some other time as explanation of the same would take too much time of the house.

Regarding parking and walking distance relationship he was still of the view that it had something to do with the road users' psychology in order to see what income level people were using what modes of transport and up to what distance they would want to walk. In America, they had made research on this subject and had gone to the extent of finding out the location of bus stops. They found that quarter of a mile was the maximum distance a person should be made to walk from the bus stop. Similarly, in the case of parking motor cars, it appeared they found that for 8 hours parking, the distance should be 650 ft, for 2 hours parking, about 500 ft and accordingly for 15 minutes it should not be more than 250 ft.

He agreed with **Shri Gupta** that there could not be enough police to enforce the traffic safety on all the points.

As regards his disagreement about changing road design where human nature could not be altered he stated, that there was a limit up to which human nature could be improved. If at a nominal expense something could be given according to road users' desire, they would gladly accept it whereas much more police personnel would be needed to enforce things against their wishes. All the bills and safety codes in road design and construction should take into consideration the human nature, i.e., what is called road users' behaviour study.

Regarding magistrates who held courts, Shri Khanna mentioned that they differed in their standard of giving punishment. One magistrate might levy a fine of Rs 40 for a particular offence and another magistrate for the same offence might let the offender off without any penalty. This way people lost respect for the law. People were more afraid of personalities than of the law. He considered there should be some special training for traffic magistrates to bring about uniformity in the courts.

He appreciated the idea of **Shri Ahuja** in taking help of social institutions in spreading road traffic education to both adults and children.

Shri Banerjee had mentioned that reaction of road users to the segregation of traffic must be watched. Shri Khanna was sure this would be most welcome by all types of vehicles ; it was just the cost that mattered. In urban areas and particularly in Delhi there was necessity of cycle tracks. Shri Khanna was proposing to the authorities that there should be express cycleways on which no other vehicle should be allowed. Shade for protection from rain and sun should also be provided for such cycle expressways. Such cycle expressways should necessarily be short cuts as compared to other roads in order to induce the cyclists to use the same. The motorists had a tendency to feel that the cyclists were the greatest traffic nuisance, but they failed to realise that the cycle would be the solution of our traffic problem in the years to come, for several reasons, mainly, because the cycle required less parking place and also occupied much less area of the road, and secondly, which was even a bigger reason, it would be a necessity in the time of war and other emergencies when petrol was rationed.

Dealing with overtaking, he said that it could not be completely banned even in peak hours because of the mixed nature of traffic. Only similar types of vehicles could be forbidden from overtaking each other during particular hours. Bullock-carts or other slow-moving vehicles could be banned for using the road during peak hours, i.e., time segregation of the vehicle rather than space segregation might be easier in built-up areas. Even that would need a lot of time.

There was a great tendency to encroach upon the road area by vendors and hawkers and also by some people who slept on the road in summer time. This caused congestion and increased the number of accidents. It was a very serious problem.

Regarding fatigue time for policeman on traffic duty, Shri Khanna said that it was found by experience that the maximum duty that a traffic policeman should be given was only 3 hours

in the morning and 3 hours in the evening. His counterpart in the police department was given 8 hours duty at a stretch.

He agreed with Shri Banerjee's view that big advertisement boards distracted the attention of motorists. He said that in America and England they had banned such boards and permission of the traffic department was required before such boards could be put up. Regarding lights, too, there was a provision that there should be no light resembling the traffic lights either for advertisement or in front of shops.

Replying to **Shri Vaswani** about vehicle inspection, he said that he had included this in the Engineering Department as he felt that a mechanical engineer could do a much better job on this type of work than the police. Even private vehicles needed inspection.

Shri Tejbir S. Khanna in his replies to the written comments stated as under:

He agreed with **Shri Durga Dass** that attention should also be paid to the humans who drive vehicles. That was why road users' psychology study had been suggested in the Paper and due emphasis had been laid on this subject.

He was fully in favour of Shri Durga Dass' idea of opening Government sponsored training centres for drivers and other vehicle operators before the driving licence was issued. As a matter of fact such training centres were necessary for cyclists as well.

Shri Durga Dass had raised a good point suggesting that some minimum standard of education should be prescribed for vehicle operators. This was specially essential to enable the vehicle operators to read road signs. He would suggest that vehicle operators should be at least middle class pass with good working knowledge of Hindi, English and Official State Language.

As far as the segregation of slow and fast-moving traffic was concerned a lot of thought had already been given to the problem. It was not always possible to allot specific areas for slow and fast-moving traffic separately. The difficulty arose in built-up areas or areas of high land value. He had already suggested cycle expressways in urban areas wherever possible and as far as other slow type traffic was concerned the only remedy seemed to be time segregation.

Shri Durga Dass had rightly pointed out that bullock carts might not be permitted to ply on the main highways and that

bullock carts should be replaced by trucks. But he did not think this could be possible for several reasons, e.g., (i) Farmers who own bullock carts could use them for a few miles extra without additional cost but if they had to have their product to market partly by trucks they would have to pay extra. (ii) It would involve cumbersome process of transferring the load from bullock-carts to trucks. (iii) Administrative difficulties would also come in the way.

As a matter of fact there was an urgent need of transferring the milk-load carried on cycles from surrounding villages to trucks to bring the same to big cities, particularly in Delhi.

He did not agree with Shri Durga Dass that there were enough traffic laws but not enough enforcement. There was a need of framing proper traffic laws for good traffic control in urban and rural areas of India.

As pointed out by **Shri Dube** it would be a difficult process to impart specialized training to traffic police in the lower ranks because lower rank staff was not educated. This difficulty could be gradually solved by prescribing a minimum standard of education for traffic police recruits. Traffic police recruits should be at least matriculates with good working knowledge of Hindi, English and the official State language.

He agreed with Shri Dube that to meet the needs of traffic police in smaller urban areas separate traffic police pools should be opened at State level.

He also agreed that there was a need of framing an urban traffic code on all-India basis.

Under the present circumstances there seemed to be need of rather strict punishment to heavy vehicle operators as pointed out by Shri Dube but it would probably be more helpful if such offenders were also required to attend safety course lectures in addition to the punishment.

Shri Pandit had mentioned that traffic units in the administration might be placed on the same level as Engineer-in-Charge of construction and the Transport Controller. He thought it would be better if the Traffic unit was placed at a slightly different level than suggested by Shri Pandit. If the traffic unit was placed directly under the Chief Commissioner with the head of the traffic unit also working as Secretary to the Administration it was likely to have better working efficiency.

Shri Pandit had very well pointed out the immediate need of traffic engineering units in big cities of India where traffic pro-

blems were likely to get more and more complicated unless efforts to arrest the same were made along scientific lines.

He very well appreciated the difficulties pointed out by **Shri Ghulati** in creating a separate pool for traffic police. (i) Corruption in lower ranks could probably be checked partly by changing the duties of traffic policemen from one area of the city to another and partly by the usual secret police methods. He did not know how far it would be correct to assume that under the present system there was no corruption in the lower ranks of traffic police with their three-year tenure for traffic duties. Corruption might not necessarily increase appreciably by creating a separate traffic police pool. (ii) It was admitted that traffic duty in the field was comparatively hard and people beyond the age of 40 to 45 were not suited for the hard job outside. But probably the Traffic police set up could be formed in accordance with the system of Air Force where early retirement became compulsory unless a person was promoted above a particular rank. Retirement age was on a sliding scale depending upon the rank held. Besides, once the traffic police pool was created and traffic administration, as proposed in the Paper, started functioning properly there would be a number of office jobs which field experienced traffic policemen would be best suited to do when they were beyond 40 to 45. (iii) Selective enforcement was necessary for performing day to day duties as well as for handling special events. For special events of very occasional nature the police could be borrowed from the general pool and put on duty on non-rush routes whereas the trained police could be put on rush routes. Probably help from volunteers from safety organisations could also be made use of on such occasions.

As already mentioned in the Paper, he agreed with Shri Ghulati that discretion of courts should be limited as far as possible to bring about uniformity in penalty standards. As a matter of fact there was a need of special training for traffic magistrates in such matters.

There was no objection to Shri Ghulati's suggestion that vehicle tax collection work might be done by Post-offices and issuing of vehicle permits by the Vehicle Administration.

He agreed with **Shri S. B. Bapat** that for urban areas it was more logical to have traffic administration placed under 'law and order'.

Shri Bapat had rightly pointed out that approval of the Traffic Administration should be necessary before any road work was executed by the Corporation.

If there was any difference of opinion on any point between the proposed Traffic Administration and the Corporation executive authorities, this might be settled by the Chief Commissioner rather than referring it to the Home Ministry. Settling all traffic matters at the Chief Commissioner's level would be better from efficiency point of view. Also the Chief Commissioner was better equipped to do such a job since he would have more practical knowledge of actual conditions of Delhi.

Shri Bapat had raised a good point that road accident investigation should be made jointly by the Traffic Police and the scientifically trained personnel of the Traffic Administration. In the absence of Traffic Administration, the Central Road Research Institute had already started such investigations in collaboration with the Traffic Police of Delhi.

Shri Bapat had raised a good point in suggesting that in case of an accident, the statement of witnesses might be taken right on the spot before at least two reliable persons (M.P. or a Gazetted Officer) and this statement might be taken as evidence for trial purposes.

Shri Bapat's suggestion for getting public assistance for bringing to book traffic offenders could be usefully employed to improve road-users' behaviour where the police force was thin.

Shri S. R. Mehra stated that this Paper was written with a dual objective, firstly to focus the attention of highway engineers in the country to the scientific aspect of highway engineering. He felt that this had been amply achieved judging from the response that the Paper had received from members. The other objective was to see whether the Indian Roads Congress as the premier highway engineering institution in the country could make some positive contribution towards traffic safety at this stage. He thought that could be achieved if the Traffic Engineering Committee of the I. R. C. considered this Paper and any other suggestions emanating from discussions with a view to see whether the I. R. C. could approach officially the various bodies concerned with definite proposals on the points about which there was no controversy.

Shri J. M. Rijhwani (Chairman) in his concluding remarks stated that the valuable and enlightening discussion that took place showed that there was a great need for a Paper of this kind as the traffic problems were assuming more and more importance every day. Population was increasing, development was taking place in the country, more traffic was coming on the roads, both in the urban and rural areas, and the traffic pattern was fast changing.

There was a general feeling, as Shri Ahuja had pointed out, that the cycle tracks which were provided generally by the side of the road were hardly used because they were not convenient. If segregation was decided upon, it should be ensured that cycle tracks were not inconvenient.

There should be some co-ordination between the traffic advisory committee and the executive. He would suggest that suggestions should be sent to the Town Planning Committee of the C. P. W. D. where they had representatives of the Ministry of Transport and Communications, engineers, municipality, and he was sure it would be possible to achieve some results—not on paper but some effective steps would be taken.

He agreed with the Author that there should be one engineering unit attached to the Ministry of Transport and Communications. Of course, even today the Ministry had been advising regarding design of crossings, traffic islands, etc.

He also fully endorsed the suggestion of Shri S. R. Mehra that the Traffic Engineering Committee of the Indian Roads Congress should consider the problems arising out of this Paper and the discussions thereon.

Discussion on Paper No. 205*

"The Importance of Subgrade Compaction in the Economic Design of Flexible Pavement"

By

S. R. MEHRA AND H. L. UPPAL

Tuesday, 7th, January 1958

Shri Kishore Lal (Chairman) called upon Shri S. R. Mehra to introduce the Paper.

Shri S. R. Mehra (Joint Author) in his introductory remarks stated that in view of changed traffic conditions in the country road crusts were required to be designed to carry greater intensity of traffic and heavier loads than before.

At present, the thickness of road crusts was not enough to carry the changed pattern of traffic. So either this thickness had to be increased or it had to be designed in a scientific manner in order to cope with the increased and heavier traffic. One of the possibilities of doing this was by utilization of aggregates which were so far considered inadequate for this purpose. But this had to be backed by proper testing facilities which were not available at present.

The Paper presented details of a scientific investigation so as to improve the road crusts carrying the present and future traffic for the next few years. It had been suggested that about 12 to 15 in. of the embankment should be compacted at optimum moisture to a minimum density of about 1.8 to 1.9. That would not need any great deal of scientific equipment or trained staff. All that would be required was a field laboratory on the site of the work manned by a couple of scientific assistants whose duty it would be to determine the optimum moisture to be added to the embankment material (soil) used on the road, and also to keep a check that after rolling with an ordinary power roller as used for water-bound macadam, the minimum density should not be below a certain level. The control would be maintained by the field laboratory.

Shri Fateh Chand suggested that all efforts should be made to implement the recommendations contained in the Paper if they were considered practicable.

* Published at pages 425 to 452 of Volume XXII-3 of the Journal of the Indian Roads Congress, December 1957.

He did not agree with the Authors that a saving of 9 in. in thickness could be attained by the method suggested by them. He considered that it was better to proceed with caution and not to reduce the thickness of the crust. He also did not agree with the Authors that the failure of the road was due to subgrade only. There were other factors, e.g., the character of traffic, quality of wearing coat, etc. which had to be taken into account. He thought that the subgrade could always be compacted and density increased to 1.9 by the method suggested by the Authors.

He was of the opinion that time had come to carry out actual road construction by the methods suggested by the Authors instead of carrying out experiments only.

Shri N. Amanullah observed that it had been shown by the Authors that an 8-ton vehicle would have an average surface pressure of 61.5 lb per sq. in. giving at 8 in. depth below the surface a stress of 18.81 lb per sq. in. In the case of a bullock cart which had been calculated to give a surface pressure of 140 lb per sq. in., at 8 in. depth, a stress equal to 9.47 lb per sq. in. had been worked out which on the face of it was incorrect. While referring to Fig. 1 of the Paper, he presumed that the stresses had been calculated on Boussinesq's equation which was meant only for perfectly elastic and homogeneous materials. The stresses calculated by this method did not take into account the materials of which the road was constructed. Dr. Whifin of the R.R.L. (U.K.) had used piezo-electric pressure gauges to study the actual stresses transmitted by the different types of vehicles on the subgrade and it was found that there was a difference of 600 per cent between one material and another. In actual observations, according to Dr. Whifin, the values of the stresses were much higher than those obtained from Boussinesq's equation. It was, therefore, not appropriate to use the same type of curve even to get a rough idea of the stresses. This was more pronounced when the subgrade had a water-bound macadam surface over it.

While referring to Fig. 3, he stated that settlements had been plotted against dry bulk density without mentioning the type of soil to which those figures applied and what was the co-efficient of compressibility (change of void ratio for a unit change in stress). One could not imagine a general relation to exist between dry bulk density and settlement independent of the nature of the soil. Even the curve seemed to be incorrect. When the dry bulk density increased the settlement should decrease, whereas this had been shown to be contrary in the Figure.

Referring to Fig. 4, he stated that it had been presumed by the Authors that whatever might be the other conditions like moisture, compaction, etc., the higher the density, the higher

was the strength. If after the construction of a road the moisture movement in the subgrade in the course of time raised the water content from 6 to 15 per cent and also with the passage of time the traffic intensity increased, it meant that the compactive effort as well as the moisture had gone up in the course of time. The curves showed that the higher the compactive effort, the lower the moisture content to achieve the best result.

If both moisture and compactive effort were high, the excess of moisture was squeezed out of the soil and pushed into the carpet, thus breaking the bond between the binder and the stone chippings. This had already been observed on several roads in India.

The Authors had given in Table 5 the C. B. R. values of soils with 3 per cent moisture which was supposed to be the natural moisture content of the alluvial soil and, on the basis of this, thickness of pavements had been designed. But one could not think of designing a road pavement on the basis of those values as in the course of time moisture was bound to go higher than 3 per cent and, therefore, the figures given in Table 5 would be of no use. The correct procedure would be to base the design on a saturated moisture content or slightly below saturation as there was absence of full information on equilibrium moisture in India.

The Authors had dealt with the economy of compaction on the basis of laboratory C. B. R. values. It might be of interest to all the engineers that Maclean of the R. R. L. (U. K.) in a recent Paper to the Institution of Highway Engineers had shown that if under similar conditions the C. B. R. values and triaxial test were tried on a soil, the failure values obtained by the triaxial test at a lateral pressure of 50 lb per sq. in. were just the same as the penetration values in a C. B. R. test for 0.1 in. penetration. It could be concluded from that data that C. B. R. test in the laboratory got automatically performed at a lateral pressure of 50 lb per sq. in. due to rigidity of the mould. The C. B. R. values in the laboratory and in the field had proved quite baffling for the engineers throughout the world. Maclean's work provided an answer to the problem as C. B. R. test in situ (field) at shallow depth had only a lateral pressure of about 5 lb per sq. in. This lateral pressure would definitely give quite low C. B. R. values as compared to the laboratory test. Therefore, the economies worked out on the basis of laboratory test would be far from truth in the actual field.

Shri Dinesh Mohan stated that in an article contributed by him in 1948 to the Journal of the Central Board of Irrigation

and Power, he had pointed out that generally monsoons were depended upon for compaction of subgrade. The method was not only very slow but led to grave results in the ultimate failure of road surfaces which could not take modern heavy traffic and caused a considerable expense at a later stage.

Shri Fateh Chand had questioned the economy as shown by the Authors. Probably there might be certain differences of opinion about that, but there was no doubt that if the subgrade was properly compacted saving in the metalling and the hard surface could be effected.

The Authors had very rightly pointed out that in the case of black cotton soil and other expansive clays, the method of compaction at the optimum density and moisture content did not hold good. Such soils were to be left below the maximum density because of swelling. A very interesting study in this connection had been carried out by M/s. Gibbs & Holt in America where they worked on a very expansive clay and plotted certain contours showing the initial density and the moisture content and the consequent swelling pressure and volumetric expansion of soil. Similar work in black cotton soil was also being tried by them but no definite trends had so far been visible. He was sure that after further trials it would be possible to give the moisture content for such expansive clays.

The method of checking the density of the embankments was a rather cumbersome and a slow process at the moment. One method being tried in other countries was the Gama technique or the neutron method for finding out density. He was sure very shortly one such equipment would be available at reasonable cost in this country also, by using which it would be possible to obtain a quick check on the density and an effective control on compaction.

Shri D. R. Kohli stated that it had been mentioned that the work carried out in the U. K. and in India had shown that densities of the order of 1.9 could be attained if soil were compacted at the optimum moisture. He wished that Table 2 could be elaborated by giving the maximum dry bulk density and optimum moisture content because, in his view, a dry density of 1.9 was attained by only a few soils.

Dr. Bh. Subbaraju made certain general observations regarding planning, organization, authority and co-ordination with reference to Shri Fateh Chand's remarks regarding implementation of the results of research. Planning and organization were there, he said, but unless there was authority to enforce the results of research in actual construction the objectives aimed at could not be achieved. Co-ordination between the various authorities concerned with roads was also very essential in this connection.

Coming to the subject matter of the Paper he stated that Shri Amanullah in his comments had explained that stresses due to trucks and bullock carts given in the Paper were not correct. He wanted to know the reason why a bullock cart with a high intensity of contact pressure had given lower stress at 8 in. depth whereas with low tyre pressure the truck had given higher stress at 8 inch depth. Research work done so far indicated that the induced stresses in the case of heavy vehicle loads were quite different from those of light vehicles. On the face of calculations the results were justifiable.

Another point raised by Shri Amanullah was that in some of the investigations it was found that there was a lot of difference between one material and another in transmitting stresses on to the subgrade. This contention was correct and there was no argument about it, but the snag was that there was very little data on this work and in the absence of that, the existing practice (the Boussinesq's equation), had to be followed.

On page 430, para. 1.6 of the Paper, it was stated: "In cases where the subgrade gets saturated due to waterlogging, etc., the applied load was taken up immediately by the pore water and, due to the suddenness of application of load, an upward pressure was exerted on the pavement and if the thickness of the pavement was not adequate, then settlement under the load and bulging on the sides was possible causing partial failure of the subgrade due to plastic deformation." It was not clear how the upward force was created which caused this sort of deformation.

He also did not agree with the statement made in para. 4.2 on page 441 of the Paper. It had to be realised that there was a certain optimum density for these expansive clays. The optimum density was that at which the minimum expansion and shrinkage characteristics of the soil could be obtained. If the Authors agreed with him, he suggested that it might be added that so long as the swelling pressure was below the optimum density the soil could be compacted and beyond that no more compaction was possible.

Shri A. K. Deb stated that Table 1 of the Paper gave the wheel loads, contact areas and average surface pressures. He thought the surface pressures given in the Paper were fairly low. Some time ago he had a chance to stand at one of the octroi posts on Bombay-Poona road where all the trucks going on that

road stopped. Enquiries made revealed that for trucks which had only one tyre on each rim of the rear axle, the pressure exerted was 70 lb per sq. in., while for trucks having two tyres on the rear axle the pressure was 90 lb per sq. in. He considered that if these were the tyre pressures given in practice by trucks which were using the roads the values given in the Paper were much lower, and this would naturally change the stress distribution as given in the last column of the Table. He would like the Authors to elucidate the basis on which those tyre pressures were given.

The second point, which Shri Amanullah had also mentioned, was about Figs. 2 and 3. It seemed more or less academic just how the dry bulk density changed with stresses. There were so many variables in such cases, such as static loads, repeated loads, etc. Some elucidation on this point would be welcome.

On the last page of the Paper, the Authors had stated that density of 1.6 should be raised to 1.9. He did not consider it a practical proposition when the subgrade was of clay. It was never possible in practice in the field to attain such a high density with clay, whatever the amount of compaction might be. It was certainly feasible when the subgrade soils were granular.

Coming to the conclusion, page 443 of the Paper, he stated that he did not understand why the top should be compacted only 12 to 15 inches. Why should it not be made a principle that the entire embankment was to be compacted thoroughly, layer by layer and adequate compaction provided. This would certainly cut out other possible reasons for ingress of moisture into the subgrade.

Lastly, he felt that adequate measures should be taken for surface drainage of our roads, and it should form a very important chapter in all specifications for road construction in the future. He could mention one instance which related to Ramnad-Mandapam soil stabilized road. This road had gone wavy because of heavy rainfall immediately after its construction. On enquiry it was found that this was due to water having clogged on the sides.

Shri P. L. De felt that where it was not possible to get compaction of 1.9, it might be done at 1.7 or 1.8. Even that would improve matters. However, it had to be ensured that this degree of compaction was obtained for all embankments particularly new ones where there was no time to allow them to settle under the rains.

Shri De also stated that examination of density was very simple and where full fledged laboratories were not available, the P.W.D. staff could be trained to do the job. In West Bengal about 20 overseers had been trained and one batch required only one week's training.

Dr. H. L. Uppal (Joint Author) thanked the various speakers for their interest in the Paper and replied to the comments.

Regarding points raised by **Shri Fateh Chand** he pointed out that the Authors had suggested that if a certain subgrade required a thickness say about 18 inches which was now built in hard stone, about 9 in. of this thickness could easily be replaced with well compacted soil, leaving the remaining 9 in. to be built in stone only. So far as the total thickness was concerned it would remain the same. About the second point raised by Shri Fateh Chand, that beside subgrade, there are other factors such as character of traffic, and quality of the wearing course, which contribute to the failure of the road, it was stated that whereas the wearing surface could be set right, without disturbing the other layers of pavements, the subgrade failure was most serious and invariably required relaying of the road, or heavy patching for a number of years till the required thickness was built up.

Referring to the points raised by **Shri Amanullah**, regarding his doubts about the stress distribution by bullock cart and 8 ton vehicle, he stated that this point had already been replied by Dr. Subbaraju, that stresses induced by heavy and light vehicles are of different forms. Shri Amanullah had raised objection to using the Boussinesq's theory for determining stress distribution and attention had been drawn to the work done by Dr. Whifin of the Road Research Laboratory, Harmondsworth, who had used piezoelectric pressure gauges for studying the stresses. It was stated by the Author that the work of Dr. Whifin had shown that even change of temperature from summer to winter would change the stresses distribution. He had had long discussion with Dr. Whifin and also with Mr. Maclean about the application of his research data to actual road design. It was believed that the work had not been able to hit upon a simple method so far.

Shri Amanullah had referred to Fig. 3 and asked how the density increased with settlement. It had been made very clear in the body of the Paper that in a 1 ft embankment originally compacted at a density of 1.5 and taking for granted that all the settlement was taking place within that 1 ft, the density increased as a result of increased intensity of traffic and when it reached a density of 2.0 the corresponding settlement in 1 ft sample would be 3 inches.

Shri Amanullah had also pointed out that it was no use confining to C.B.R. at 3 per cent moisture. It was stated by the Author that in the Paper, it had been made very clear that all subgrades in India were not likely to be saturated and there might be large dry areas, water-logged areas where the subgrade moisture might never have exceeded that limit. The economics of campaction had, therefore, been studied under those conditions.

Another point raised by Shri Amanullah was that the C.B.R. values in the field and in the Laboratory were different. He agreed with him on this point, but the C.B.R. determined in the field varied so much that one had to come back to the laboratory C.B.R. at a particular density for design purposes. The economics worked out depended upon the change in C.B.R. values attained as a result of increased density, and should apply wherever such changes in density could be brought about.

Shri Dinesh Mohan had referred to the cost of compacted soil. The cost had been worked out on the basis of about 200 miles of roads constructed in the Punjab. It costs about Rs 500 to Rs 600 per mile per inch thickness for a 10 ft wide road. Regarding the Gama ray technique for determination of density, it was considered to be a quick device for density tests and the Institute was already in touch with the manufacturers.

Regarding raising the density from 1.6 to 1.9, as referred to by **Shri D. R. Kohli** and other speakers, it was true that all soils would not give equally high density and, therefore, it was very essential to select not only correct moisture but also correct type of roller. In this connection attention of the speaker was drawn to the work done by the Road Research Laboratory, Harmondsworth, in their publication No. 17 and similar work done by the Central Road Research Institute, India on compaction of alluvial soils. About giving the values of highest density attainable for a particular soil, in Table 2, the same had been given in Table 5, for purposes of convenience.

Regarding the points raised by **Dr. Bh. Subbaraju** it was stated that it was an established fact that in case of soils with low permeability the sudden transmission of load at the surface results in the stresses being taken up by the water. This affects the intergranular pressure in the soil particles and causes side bulging.

Regarding his views about optimum density at which there was least swelling, it was stated that whereas it might be true for less cohesive soils, in case of fat clays this optimum density was so low that for all contents and purposes it could not be called compacted soil.

In reply to points raised by **Shri A.K. Deb**, he stated that the figures given in Table 1 were correct limits permissible by the State Transport Department. If the speaker had seen a certain driver on Bombay–Poona road with tyre pressure higher than permissible he might be violating the law, for certain advantages because vehicle with higher pressure could carry more load.

Regarding his second point about change of density with increased stresses, it had already been explained that when the subgrade moisture increased from dry to wet stage, at a particular moisture, depending upon the corresponding intensity of load, compressive deformation took place and increased the density of the subgrade.

Regarding the increase of density from 1.6–1.9 in case of clays, it had already been mentioned on page 441 (d) that "For black cotton soils, neither had it been possible to compact it to a density higher than 1.7, nor had the C.B.R. value increased with density (from 1.5–1.7)". About compacting top 12–15 in. ement Dr. Uppal stated that if the speaker thought one could afford to compact the entire thickness of embankment it would be better but for purposes of design it would require 20 in. of pavement over the saturated subgrade at a density of 1.5. Normally 8 in. of stone metal crust was provided and the remaining 12 in. could be provided in compacted soil. Dr. Uppal agreed with **Shri P. L. De** that the whole technique was very simple and the results had far reaching effect in economising the cost of road construction.

Shri Kishore Lal (Chairman) in his concluding remarks stated that the Authors had brought out a Paper that was in conformity with the principle of building roads cheaply particularly for the needs of rural areas. The intention behind the present Paper was not to reduce the thickness of the crust, but was to make the best possible use of the local soil and thus make the cost of construction economical.

Discussion on

"General Report on Road Research in India"*

Tuesday, 7th January, 1958

Shri M. S. Bisht (Chairman) while calling upon the Director, Central Road Research Institute to introduce the Report said that road research should be given first priority. There are still many States without research laboratories and in the interest of providing cheap and durable roads he would urge those States to take necessary steps towards this direction.

Shri S. R. Mehra in his introductory remarks stated that there had been a growing feeling that due to lack of proper understanding between the research worker and the engineer in the field, the research in the laboratory was far out-pacing field practice. One of the main reasons for this was the fact that there was a certain amount of lack of commonness in viewpoint between the two parties concerned—the research worker on the one side and the highway engineer on the other. The objective of both of them was exactly the same, and, therefore, there seemed no reason why they should not look at it from the same point of view. In a gathering like the Indian Roads Congress meetings where both research workers and road engineers discussed the results of research on a common platform, it should serve very useful purpose towards bringing them to the same point of view.

RIGID PAVEMENTS

Shri C. L. N. Iyengar stated that four types of pavements for tracked vehicles had been experimented upon by the College of Military Engineering, Poona. The concrete strength as mentioned under item (c) of the specifications is 5,000 lb per square inch at 28 days, which he felt was on the lower side for the heavy duty performance under wear expected of concrete. The original impression in the minds of engineers that the wear resistance of concrete was primarily dependent on the wearing qualities of the coarse aggregate had since been re-oriented by certain findings in concrete of higher strength than 5,000 psi. Actually the wearing qualities of concrete made from the poorer aggregates such as limestone, gravel, etc. and those made with good crushed rock such as trap, granite, etc. all approach the same degree when the concrete strength is of the order of 8000 psi.

* Published at pages 549 to 576 of the Journal of the Indian Roads Congress, Vol. XXII-3, December 1957.

Therefore it would have been desirable to test one such pavement along with the other specifications.

Another type of pavement made by using a proprietary type of concrete blocks manufactured by the shocking process (Ipro Blocks) had been reported to give very good performance for track vehicles. These blocks are of the interlocking type and can be very easily replaced, if they are damaged.

Under the last paragraph of this subject dealing with failure investigations, it had been tentatively concluded that highly expansive subgrade soils were the cause of failure of concrete slabs inspite of fairly good granular base courses. Since under identical conditions 2-lane pavements of concrete had not suffered similar damage as the single-lane pavements, it was suggested that the investigations should not be finally concluded upon without studying these cases.

Dealing with vibratory compaction of beams, Shri Iyengar stated that the statement that hand-compacted concrete reduced in strength with age was very much against the established phenomenon of all types of good concrete increasing in strength with age irrespective of the method of compaction; the special reasons for such a strange finding should have been properly investigated before making a generalised statement of this type. The finding was even more surprising as the same laboratory had reported in one of the other Papers discussed during this session that 1 : 2 : 4 hand-compacted concrete on some roads when tested gave strengths as high as 13,776 psi.

Shri P. J. Jagus referring to the comments of Shri C. L. N. Iyengar suggested to him to contact the Central Road Research Institute where zephro or dumbbell shaped blocks had been prepared by methods of compaction other than specialised methods and these blocks could give wearing resistance which could match the best type of pavements. These blocks are placed with hardly a clearance of 1/16 to 1/32 in. between them. This clearance is generally filled with very fine sand. Tanks of 70 to 80 tons load were made to run on a stretch made with these types of blocks to test the heavy impact caused by the treads of the tanks. Tanks were also made to turn round with a view to study the frictional properties of the pavement. These dumbbell blocks gave very good performance.

It had been already found that if we could design a concrete mix which had compressive strength equivalent to 5,000 lb and above, the abrasive properties of concrete used play very little part. Based on this finding he requested the military authorities to experiment with high strength concrete precast blocks.

Referring to air entrainment, he stated that he always wondered in his mind over the advisability of air-entrained agent in pavement concrete.

With regard to the use of pozzolanas, it was discussed at the last meeting of the Research Organization Committee where it was decided that work of various research laboratories should be collaborated with each other and a definite programme of work formulated. It was a very good suggestion and the Central Road Research Institute had done significant work in this regard.

Brig. S. K. Bose referring to the remarks of Shri Jagus stated that the work track vehicle was a very general term. Bulldozers which have teeth in the track were the worst of the lot. As far back as in 1949 a special concrete floor was laid in the College of Military Engineering yard where there was this type of machine. In spite of using a special type of concrete, the concrete floor did not last long. From the information available the specification suggested in B was standing well.

Dr. M. L. Puri stated that a thorough review of the work carried out by various research workers reveals that there is a great divergence of opinion, as to the extent to which the strength of air-entrained concrete could be maintained by a judicious redesign of the concrete mix. He felt that most of the workers had not taken full advantage of the fact that entrained air acts as an efficient fine aggregate (sand) in concrete. Definite data obtained by following improved methods of concrete mixture design, by using actual road making materials, is needed to find a conclusive answer to the question as to whether the strength lost due to the entrainment of air would be made up by reducing the quantity of sand and water and keeping the cement factor constant by judging the actual workability of the mixes by various workability tests in addition to the slump test, but having more reliance on the workability, placeability, cohesiveness and plasticity of the concrete mixtures.

It had been fully established, as a result of several experiments carried out both in the laboratory as well as in the field in the U.S.A., that entrainment of air improves the resistance of concrete to freezing and thawing. No doubt, freezing conditions do not exist in most parts of India. However, recent tests, carried out by the United States Bureau of Reclamation, had shown that air-entrainment also improved the resistance of concrete to disruption resulting from wetting and drying and heating and cooling. When concrete is subjected to alternations in moisture and temperature, it will be subjected to alternations of stresses. The presence of minute air bubbles or air cells in the form of entrained air, would act as cushions for dissipation

of these stresses, thus avoiding the disruption of concrete. Since wetting and drying and heating and cooling conditions are encountered in all parts of the country, the use of entrained air should have a wide application for concrete pavements in India.

U. S. S. R. had found that entrainment of air improved the resistance of concrete to sulphate attack. Thus entrainment of air would be useful in vast areas where concrete roads were liable to sulphate attack.

The expansion of mortar and concrete, as a result of alkali-aggregate reactivity, was due to development of osmotic pressures in alkali-silica gels formed. The presence of entrained air would give some void space within the mortar, which could serve to relieve the hydrostatic pressures, which otherwise would be exerted against the cement paste. Where the aggregate is only moderately reactive or where the cements are comparatively low in alkalies, this void space may completely relieve distress within the concrete, thus preventing the deterioration due to alkali-aggregate reaction. Thus from the point of view of alkali-aggregate reactivity also, the use of air entrained concrete should have some utility in India.

Some of the pozzolanas, used as admixtures with cement result in increased water demand and reduction in strength of concrete. In such cases, use of entrained air, due to considerable reduction in water demand, may result in even increased strength. Such experiments may yield valuable data and may have further application.

It is universally recognised that entrainment of air in concrete greatly improves its workability and permits the use of poorly graded aggregates. Its use reduces bleeding and segregation and also facilitates placing of concrete. Due to reduced bleeding, it is possible to achieve finishing of concrete slabs earlier and with less labour, which should be an economical proposition.

Due to the various advantages of entrainment of air in concrete, as given above, Dr. Puri suggested that various laboratories in India should undertake work in this respect.

Shri M. S. Ahmed (ECAFE) stated that in the region of Asia and Far East, research work had been fairly well developed in the Phillipines. They had a very well equipped laboratory and it was being worked under the Bureau of Public Works. He thought that perhaps the Indian Roads Congress might wish to record that the Director of the Central Road Research Institute should pay a visit to the Phillipines and also find out how our

research Institutes compare with that of the Phillipines and whether they are wanting in any respect. Unofficially and in his personal capacity he would be too happy to make all the necessary arrangements.

FLEXIBLE PAVEMENTS

Dr. I. S. UPPAL referring to dense carpets, stated that a lot of work had already been done in other countries, but our attempt was only to check on these results, according to conditions prevailing in this country. They had confined their study only to 1 in. carpets, using the maximum size of stone passing ½ in. and retained on 1 in., and passing ½ in. and retained on 10 mesh. About 72 gradings were made and 7 to 8 per cent of bitumen was used taking 30/40 as well as 80/100 penetration bitumen. Two thousand blocks were prepared for testing stability and gradings. An apparatus on the design of Taylor's apparatus for obtaining comparative results was adopted. As a result of experiments it was found that proper grading increased the stability. The effects of different temperatures on the behaviour of these gradings were now being studied and the tests were in progress.

Shri M. B. Jayawant referring to the use of 30/40 penetration bitumen which had given better results than 80/100 bitumen, stated that it had been proved by stability and other tests in other countries, having similar conditions of our climate that asphalt with less than 20 penetration was not satisfactory for pavement surfaces. He felt that 30/40 bitumen for wearing course was not suitable.

Shri M. S. Bisht referring to flexible overlays on rigid pavements, stated that some experiments were carried out in U. P. An investigation was carried out on an old 3 to 4 in. concrete pavement near Aligarh which served well for about 19 years and then showed signs of failure.

For improving the failed sections, two methods were adopted, one was to overlay a bitumen carpet and the second was to provide 3 in. coarse aggregate and surface treatment. Some members had said that asphalt overlay would not help. The answer to that is that the concrete pavement had not disintegrated wholly. The road was still giving service. 200 to 300 tons traffic was passing on it every day, but the road had become inconvenient in some places. The first experiment done over 1½ years ago was very successful. There were no waves or ripples in the road surface. The second experiment of overlay was also proving successful.

Shri N. H. Taylor said that he was sorry to learn that, in using the Taylor Stability Test in the Karnal Laboratory, a 1¼ in. diameter plunger had been substituted for the standard 2 in. diameter plunger. The larger diameter plunger had always been used by him as it was twice the width of the largest stone likely to be present in mixtures tested. If the diameter is reduced to a size approaching the stone size, the test results are likely to be affected. He suggested that the deformation of the sample as measured by a dial gauge should always be plotted against pressure in order that the resistance to deformation as well as the load at failure can be measured.

It had been stated by Shri M. B. Jayawant that a high penetration bitumen should be used in dense asphalt carpets instead of 30–40 penetration bitumen mentioned in the General Report to have given good results. Although Shri Jayawant had quoted a figure of 15 points loss in penetration during mixing, Shri Taylor said that he was checking the penetration of bitumen recovered from fresh mixed material as a routine test and seldom found any measurable change in penetration in 30—40 grades of bitumen. On the other hand, the use of high penetration bitumen, such as 180–200, in dense mixures often resulted in a lower density in the field than was obtained with laboratory compacted specimens.

Shri C. D. Harris in his comments stated as under :

Dense Carpets : There could be little doubt that there were many places in India where dense carpets could be used with advantage. However, he considered that research into carpets should be two-fold. The first and most pressing requirement was research into the methods of improving our existing so-called chipping carpets. He considered that definite improvements in gradation could be effected by gradation of the coarse aggregates and the inclusion of upto 20–30 per cent fines.

It was obvious that the use of chipping carpets must continue for some years to come due to plant limitation and also the cost angle which must militate against the use of dense carpets on many of our lightly trafficked roads.

Plastic Sand : He noticed in the Research Note on sand bituminous stabilization that reference was made to withholding traffic from a sand mix surface for upto 3 months. This was contrary to practice in many countries where sand mixes were being used, namely Malaya, Egypt and Borneo, where it had been found that early application of pneumatic tyred traffic was advantageous and assisted in early compaction. Should iron-tyred rollers have to be used, then it is doubtful whether adequate

compaction can be obtained, as initially an extremely light roller had to be used to avoid excessive " pushing " of the mix.

Flexible Overlayers on Rigid Pavements : He did not consider it likely that a ¾ in. bituminous premix carpet would provide any satisfactory permanent solution to cracked concrete pavements. If the concrete pavement showed signs of failure, it was unlikely that three-fourth of an in. will provide, any additional appreciable strength. He expressed that the specifications proposed by the P.W.D. Research Institute, Lucknow of a 3 in. macadam stone layer followed by a bituminous surfacing might give promising results.

Surface Dressings : He did not consider the proposals put forward by the Central Road Research Institute for 2 coat surface dressing as practicable.

He considered that the principle of close attention to single stone size was an admirable suggestion and coupled with this an attempt should be made to improve the shape of chippings by improving crushing and granulating methods. If two stage applications are to be made, then this could best be done by following more conventional methods of two stage binder application.

As regards the method of specifying aggregate quantities, he thought that the question of whether volumetric or weight methods were adopted was not quite so straight forward as the Authors had suggested. If weight methods were used, then variations must arise due to the varying specific gravities of different aggregates.

Foaming of Binder : Recommendations were made for the use of 4 per cent lime or 2 per cent cement for preventing foaming or frothing of tar or bitumen. The use of such quantities would seem to be rather cumbersome and unwieldy as for even a 200 gallon boiler, approximately 80 lb of lime would be required, i.e., approximately one sack. It had been found that silicones in very small quantities were extremely effective in preventing foaming and the theoretical quantity amounted to only 3 to 4 parts per million. Thus, whilst silicones themselves were expensive, their cost in application was not prohibitive. The normal practice was to make up 1 per cent solution of silicones in, say, kerosine and add approximately one pint of this solution to one ton of bitumen.

Mechanised Surface Dressing : No one could dispute the advantages of mechanised surface dressing by the use of mechanical chipping spreaders and bitumen distributors. However, he

said that if such methods were to be adopted then our quarries must also be mechanised so that ample supplies of aggregate were available, and also arrange for surface dressing to be so programmed that reasonable stretches of roads could be resurfaced in one place. The whole advantage of mechanised surface dressing would be lost if stretches of half a mile or so at wide spacings were undertaken. Bulk bitumen was likely to play an important part in mechanised surface dressing.

Shri C. G. Swaminathan stated that there should be no doubt that a properly designed dense carpet would yield a surface giving a decidedly better performance than a normally employed open graded premix carpet. The investigation in this respect being carried out at the Central Road Research Institute was not only to suggest a proper stability test, if possible, but also to stipulate the limits such as the percentage of voids, gradation etc. of the aggregates.

The grading suggested by the B & R Laboratory at Karnal, he found, did not give the details regarding the filler content, nor the stability limits or the percentage of voids, etc. He would like to know the basis for the suggested gradation.

Regarding plastic sand, laboratory investigations at the Central Road Research Institute for stabilizing fine desert sands showed that from stability requirements a highly viscous binder such as a cut back with 30–40 might prove better. However, as mentioned in the Report a series of specifications using standard RC-3 had been laid and the behaviour of the various specifications was being watched.

As regards the work on surface dressing a previous speaker had mentioned that it was not necessary that the aggregate should be in terms of weight. He would like to invite his kind attention to Table 1 on page 42 of the Road Research Bulletin No. 4, in which it had been very clearly shown that the quantity of material required for shoulder to shoulder packing is the same when expressed on the weight basis but differs widely when it is expressed on the volume basis. For example if a bulk density of 80 lb is taken and if the quantity of spread is 5½ cu. ft. per 100 sq. ft. it is seen that the aggregates would be insufficient for shoulder to shoulder packing. The same speaker had also mentioned that there might not be a proper adhesion between the second layer of stones and the base. It would be seen that since the quantity of aggregates for the first course does not give a complete coverage and leaves nearly 40 per cent of the area uncovered, the second layer of stones not only gets wetted but also embedded in the binder to a great extent. A series of small

stretches had been laid in the premises of the Institute and it was seen there that sufficient adhesion was present.

Perhaps to quite a few engineers, the term low temperature tar might be something new. It is a tar which is obtained as a result of low temperature carbonisation of some coals which are used for domestic fuels. The by-product in the process is a very thin liquid and although, based on physical characteristics, the heavy fraction of this by-product might be similar to the standard RT-3 yet, because of the high phenolic content in the case of low temperature tars, it is likely that the surface would crack as a result of weathering of the binder. Work was being done at the Central Road Research Institute to treat the low temperature tar suitably, if necessary, so as to make it usable for road purposes.

Lastly, he stressed the necessity for introducing mechanical spreaders and sprayers for surface dressing work. Perhaps it might not be far wrong if one were to say that the success of a surface dressing work depends to a greater extent on the uniformity of spraying the binder and spreading the aggregates than even on the exact sizes and quantities of the materials required about which there was a good deal of information available at present.

Shri Sujan Singh said that under the action of tracked vehicles, road surfaces either bitumen or concrete deteriorate rapidly. In this country no work had been done on flexible pavements for tracked vehicles but considerable research had been carried out in other countries. Harmondsworth Laboratory had done a number of trials and details of successful specifications had been issued in their Bulletin No. 13. Specifications for both heavy tracked vehicles and light tracked vehicles were given. He suggested that these might be tried in our country.

Most of the Laboratories in the country were doing experiments on pre-mix including dense carpets. These experiments were being done with 30/40 and 80/100 penetration bitumen. There was a big gap between 30/40 and 80/100. Perhaps some of the Laboratories were not yet aware that 60/70 penetration bitumen was also produced at Trombay Refineries.

As regards surface dressings with graded blindage, he would like to mention one point. Graded aggregates for surface dressings were actually used in the Punjab for many years. It did serve the purpose so long as the volume of fast-moving traffic was small but at present the specification was given up. Possibly the reason was that under fast-moving traffic the smaller particles of aggregate were blown away as they were not held by bitumen. He strongly recommended the use of one size of stone for surface dressing which had proved satisfactory in our country as well as in other countries.

Coming to flexible pavements on top of broken concrete, as a matter of fact the section in question was referred to him and he was against laying a bitumen carpet over it. The only alternative was to cover it with water-bound macadam which was done. There were no two opinions that cement concrete surfaces when broken become unstable and do not form a suitable base for bitumen treatment.

The C.M.E., Kirkee, was experimenting with different solvents for preparing cutbacks. A lot of work had been done in this connection and the Indian Standards Institution had issued a standard on series of cutbacks which covered most of the requirements. It was suggested that these grades might be tried instead of introducing new cutbacks, unless it was absolutely essential to do so for special reasons.

It was interesting to note that the Lucknow P.W.D. Research Laboratory had been experimenting with anti-frothing agents. The agents they had used were actually meant for anti-stripping. Oil Companies had useful information on this point and they would be pleased to furnish the same to the party concerned.

Shri S. R. Mehra said that with regard to superimposing of flexible pavement on old concrete roads, he considered that the obvious thing to do was to redesign the road and try various thicknesses. It was quite possible that for a year or two the subgrade condition might not be brought to the same adverse condition as it was a couple of years ago. This might lead to wrong conclusion, and carrying out of large-scale work on wrong assumption.

With regard to the use of dense carpets or open graded premixes or ordinary surface dressing there seemed to be a lot of controversy about it. To his mind, each one of them had an application in accordance with the circumstances. It had just been stated that the Punjab had given up ordinary surface dressing work probably because it was not successful. So far as he was aware the Punjab had not given up surface dressing work and they were still doing it and they had made a success of it. The trend of results of an open test track experiments carried out at Delhi seems to be that under the conditions in which the experiments were carried out the surface dressing with lesser quantity of aggregate and binder gave no worse results than open graded premix with higher quantities of aggregate and binder and therefore surface dressing work should not be summarily dismissed like that. It was quite possible

that a lot of bad surface dressing work had been done possibly due to defective method of spreading binder. He saw no reason to decry surface dressing work as such and this aspect should be looked into as in the U. K., France and many other countries this work had been done successfully indeed. However, where the traffic was not high enough to bring about movement of binder from bottom upwards or where the traffic was so low that it was not possible for the aggregate to properly adhere to the surface, there was definite case for using open graded premix dressings. But even there the trend of results seemed to be that even if it was not better it was probably equally good to use the same quantities of the aggregate and the binder. This aspect of the work was being done in the Central Road Research Institute and before long the results of research would be available to the Congress.

So far as dense carpets were concerned quite a few States had imported properly designed mixing equipment. There seemed to be no reason why, where traffic conditions warranted, dense carpets should not be used rather than to have to go for surface treatment every year or every two years as the case might be.

As regards low temperature tar, there was a possibility that this type of tar would be available in fairly large quantities in the country. Some of its properties were very favourable but the phenolic property was high and work was being done with a view to see whether it could be utilized for road construction particularly for the first coat. It did not have as much weathering resistance as other types of binders. In any case if quantities were available at fairly reasonable cost it would not be a bad thing to use it.

Brig. S. K. Bose said that in regard to flexible overlays on rigid pavements, it was stated in the Report that the important point that was to be considered in this direction was whether it was advisable to delay reconstruction till the pavement was completely destroyed or whether it was better to strengthen such pavements during the early stages of cracking as a result of structural failures. He suggested plate bearing tests for purpose of evaluation.

WATER-BOUND MACADAM AND GRAVEL ROAD

Shri N. H. Taylor stated that he had recently completed 37 miles of water-bound macadam through an area which was desert for ten months during the year. The stone had to be broken by hand because machine breaking would not give the restricted grading of 1½ in. - 2 in. called for in the specification.

The broken stone was laid on a 2½ in. thick cushion of earth over brick soling and moorum was used for blinding in conjunction with thousands of gallons of water per furlong, the water being drawn from tube wells. The water-bound macadam was to be surfaced with ¾ in. thick premix and ten miles of the surfacing was completed before the monsoon. The monsoon was unusually heavy, the rain being almost continuous for two weeks. As a result, the water penetrated to the earth cushion, removing the support to the water-bound macadam and resulting in ruts in many miles of the completed surfacing.

Shri Taylor suggested that, if asphalt surfacing was to form part of the road crust as designed, the water-bound macadam could be replaced by a graded crusher run stone, which could have its interstices filled with sand, stone-dust or other non-plastic material. Properly graded stone could be consolidated using little or no water and would form a firm, free draining base for the asphalt.

In the case of the failure mentioned by him, Shri Taylor considered that, had the base consisted not of water-bound macadam but a crusher-run graded stone laid directly on the brick-soling, with no moorum and water, such a failure might not have occurred.

Shri S. R. Mehra in reply to Shri Taylor stated that it was never intended that water-bound macadam should not be used with graded stone if it was available at reasonable cost. The reason why a stone of particular size was indicated in the specification was that by hand-breaking almost uniform size of stone was obtained. Whatever small chips were obtained were usually used to fill in the voids. In the case of limestones and sandstones other fillers were used. It would be very nice if a totally bituminous road could be constructed, but the question was of cost. Shri Taylor had described a very unusual situation. This did not happen everywhere and every year. Taking the design of underground sewage system for surface drainage, it was never designed on the basis of maximum intensity of rainfall because the cost becomes so much as nobody could afford it. He agreed that improvements should be made in water-bound macadam.

Shri C. C. Bagchi agreed with Shri Mehra that specifications of 1½ in. gauge did not mean that it should not be a graded stone. Hand broken ballast had been used in Lucknow for long. Machine crushed ballast had not yet been used though grit was being used in surface dressing and premixed carpets. From his experience he said that hand broken ballast was better than crushed run material. His experience also showed that loamy earth was better for blinding than moorum.

Dr. H. L. Uppal stated that some preliminary trials made in the Punjab in 1945 where two miles of road construction was carried out in an area of 75 in. rainfall, showed that if gravel was properly used, it had a definite place in road construction. The cost of gravel was very low. Experiments were being made by the Central Road Research Institute about gravel deposits in various States and their use in road construction.

The studies carried out in the Central Road Research Institute showed that none of the laterite available in India is weaker than well-burnt brick. It can be used in place of bricks, without any hesitation in dry regions.

Regarding water-logging conditions, he stated that some preliminary experiments carried out in the laboratory showed that some of the bitumen cutbacks check the movement of moisture effectively. This was now being tried in one of the roads in the Punjab. Sand was also used to check capillary action.

Regarding soap, he stated that it had given very good results and they had carried out some experiments on water-proofing of mud plaster. It was high time to find out what was meant by soap. Before that was done, it would not be sound to go on recommending any kind of soap.

SOIL ROADS INCLUDING STABILIZATION

Shri S. K. Laha stated that on the coastal areas in West Bengal there is a fair amount of salt in the clay. In the course of one of the major road constructions it was noticed that there was practically no settlement of the embankment for two years. Then in the third year suddenly the embankment started developing undulations. He wanted to know whether investigations had been started on soil having a fair amount of salt in it.

Shri P. L. De referring to soil classification stated that he was not sure if the Casagrande system with some modifications could be adopted in our country particularly for roads. He considered the PRA system was more suitable for road purposes while the Casagrande system was suitable for irrigation purposes. So far as he remembered the Indian Standards Institution in their last meeting at Mysore had recommended that both the systems should be tried simultaneously in the various research laboratories in India and the information from different laboratories be obtained regarding the suitability of one system or the other. Before that was done, one system could not be recommended for acceptance.

As regards bitumen stabilization, he stated that in the Research Report only water resistant properties of bitumen stabilized soils had been discussed, but other points, viz., the maturing period of bitumen, soil or sand and the load carrying capacity had not been touched. The bitumen stabilized road would be quite resistant to water and might have better compressive strength. In actual practice it had been found that when bitumen stabilized road was opened to traffic, there was lot of deformation. He thought this was due to not giving proper curing time. So these two aspects should be looked into before acceptance of stabilized bitumen soil roads.

Regarding the cement-sand wearing course, the criteria for fixation of percentage of cement had been suggested to be the compressive strength only. This might be quite sufficient when it was used as a base course. But for a wearing course, the wearing qualities of soil-cement should also be studied as the abrasive quality of the iron tyres could not be ignored.

Regarding low grade aggregates, he stated that moorum was also being used abundantly in West Bengal and roads built with moorum had stood well.

Dr. I. S. Uppal stated that certain experiments about the water-proofing membranes carried out in the Karnal Laboratory showed that if bitumen was mixed with soil in the ratio of 4 to 5 per cent and then compacted to 1 in. thickness and later allowed to saturate with water it served as a good water-proofing agent.

In the second method the sand was treated with soap and it became absolutely water resistant. The treated sand with 0.2 per cent of soap was put in a bottle. For one year the water had not gone up by more than half an inch. Of course, this needed further investigation.

He further stated that so far they had been using commercial soap available in the market. Now they were carrying out scientific research about some liquid compounds and other materials. The results would be reported in due course.

Chemical stabilization was recommended only if the mechanical stabilization did not prove effective.

Dr. H. L. Uppal said that regarding the system of classification of soil, the object was not to have one system for dams, one for roads, and another for buildings. The idea was to have one system which could be used all over India. The PRA system had certainly no drawbacks. But in the interest of suggesting one system for all engineering projects, it was suggested to have

the modified Casagrande system. He was himself present at the Mysore meeting of the Indian Standards Institution when modification of Casagrande system was suggested which had further been modified.

He did not agree that cement-soil should be used for wearing course as experiments carried out had shown that this would not prove successful. They had carried out both the American and British tests with 4 in. cylindrical blocks. It was found that if a strength of 150 lb per sq. in. was attained it ultimately covered all the conditions. But this 150 lb strength was only good enough where cement-soil was subjected to wetting and drying test but not when subjected to freezing and thawing effects.

Shri C. L. N. Iyengar said that in connection with cement stabilised wearing courses he would like to draw the attention of the Congress to a Report made by West Germany during the discussion on Low Cost Roads at the International Congress on Roads at Istanbul in 1956 about the desirability of grafting cement coated broken stone of 1 in. to 2 in. sizes into the soil cement base by rolling and thereafter the top recesses being made up with cement-sand grout. Satisfactory service as a wearing course of such surfaces had been recorded upto 7 or 8 years in housing estates. The same suggestion without cement sand grouting would also be quite suitable for developing greater mechanical bond between the soil-cement base and bituminous surfacing and might be experimented upon at the Road Test Track, Alipore, Calcutta.

Shri C. C. Bagchi stated that if kankar quarries were well selected, the kankar from those quarries would be as good as stone. For example, roads in Lucknow built of this material and with surface coating had lasted 15 years.

TRAFFIC AND TRAFFIC SAFETY

Shri R. L. Nanda stated that road unevenness had been a factor in the safety and comfort of the travellers. This aspect had drawn the attention of many research workers. Some of them had produced graphical profiles with the help of travelling profilometers while others had measured the displacement of the vehicle. But unfortunately none of them had been completely satisfactory. As a result of continuous effort by organisations like the Bureau of Public Roads, U.S.A., Virginia Highway Department, and Road Research Laboratory, England, the modified Bump Integrator had been evolved. This apparatus is satisfactory and forms a quick means of assessing the riding quality of pavements. The results obtained are reproduceable.

Shri C. L. N. Iyengar stated that under para. 3 of the item dealing with geometric design of roads, a suggestion had been made for a stage development for increasing the width of the paved way from 1-lane to 15 ft where it was not economically feasible to have 2 paved lanes. He had a feeling that this suggestion was not very appropriate as when traffic conditions showed the need for more than one-lane, things would soon prove that there was need for increasing from 15 ft to two lanes. Therefore, an interim improvement of this type would not prove satisfactory both from operational as well as constructional points of view.

Regarding the suggestion that the safe speed limits at night on rural highways could be increased to 50 miles per hour by insistence of lighting equipment on bullock carts, it might be pointed out that at present the Motor Vehicles Act did not impose any speed limit on private motor vehicles on rural roads except that it expected a prudent speed limit to be adopted by such vehicle users. Therefore, the practicability of posting advisory speed limits of the order of 50 miles per hour appeared to be remote, as also the enforcement of lighting equipment of bullock carts using such roads.

Under the paragraph dealing with bullock cart effect on motor vehicle flow it had been suggested that where more than 4 bullock carts ply per hour in one direction it would be desirable to induce platoon or caravan movement of such vehicles. It might be pointed out that platoon movements were easily induced by control devices such as signals when large number of vehicles were concerned; it was very doubtful whether such arrangement could be achieved when the number of vehicles was very small.

In city streets where the number of bullock carts exceeded 6 per hour in one direction, recommendation had been made for the encouragement of such vehicles to ply in singles rather than in caravans or platoons. This suggestion had possibly been made on the basis that lesser time would be occupied during each passing manoeuvre of the bullock cart, but as a larger number of lane changes were involved for the faster vehicles in such an arrangement, the suggestion appeared to be practicable only where the volume of oncoming traffic was very small. Where volume of oncoming vehicles was high, it was obvious that some sort of a prohibition of the movement of such slow moving vehicles would have to be enforced.

Referring to the use of sampling techniques in road traffic counts Shri Iyengar stated that it was commendable that some independent attempt was being made for establishing the size of samples for different types of traffic surveys under Indian conditions. However, to start with, the sizes of samples and tests for

determining the degree of fitness of such samples as evolved by the Yale Bureau of Traffic, would serve most of the purposes.

Dealing with the use of plastic markers, he stated that to the best of his knowledge most of these markers were imported from abroad and it might be desirable also to try stainless steel markers which were being installed in a number of places in Bombay City. It was likely that these steel markers would prove most serviceable under steel tyred traffic.

Shri T. S. Khanna stated that Shri Iyengar had said that instead of changing over from 12 to 15 ft and then gradually to two lanes why not switch over to two lanes straightaway. He must be aware that every inch of the land matters because of shortage of money. A Paper on that subject was under publication and would fully explain the lateral displacement of vehicles under different speeds.

Shri Iyengar believed in enhancing the speeds. The idea was not to enhance the speed but to give the highway engineer some clue as how to judge the speed of vehicles on roads during day time and during night time.

He agreed with him that the number of bullock carts might not be regular. It would take a long time to control that but this was only a study. On the effect of bullock carts on motor vehicle flow and how it affected the roadway capacity he stated that when our geometric designs and standards were evolved we had to go by stage construction and also recommend that six bullock carts in caravan should travel together.

Experiments are being made with plastic markers. Stainless steel markers was also a brilliant idea but plastic markers were definitely better as they were easily recognisable. These had been put on our test track and were also being installed at certain road junctions in Delhi.

Shri J. K. Banerjee who took Chair in the middle of the discussions thanked all the speakers for taking part in the discussions. He hoped that not only the Central Road Research Institute but also all the State laboratories would conduct the necessary research on road problems. Those States which had not set up laboratories so far should take necessary steps to do so in the near future.

Panel Discussion on

"USE OF SOIL IN ALL-WEATHER CHEAP ROAD CONSTRUCTION"

SHILLONG-MAY 15, 1957 & NEW DELHI-JANUARY 8, 1958

Shri K. K. Nambiar (Chairman) while calling upon members to comment, stated that if soil could be used for road construction, it would help to utilise the limited funds available to provide a greater mileage of roads to connect the rural areas. The problem was, therefore, a big one and vital to the whole of the country. Panel discussions on such subjects would help to pool the experience of engineers all over India and the results would prove very valuable to further the cause of low-cost roads in the country.

Question No. 1 :

(a) *Do you use soil in road construction either as a base course or base coat ?*

(b) *If so, what is the length of such roads constructed in your State ?*

(c) *How does the cost of such roads compare with other types of conventional roads?*

Shri S.R. Mehra (a) stated that a lot of work had been done in the Punjab, where for the last 10/12 years stabilised soil had been used for road construction. The first official experiment was carried out in 1944, after a lot of other small experiments had been performed. This official experiment, which was backed up by the Roads Wing of the Ministry of Transport and Communication, consisted of building roads where both the base course and the wearing coat were of stabilised soil without any surface treatment. Surface treatment was given only to the gaps where flood water passed. In the base course, only graded soil was used with normal specifications accepted almost all over the world with a plasticity index of not more than 6 or 7 and sand content of more than 50 per cent. In the wearing course, the mixture was of soil and soft aggregate. The soft aggregate that was most easily available in the Punjab, viz., brick ballast, was used. Brick ballast as such was too soft to take the traffic and it was feared that the interlock would break in a short time as it happened in certain other small experiments. The optimum percentage of brick ballast was fixed from the consideration that there should be enough soil

to surround the particles of the aggregate in order to protect them from getting crushed within the crust itself. It is true that the specification was based on very rough tests which were done mostly in a private laboratory. There was no official laboratory at that time. But subsequent testing showed that as more and more soft aggregate was added to the soil-mix, the C. B. R. value went up from something like 5 to 90 or so and the aggregate crushing value of the mixture seemed to go down in that way and the two crossed in the neighbourhood of 35 to 40 per cent. Another test that seemed to support this percentage was the Plate Bearing test which gave a peak value at 35 to 40 per cent. That is why these percentages of aggregate were adopted. The mainstay of this type of mixture was the grading of the soil as there was no interlock between the particles which were kept apart. But the binding properties of the soil and the behaviour of the soil under changing moisture conditions had to be taken care of. This was done by blending the soil. In the plains of India it was possible to blend the soil reasonably economically to obtain a soil of the required specification.

(b) Experimental roads, 10 ft wide, were constructed in an area where the traffic was of the order of 200 tons per day consisting of mixed bullock cart, both iron and pneumatic tyred, and heavy pneumatic tyred lorries. It was realised that a specification without surface treatment was too weak for traffic of that type; however, the idea was to carry out an accelerated test and, therefore, it was allowed to be put on. The roads were : Batala to Srigobindpur and Batala to Dera Baba Nanak, connecting fairly important towns. These roads behaved reasonably well for a period of about 5 years. In 1947, with the partition of the country, the big volume of refugee and military traffic moved on these unsurfaced roads and the wearing course was completely worn out. But so far as the gaps (surface treated) were concerned, they remained in perfect order. When these miles were ultimately renewed, the wearing course had to be replaced and the miles were surface treated. In the miles not subjected to heavy traffic the life of the wearing course was about six years, giving a wear of about 3/8 in. per year, and the thickness of the crust was 3 to 3¼ in. in all. After this experiment a total length of about 250 miles of roads was constructed in the various areas, mostly refugee colonies, and several other community project areas.

(c) As regards cost, whereas a water-bound macadam surface treated road, 10 ft wide, costs on an average Rs 35,000 per mile, the cost of a soil stabilized road, including the surface treatment, is of the order of Rs 20,000. Where the traffic is of a slightly higher order and where it is expected to develop, the present practice is to graft a thin skin of stone on top of the wearing course as normally

adopted and then to surface treat it. It was, however, felt that this was purely a psychological expedient but it was a good thing to continue it till the behaviour of the brick aggregate under surface treatment was known. The danger was that under the bullock-cart traffic, the brick aggregate might get crushed on the surface and the surface treatment might leave it. However, judging from the crust that had been taken out from the gaps laid in 1944 it appeared to be in good order and no crack or damage had occurred.

Shri S. N. Gupta: (a) The answer was YES both for base course and wearing coat in West Bengal.

(b) It was regretted that the exact length could not be given off hand but it would be made available from the records. An experimental stretch was laid in 1949-50, but since then, except for a few short lengths, nothing much had been done.

(c) Here again, exact figures could not be given. It could be stated roughly that the cost per mile was about Rs 6,000 to Rs 10,000.

Shri K. Sreenivasa Rao: (a) In Madras State soil stabilization had been mainly used for base course.

(b) The total length of roads laid was 65 miles.

Question No. 2:

(a) *Do all your stabilized soil roads have bituminous wearing coat?*

(b) *If so, what length?*

Shri S. N. Gupta: (a) Yes.

(b) Regarding length he had already stated the position in answer to the first question.

Shri K. Sreenivasa Rao: (a) Yes.

(b) 65 miles.

Question No. 3:

(*a*) *What is the type and intensity of traffic on such roads?*

(*b*) *If bullock carts ply, what is the nature and width of the tyre?*

Dr. H. L. Uppal: (a) The intensity of traffic was of the order of 200 to 500 tons usually per day in Punjab, but on some

occasions the intensity had gone up to 1000 tons and even beyond that.

(b) Bullock carts did ply on such roads and the width of the wooden tyre was 4 in. Iron tyres were used only on Gohana road.

Shri K. Sreenivasa Rao: (a) Traffic intensity: 2000-3000 tons.

(b) Width of tyre: About 1-1½ in.

(The stabilized soil being used only in the base course).

Shri S. N. Gupta: All types of traffic used the roads that were being built. The intensity of traffic was 300 to 400 tons per day or even more. Bullock carts did ply on the roads and the width of iron tyre was 1¾ to 2 in. and that of wooden tyre 3-4 in.

Question No. 4:

How are the roads behaving where soil has been used both with and without bituminous wearing coat?

Shri S. N. Gupta: As already stated, all the soil stabilised roads in West Bengal had bituminous wearing coats, but they had opened one road to traffic before putting the wearing coat and tried it for some time. The thickness of the crust was reduced gradually. So the wearing coat had to be given very soon. But with wearing coat there had been no failure so far. In one case, where stabilised soil was used as base course it was noticed that in course of time the wearing coat got pushed aside and the crust of the wearing coat became thinner at this point, but it did not go to the extent of damaging the stabilised base course. The thickness of the wearing coat was 1 in. chipping carpet.

Dr. H. L. Uppal: The unsurfaced roads gave satisfactory service and wore off evenly at the rate of about 3/8 in. every year. The crust with bituminous surfacing coat gave the same service value as surfaced water-bound macadam road for light traffic.

Shri K. Sreenivasa Rao: In Madras State there was no case of stabilised soil roads without bituminous wearing course.

Question No. 5:

What is the climatic condition of the area where such roads have been laid? Give rainfall and position of the water table.

Shri S. N. Gupta: Rainfall might be taken as between 15 to 18 in. for West Bengal and the water table in the worst conditions might be taken within 1 ft of the road level.

Dr. H. L. Uppal: The average annual rainfall ranges between 30-40 in. in the Punjab. The position of the water table was about 10 ft below the surface. The water table had since risen due to heavy rains and unprecedented floods which have caused damage to the road.

Shri K. Sreenivasa Rao: Dry area. Annual rainfall is 30 to 35 in. for Madras.

Question No. 6:

What are the reasons for not using soil more freely in road construction in your State?

Shri S. N. Gupta: This had been discussed several times as members were aware. One reason was lack of adequate personnel. Attempts were now being made to train the personnel as quickly as possible. A road and building research institute and a research laboratory had also been established in West Bengal. The other difficulties regarding climatic conditions, etc., could be overcome.

Dr. H. L. Uppal: Question 6 does not arise for Punjab.

Shri K. Sreenivasa Rao: Wherever the stabilised soil base course was cheaper than other types like moorum base course or stone soling, this was being adopted in Madras.

Question No. 7:

Specifications:

(*a*) *What are the specifications for the material used in*

(*i*) *stabilised soil base course,*

(*ii*) *stabilised soil base coat, and*

(*iii*) *wearing coat.*

(*b*) *How do you pulverize the soil and to what degree?*

(*c*) *How are admixtures added to the soil?*

Shri R. N. Dogra: Two coat courses were being previously used in Punjab. Mostly the base course was laid without pulverization and the wearing course with hand pulverization. The specification for the base course was more than 50 per cent sand and for the wearing course 33 per cent sand with P. I. 8.5 to 10. It also contained 40 per cent brick aggregate. A surfacing of the normal type was usually given. In the beginning all the work was done by manual labour, i.e., the soil was collected

along the road side and pulverized by hand and the necessary amount of moisture was added the next day. The soil put on the roadside was compacted with sheepsfoot roller but subsequently mechanical pulverization which yields equally good results had been resorted to. In fact mechanical pulverization had made soil stabilisation a little more popular because people were not afraid of the uncertain factors of manual handling of the soil. Pulverization is mechanically done with an ordinary tractor e.g., an agricultural tractor using a road weighter behind it. Bigger machinery had not yet been used. It was found that pulverization in most of the cases was satisfactory. In the case of heavy machinery it becomes rather difficult but it was found that if water is used in the first instance pulverization in the wet stage with heavier machines becomes equally satisfactory. For mechanical pulverization the soil was tested at the site and its analysis determined to find the quantity of sand to be added to it. Then it was laid on the base and pulverized. Water was added and was allowed to sink down for over a period of three or four hours. Then the mixture was again turned over with a rotavator for a short period.

Shri K. Sreenivasa Rao:

Specifications: For stabilised soil base course in Madras samples of the sub-grade soils were tested for significant engineering properties viz., mechanical analysis, consistency, limits, Proctor density and cone bearing power with a North Dakota Cone. For the first few experimental works the designs for moorum-sand and sand-clay mixes were in strict conformity with U. S. practice with regard to both gradation and plasticity requirements, though it is known that the specifications applicable to the average soil and climatic conditions obtaining in the U.S.A. have limited value for adoption in tropical countries like India. Later on, however, these specifications were taken only as a guide and reliance was placed on observation of the service behaviour of stabilised course laid under different conditions. In a number of cases granular soil mixes with gradations outside the prescribed U. S. limits and a North Dakota cone bearing power after soaking for 3 days of not less than 200 p.s.i. and P.I. more or less within U. S. prescribed limits were used for foundations of secondary roads and these were found to give satisfactory service. Where sand-clay mix was used for base course the maximum particle size of mix was 0.43 mm. while the maximum particle size specified was 2 mm. The base course had given satisfactory service. The design of mixes for most cases was mainly based on considerations of maximum density and maximum bearing power after soaking for 3 days. Where the sub-grade soil was well drained and where intensity of rainfall was

not high, the maximum value of P. I. permissible was raised to 10.

Pulverization of soil was done by use of pulvi-mixer.

Shri S. N. Gupta:

(a) **Specifications for stabilised soil base course.**

Both (i) soil-sand and (ii) soil-cement had been used in the base course or sub-base course in West Bengal. In the former case different proportions of soil (as found at site) and sand locally available were mixed and tested in the laboratory. The optimum mix was actually adopted. In the latter case, laboratory tests were carried out for finding the optimum percentage of cement to be added with or without granular material in the form of sand. It usually varied from 5 to 7 per cent.

(ii) Base coat: Types adopted —

(i) Soil-cement and (ii) Moorum-sand.

In the former case 7 to 8 per cent cement was used as indicated by laboratory tests in individual cases.

In the latter case laboratory tests were carried out to find out the optimum mix of moorum and sand and the actual mix was carried out accordingly. The proportion of moorum to sand varied from 1 : 0 to 1 : 2.

(b) The crude method of pulverizing the soil by wooden mallets with manual labour was still adopted although in one case a rotavator was used. It was proposed to acquire a pulvi-mixer and a number of rotavators this year.

The degree of pulverization was such that 100 per cent passed through $\frac{1}{4}$ in. mesh, the screen being placed at an angle of 45 degrees.

(c) The pulverised soil was arranged in a windrow and a pre-determined quantity of cement of sand was spread uniformly over it. The two were dry mixed with hand and spread evenly over the pavement. Hygroscopic moisture was measured by the field laboratory and hence the quantity of water to make up the Optimum Moisture Content was added and mixed with hand and the mix allowed to temper over night. Next morning some more water may have to be added to compensate for the loss by evaporation. As already stated a rotavator was used in one case for mixing.

NEW DELHI, JANUARY 8, 1958.

Shri U. J. Bhatt (Chairman) stated that among various road construction materials, soil was one of the most universally available and, at the same time, a versatile material. It was, therefore, essential to know and study the properties of soil and its admixtures.

The Indian Roads Congress had introduced this very important subject last year and those who had attended the Shillong Session would remember the discussions held at that time.

As an outcome of the discussions, the Indian Roads Congress had appointed a high-power Committee to consider the results of experiments on actual road construction laid out in the various States, particularly in the Punjab, U. P., Madras and to some extent in Bombay. This was a very important subject and he was glad that research work was being done in many of the State research laboratories. Even a rich country like the U. S. A. was paying attention to this subject and carrying out a lot of research on the construction of low cost roads. Those States who had research laboratories should, therefore, take up the task of designing cheap roads. The Director, Central Road Research Institute was willing to help those States who did not have any laboratories to carry out research for them.

Question No. 8:

COMPACTION:

(a) *What thickness of loose layer is generally laid for compaction, at a time? Give details both for base course and base coat.*

(b) *What is the compacting unit, and how do you find its performance?*

Shri Bhupinder Singh: In Punjab, a base course of 4½ in. loose soil was compacted to 3 in. thickness. Previously sheepsfoot rollers were used which would leave about 1 in. loose soil at the top which used to be rolled smoothly by a steam roller of 6–8 tons capacity. It had been found in the Central Road Research Institute that 9 in. thickness of loose soil could be compacted in one stage, without affecting efficiency, with 6-8 ton steam roller.

Shri K. Sreenivasa Rao: (a) A thickness of 6 in. was usually laid in Madras.

(b) Sheepsfoot rollers were being used for compaction. The compaction was effected first with about 10 passes of a sheepsfoot roller, then with 2 to 3 passes of pneumatic tyred wheels and finished with a single pass of a smooth power roller.

Shri S. N. Gupta: (a) The thickness of loose layer was dependent upon the designed thickness of the compacted layer. A compacted thickness of 3 in. and 4 in. which required 4½ in. and 6 in. loose layers respectively was adopted in West Bengal. But probably in one case a duly compacted layer of 6 in. which required a loose layer of 9 in. was taken. This applied to both base course or base coat depending on laboratory findings.

(b) The compacting unit adopted so far was rather crude. Initial rolling was done first by an empty lorry and later by a loaded lorry—a substitute for a rubber tyred roller. The final rolling was always done by a flat tyred roller. Good results were obtained with this type of rolling, but light field densities in some cases were obtained. Naturally it is expected that improved types of compacting units would have to be used.

Shri K. S. Sankaran stated that when the sub-grade was compacted, it was always compacted at the optimum moisture content to the maximum density. It had been shown in the laboratory that even if the soil is compacted to the optimum moisture content, later when moisture content increases, the C.B.R. value falls. It was very ideal to find out the equilibrium moisture content and then compact the soil to the maximum density available. The Central Road Research Institute had taken up a survey to find out the highest moisture likely to be attained by the base in the monsoon. This would help to find the equilibrium moisture later on.

Dr. I. S. Uppal said that experience in Punjab showed that a sheepsfoot roller was very essential for the compaction of the base course, although now it was being eliminated and a flat roller was being recommended. The thickness usually adopted was 4½ to 6 in. Recently a base course of soil just to replace brick soling in a desert area had been laid, 9 in. of loose soil compacted to 6 in. There also it was essential to have a sheepsfoot roller as well as a flat roller for purposes of compaction.

Sri J. F. Mistry said that from his experience of one experiment of rolling the subgrade of black cotton soil, he had found that it was not necessary to add water to optimum moisture content. At the time of rolling the subgrade, particularly in the embankment, when water was added the Proctor density was 102 and the optimum moisture was 17.6 per cent. The subgrade being highly clayey became very sticky and rolling with a sheepsfoot roller was not easy. It was necessary to wait for 24 hours to overcome the difficulty. He had experimented with

the moisture content varying from 10 to 17 per cent up to the optimum moisture content and had observed that with 10 per cent moisture content higher Proctor density could be obtained.

Shri S. R. Mehra referring to the point raised by Shri Sankaran stated that, in theory, if compaction was done below the optimum moisture content and the compacted base allowed to dry out to a reasonable moisture before imposing anything else on it, then ingress of moisture would take place. But if the compaction was done at optimum moisture content and it was dried out to a suitable moisture content to obtain maximum practical stability, then the ingress of moisture should not go beyond this.

There was no conflict about the point that nowhere compaction should be done at optimum moisture. In relation to equilibrium moisture, in England they had established that there was a positive equilibrium moisture in their soils which was lower than the saturation moisture and, therefore, compaction was done at that moisture with the assurance that the moisture would not go above that point, even though it was not the optimum moisture for the soil concerned. This moisture condition did not arise there and, therefore, they could afford to compact at equilibrium moisture.

Dr. H. L. Uppal stated that Dr. I. S. Uppal from Karnal had said that the sheepsfoot roller was very essential for sandy soil. But the findings of the workers were that, for sandy soils, sheepsfoot roller was not good and, therefore, pneumatic rolling should be resorted to, for attaining higher density in the field. Sheepsfoot roller does give good results in clayey soils. But for obtaining a density of 1.8 or so, it was not necessary to resort to sheepsfoot roller. For a density higher than 1.9, the sheepsfoot roller would help.

Shri Mistry from Bombay had stated that he had tried optimum moisture of 10 to 17 per cent. He would like to make one point clear. Each soil had its own optimum moisture and the ideal method of determining the optimum moisture for a particular rolling and compacting unit would be to lay stretches of different moisture and then by carrying out increasing number of passes on them find out the maximum density for a particular roller and not assume the results from the laboratory optimum moisture. This had been done in other places.

Question No. 9:

Soft Aggregates: *What are the inferior types of aggregates such as moorum, laterite, kankar, soft stone, shale etc., available in your State?*

Shri K. Sreenivasa Rao:

Moorum, Laterite and Kankar are available in Madras State.

Shri S. N. Gupta stated that moorum and laterite were available in West Bengal and both of them had been used in their roads. Moorum was used for soling but moorum stabilized with sand had also been used and had given very good results.

Dr. I. S. Uppal said that in Punjab mostly soft aggregates were used in the subgrade, as also brick ballast. He had recently used kankar, 30 to 50 per cent by volume of the total aggregate, and it had given very satisfactory results.

Dr. H. L. Uppal said that a detailed study of soft aggregates had been carried out in the C.R.R.I. with the object of finding out which part of the road pavement could actually make use of this material. Before using moorum it is very essential to know its properties; as it could vary from clayey to gravel in composition. The word moorum has been generally confused but technically by moorum was meant iron oxide metal red in colour. In some parts of India, moorum was available even with a P.I. of 40. Therefore, by moorum we should not understand the coarse fraction of it only.

In the laboratory, a detailed study on the laterite deposits and other soft aggregates in various parts of India had been carried out. It was found that none of the soft aggregates either kankar, moorum or laterite was weaker than burnt brick. Therefore, coarse fraction of moorum could, after screening, be used in place of brick ballast. There were other places where kankar was as hard as Delhi quartzite. Therefore, it is very essential that the soft aggregates should be put to various tests before finding their actual place in the road pavement.

Shri M. M. Gidwani stated that cement concrete road (Colloidal concrete process) wearing coat using laterite stone chips as aggregate was laid sometimes in 1944 over the existing Raniganj-Midnapur road, in the portion from Midnapur to Vishnupur via Godapaisal, Salboni, Chandar Kona, Garbeta, Piardoba and Vishnupur. In the reaches of the road passing through villages a pre-mixed carpet was also laid over the concrete pavement. He asked forinformation as to how the concrete road had behaved in the reaches (i) within the villages and (ii) between the villages, and whether any further work had been done on them. What was the nature of these improvements and in what reaches they had been done? Was the use of laterite aggregate in cement concrete recommended for future road construction programme?

Question No. 10 :

Surfacing :

(*a*) *What is your experience of the performance of bituminous wearing coat over a stabilised soil base coat?*

(*b*) *In such cases, do you find a priming coat necessary? If so, at what rate?*

Shri K. Sreenivasa Rao stated that the surfacing was fairly satisfactory. An experimental work had been taken up in Madras State to study the adhesion between stabilized soil base with and without primer.

Shri S. N. Gupta stated that in the field experiments in West Bengal, the bituminous carpet had not been laid directly on the stabilized base. A small scale experiment on the Test Track in Calcutta was carried out and experience had not been very happy. The reason was that under the test load the surface of the stabilized base or the base coat formed some loose layers on the top and the carpet came out with thin layers of soil below it. So something had to be done to ensure a better base and carpeting on top of it. Of course, no primer was used in the above stretch.

As suggested by Shri Mehra, grafting of stone was now being tried. It was hoped to get better results with this.

Shri Hukam Singh stated that some years ago, big lengths of stabilized soil road with surface treatment were laid in the model towns of the Punjab. Two types of primers, one with diesel oil base and the second with furnace oil base were used for the surface treatment. In the former case, the bajri did not stick very well to the surface for about a month, but when diesel oil evaporated the surface was very satisfactory. In the case of furnace oil, there was no difficulty.

Surface treatment was also used in some of the stabilized soil roads without any primer, by using tar coat first, and that also proved very satisfactory.

Shri Sen Gupta wanted to know if another method could not be tried regarding bituminous carpets sticking to the base, e.g., by using mixture of sand and bitumen?

Shri C. G. Swaminathan said that a small scale investigation about bituminous stabilization of sand and sandy soils was taken up in the Central Road Research institute. Very fine sand obtaining in certain parts of India, round about Rajasthan,

was used. In order to bring up its stability normal R. C.-3 graded cut-back was used, and from the laboratory results it was noticed that the standard R. C.-3 might not be the correct binder. However, certain laboratory experiments with hard-penetration bitumen were carried out and it was found that harder binders satisfied the stability requirements. Because R. C.-2 and R. C-3 were available, the test track was laid using R. C.-3 cut-back. The overall cost being rather prohibitive due to high percentage of binder, effort was made to cut it down by using softer aggregates and a test track laid with these was still being observed under traffic. It was hoped it would prove successful.

Question No. 11 :

Design of Pavement :

What design methods do you adopt for determining the pavement thickness for

(*i*) *stabilised soil road, and*

(*ii*) *other types of flexible pavement.*

Shri K. Sreenivasa Rao said that for the few experimental works undertaken so far in Madras the base course had been laid in varying thicknesses of 4 in. to 6 in. He advocated the C.B.R. method of design.

Dr. I. S. Uppal stated that in the Punjab also use was being made of the C.B.R. method for designing the pavements.

The climatic conditions of the base, rainfall, waterlogging conditions and height of the embankment were determined and on the basis of these the thicknesses were being designed both for stabilized soil roads and flexible pavements.

Shri S. N. Gupta said that the scientific method of the design of flexible and other pavements had not been adopted in West Bengal, but the stabilized base and sub-base had been provided on the present conventional method. The minimum thickness varied from 10 to 12 in., depending on the local conditions and the method used was the C. B. R. method.

Dr. H. L. Uppal stated that C. B. R. method of determining the thickness of flexible pavement could also be applied to stabilized soil roads for dry areas. But in those areas which have high water table or, are subjected to frequent flooding, the subgrade shall have to be painted with bituminous cut-back to check up the rise of moisture before providing thickness of crust as required by the C. B. R. Test.

Question No. 12 :

Black Cotton Soil :

(a) *Do you have black cotton soil areas in your State ?*

(b) *Has it ever been treated for use as a subgrade or base course ?*

(c) *What is the treatment adopted ? Give details.*

(d) *How does the surfacing behave in such cases ?*

Shri K. Sreenivasa Rao said that there were small areas of black cotton soil in Madras. Black cotton soil was stabilised for use as base course in areas of the composite Madras State. These were now lying in the present State of Andhra Pradesh.

(b) Clay-sand mix had been adopted.

(c) Use of common salt had been tried.

Shri Govind Das Aggarwal stated that there were deep black cotton soil areas in Hoshangabad District in M. P., the depth of soil being 10 to 20 ft sometimes. At one place the local people in the N. E. S. Block brought sand, the size of grain being about 0.2 in. and 0.3 in. Then they took up the construction of about 14 miles length of road with 12 in. depth.

Another experience was in the Dimni Bridge in the Morena District of the M. P. where the soil was so sandy that it did not adhere. For the approaches of the bridge some sort of hard crust was being adopted. He would like to know the depth which should be adopted for the upper layers.

Fine sand was available in northern portions of Madhya Pradesh and also in the rivers. Effective results could be achieved by using this sand and for this the help of research workers would be needed.

Shri B. S. Jootla stated that there were certain stretches of black cotton soil in Orissa. Generally, a layer of sand was laid on a stretch and it was left for one season. Thereafter, gravel was put on it and then soling and metalling was done. These stretches had stood very well. This method was also applied for improving the berms and shoulders of roads.

To a query, he replied that they had used 3 in. layer of sand in one season and that the experiment had been successful in Orissa. Of course, good drainage conditions should be there. If the base became muddy after the rains, another layer of 3 in.

thick sand was laid and, lastly, a 3 in. layer of gravel was laid. The depth of black cotton soil was only 1 to 2 ft.

Shri M. M. Gidwani

Cement concrete roads had been constructed on the existing W.B.M. formations in black cotton soil areas in Surat District of Bombay State. The concreting was completed sometime in 1954-55. The reaches referred to were :

(i) Surat-Karodra

(ii) Madhi-Tarsara

(iii) Kim-Mandvi.

He wanted to know how the roads had since behaved and whether it was proposed to repeat this specification in any other reaches in black cotton soil areas. In case the concrete surfacing had not proved satisfactory he would like to know the defects and how they had been rectified.

Question No. 13 :

Methods of Soil Stabilization.

Dr. I. S. Uppal stated that they had done a lot of stabilization of soils. The method most commonly used was mechanical stabilization without soft aggregates which had been used only in the base course. Some experimental stretches had been recently constructed using various chemicals. Cement was also used. One stretch was taken up which consisted of ordinary stabilized soil with a base course of P.I. 5–7, sand content minimum 50 per cent, and wearing course of graded soil with about 30 per cent soft aggregate of brick ballast. Side by side they had laid another stretch where 5 per cent cement was used in the wearing course. Molasses and lime were also used in one stretch. The roads were constructed sometime in December 1956 and had been under traffic till now and one monsoon season had already passed. The traffic mostly consisted of bullock carts, lorries, pedestrians, about 200 cycles per day and also a good number of cattle herds. No surfacing was done on any of the stretches. The road was not at all dusty and was behaving very satisfactorily under traffic.

Question No. 14 :

Soil Gravel Roads.

Dr. I. S. Uppal said that about 6 miles of road near Bassi, near Kalka, had recently been constructed, where the rainfall was

of the order of 30 to 40 inches. They had constructed both the wearing course and the base course with gravel. Being only recently constructed, the behaviour under traffic was under observation. So far it had behaved satisfactorily.

Shri B. S. Jootla stated that there were thousands of miles of gravel roads in Orissa. So long segregation of traffic was enforced by the Rajahs, there was no trouble. But with the merger of the States, when bullock carts started using those roads, the surface had become bad. Rainfall in the area was of the order of 50 to 60 in. The procedure normally adopted was that gravel was spread and it was left for a season to receive the monsoon. The local traffic stabilized the surfaces. Now they were trying to convert some of the roads into water-bound macadam.

Shri U. J. Bhatt (Chairman) in winding up the discussions said that he hoped the Stabilized Soil Roads Committee of the Indian Roads Congress would take up all the points raised during discussion into consideration and make available the results of their investigations.

There was no doubt that the use of local materials would be of great help in building up cheaply the extensive road milage of the future.

INDIAN ROADS CONGRESS

Classified List of Papers, etc., in the Proceedings I to XXII

SUBJECT INDEX

Classification

I. Roads in General.
II. Road Surveys, Design, Layout and Construction.
III. Soil and Earthwork; Soil Science as adapted to Road Foundation, Banks and Earth Surfaces, Soil Stabilization, etc.
IV. Water-Bound Macadam Roads and other Low-Cost Roads, such as Moorum, Brick and other Forms of Trackways.
V. Tar and Bitumen Surfacing Carpets, etc.
VI. Concrete.
VII. Miscellaneous Materials and Processes; Aggregates, Tests, Sizes, etc.
VIII. Bridges, Retaining Walls and other Structures.
IX. Traffic Statistics; Regulation and Control of Traffic; Economics of Roads and Road Transport.
X. Road Maintenance and Road Usages.
XI. Standardization, Designs, Loadings, Impact, Specifications.
XII. Research and Experiments.
XIII. Administration and Finance.
XIV. Plant, Machinery and Apparatus.
XV. Miscellaneous.

I. Roads in General.

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
1	Roads and Public Health in India with special reference to Malaria, Borrowpits and Road Dust.	Raja Ram	III	33	64-73	37
2	Safe Wheel Load for Indian Roads.	K. G. Mitchell & Jagdish Prasad	IV	E	1 (e) to 32 (e)	49

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
3	Corrugations on Road Surfaces.	C. B. E. Trustcott	IV	G	1 (g) to 24 (g)	51
4	Ribbon Development.	A. S. Trollip	V	M	1 (m) to 30 (m)	58
5	Slip and Subsidence in a Hill Road.	D. C. Datta	VI	I-39	1 (i) to 17 (i)	72
6	The Broad Classification of Traffic and Contributory Causes of Wear and Tear of Roads.	Sir Kenneth Mitchell	VIII	A-41	1 to 4 (b)	85
7	Drainage in Hill Roads.	M. Mahapatra	X Parts 1 & 4	106	183 to 184-1 and 724 to 729-4	106
8	Cycle Tracks.	Fateh Chand	X Parts 3 & 4	111	429 to 433-3 and 796 to 809-4	111
9	Causes of Landslips and Suggested Remedies.	Geological Survey of India	XVII-3	—	485 to 492	—
10	Road-side Development in Madras State.	K. Ramaswamy Reddi and P. G. Nambiar	XVIII Parts 3 & 4	169	309 to 370-3 and 607 to 617-4	169

II. Road Surveys, Design, Layout and Construction.

1	Construction of Shillong-Jaintipur Road, Khasi Hills, Assam.	F. E. Cormack	II	30	390-397	34
2	A Method of Rapid Road Reconnaissance.	Captain W. G. Lang Anderson	II	31	398-416	35
3	Some notes on the Layout of Rural and Suburban Roads in the Punjab.	R. Trevor Jones	III	32	10-26	36
4	Optimum Weight of Vehicles on extra-municipal Roads.	K. G. Mitchell	III	39	92-105	43

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
5	Layout of Roads.	R. Trevor Jones	V	k (ii)	4 (k) to 17 (k) & 18 (k) to 43 (k 2)	56
6	Transition Curves for Roads.	W. R. Fleury	IV	C-40	15 to 47	78
7	Calculation of the Structure of Roads.	Brigadier Lang Anderson	IX Parts 1 & 4	98	1 to 6-1 and 1 to 18-4	98
8	Basis of Road Planning.	Jagdish Bahadur	XII Part 5	134	267 to 282 and 448 to 455	134
9	Fundamentals of Highway Needs and Highway Planning.	D. G. Bhagat and Jagdish Bahadur	XIII Parts 3 & 4	141	377 to 417 -3 and 193 to 197-4	141
10	Some Examples of Planning Surveys.	R. P. Chanda	XV Parts 3 & 4	153	365 to 392 -3 and 648 to 650-4	153
11	Construction of Shillong-Silchar Road, Assam.	S. C. Pal and R. C. Das	XVI Parts 2 & 4	158	151 to 204 -2 and 537 to 544-4	158
12	Location of Roads in Hilly and Mountainous Country.	B. Chaudhury	XVIII Parts 1 & 4	166	41 to 57-1 and 577 to 582-4	166
13	Fact Finding Survey and Highway Planning in Uttar Pradesh.	P. N. Srivastava	XX Parts 3 & 4	186	297 to 323-3 & 578 to 583-4	186
14	Study and Investigation of Performance and Failure of Road Pavements in U.P.	H. G. Verma & D. C. Chaturvedi	XXII 3 & 4	203	347 to 393 -3 & 741 to 755-4	203
15	The Importance of Subgrade Compaction in the Economic Design of Flexible Pavement.	S. R. Mehra & H. L. Uppal	XXII 3 & 4	205	425 to 452 -3 & 775 to 783-4	205

III. Soil and Earthworks; Soil Science as adapted to Road Foundation, Banks and Earth Surfaces, Soil Stabilization, etc.

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
1	Earth Road Construction and Maintenance by Machinery.	G. W. D. Breadon	I	3	90-105	4
2	Earth Road Development and Stabilization with Gravel.	Lt.-Col. A.V. T. Wakely	I	4	68-89	5
3	Roads in Rural Areas (village roads).	Chowdhary Lal Chand	II	23(a)	191-194 and 227-233	25
4	Oil as Binder for Earth and Gravel Roads.	T.G.F.K. Hemsworth	II	24	205-233	28
5	Soils in relation to Roads—A Bibliological Study.	G.W.D. Breadon	V	N	1(n) to 12(n)	59
6	The Use of Soil Stabilization in Unmetalled and Metalled Roads in India.	S. R. Mehra	V	O	1(o) to 21(o)	6
7	Stabilization of Unmetalled Berms of Metalled Roads.	S. R. Mehra	VI	F-39	1(f) to 25(f)	69
8	The Use of Soil Stabilization in Unmetalled and Metalled Roads in India.	S. R. Mehra	VII	H-40	135-156 (g)	83
9	Some Experiments to Stabilise Moorum Roads in Chota-Nagpur.	K. Gupta	VIII	D-41	57 to 74 (b)	88
10	Fundamentals of Soil Mechanics.	F.L.D. Woolterton	VIII	L-43	211 to 298 (b)	96
11	Road Construction in Black Cotton Soils.	A. Nageswara Ayyar	X Parts 1 & 4	104	125 to 132-1 and 697 to 712-4	104

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
12	A Method of Soil Stabilization for Low Cost Roads.	S. R. Mehra	X Parts 3 & 4	110	379 to 427-3 & 790 to 795-4	110
13	Analysis of Soil Samples.	Indian Roads Congress	XIV-1	—	123 to 135	—
14	Stability of Densified Soil under Adverse Moisture Conditions.	Sachindra Nath Gupta	XIV Parts 2 & 4	145	193 to 246-2 & 523 to 531-4	145
15	Use of Stabilized Soil in Engineering Construction—Section I.	S. R. Mehra & H. L. Uppal	XIV-3	—	293 to 310	—
16	Use of Stabilized Soil in Engineering Construction—Sections II & III.	S. R. Mehra & H. L. Uppal	XV-1	—	184 to 204	—
17	.....Do.....Do..... Section IV.	Do.	XV-2	—	320 to 335	—
18	Stabilization of Gumbotil Soil for Highway Use.	O. H. Patel	XV-2	—	336 to 356	—
19	A Note on the Use of Moorum Soil for Base Course for Macadam Roads.	G. Sriranga-chary	XV-2	—	357 to 361	—
20	Use of Stabilized Soil in Engineering Construction—Section V.	S. R. Mehra & H. L. Uppal	XV-3	—	469 to 482	—
21	.....Do.....Do.... Section VI.	S. R. Mehra, H. L. Uppal & Labhu Ram	XV-3	—	483 to 491	—
22	Waterproofing of Alkaline Soil by Linseed Oil-Cake.	B. R. Sen & Manohar Lal	XV-3	—	492 to 500	—
23	Design of Road Beds.	G. Sriranga-chary	XVI Parts 3 & 4	160	301 to 353-3 & 556 to 563-4	160

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
24	Compaction of Some Alluvial Soils of India.	Central Road Research Institute Okhla, Delhi	XVII-2	—	291 to 344	—
25	Soil Cement in Road Construction.	K. F. Antia	XVII-2 & 4	163	205 to 270-2 & 594 to 601-4	163
26	Stabilization of Certain Clayey Soils in India by Heat Treatment.	S. K. Bose	XVIII-2 & 4	168	215 to 245-2 & 591 to 606-4	168
27	A New Approach to the Analysis of Stability of Slopes.	P. C. Varghese	XIX-1 & 4	171	23 to 43-1 & 651 to 659-4	171
28	Stabilized Soil Construction in the Formation of Tuticorin-Tiruchendur Road.	E. C. Chandrasekharan and T. S. Chandrasekhar	XX-1 & 4	180	69 to 118-1 & 522 to 540-4	180
29	Study of a Clay Bank Failure on an Indian Railway.	U. G. K. Rao	XXI 1 & 4	190	49 to 61-1 & 645 to 657-4	190
30	Experimental Soil Stabilised Road Construction in Black Cotton Soil Area.	J. F. Mistry	XXII 2 & 4	202	261 to 296-2 & 726 to 740-4	202
31	Role of Calcium Chloride and Sodium Chloride in Soil Stabilization.	I. S. Uppal & B. P. Kapur	XXII-3	—	485 to 516	—
32	Sand-Bituminous Stabilization for Road Construction.	L. R. Chadda & H. R. Aggarwal	XXII-3	—	527 to 544	—

IV. Water-Bound Macadam Roads and other Low-Cost Roads such as Moorum, Brick and other Forms of Trackways.

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
1	Corrugation of Water-Bound Macadam Surface in the Bombay Presidency and a Cure.	Henry J. N. Cousins	I	10	184-189	12
2	Some Physical Aspects of Roads and Tyres.	G. L. W. Moss	I	12	190-198	12
3	Treatment with Molasses of Bangalore-Mysore Road.	N. N. Ayyangar	II	19	105-109 & 125-130	21
4	Gravel Roads.	N. N. Ayyangar	II	23(b)	199-203 & 227-233	26
5	Vitrified Bricks for Surfacing Roads in Deltaic Districts.	Gopalacharya	II	23(c)	111-116 & 125-130	27
6	Roads under Local Bodies and how to maintain them.	Fateh Chand	IV	F	1(f)-20 (f)	50
7	Collection of Material for and Consolidation of Water-Bound Macadam.	R. Trevor Jones	V	k(i)	1(k)-5(k) & 6(ki)-40(ki)	55
8	Some notes on the Maintenance of Water-Bound Macadam.	A. L. Rao	VIII	G-48	151-155 H	91
9	Water-Bound Macadam.	G.M. McKelvie & K. S. Raghavachary	XI Parts 2 & 4	117	177 to 284-2 & 566 to 568-4	117
10	Low Cost Roads for the East.	Col. F. L. D. Wooltorton	XII Parts 3 & 5	125	283 to 327-3 & 412 to 424-5	125
11	Low Cost Roads in India and Use of Soil Science for their Improvement.	G. Sriranga-chary	XIII Parts 1 & 4	135	59 to 146-1 & 112 to 132-4	135

V. Tar and Bitumen Surfacing Carpets, etc.

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
1	Recent Methods used for the Treatment of Roads with Bitumen and Tar in Delhi Province.	A.W.H. Dean	I	1(a)	21 to 50 & 56 to 67	2
2	Progress made in the use of Tar and Bitumen in the Punjab since the last International Road Congress in Washington in October 1930.	S. G. Stubbs	I	5 (a)	121-134 & 168-182	6
3	Notes on the use of Tar, Bitumen and Emulsions in the Punjab.	R. Trevor Jones	I	5 (a)	135-145 & 168-182	7
4	Asphalt Roads.	G.G.C. Adami	I	6	146-182	8
5	Necessity for Surface Treatment of Important Tourist Lines and some Aspects of Economical Works in that direction.	V.S.S. Acharya	II	18	74-83 & 93-104	20
6	The Road Problem in India with some Suggestions.	Col. C. E. Sopwith	II	20	84-104	22
7	Further notes on the Treatment of Roads in Delhi Province, with Bitumen & Tar.	A.W.H. Dean	III	34	27-63	38
8	Some Aspects of Bituminous Road Construction in India.	Col. C. E. Sopwith and W. A. Griffiths	V	L	1 (l) to 24 (l)	57
9	Revitalisation of Tarred or Bitumened Surfaces by mix-in-place methods using Cutback Asphalt.	Capt. R. C. Graham	V	P	1 (p) to 12 (p)	61

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
10	Surface Treatment of Concrete Road when outworn.	W. A. Radice	V	Q	1 (q) to 18 (q)	62
11	A Note on "Experiments with Cutbacks of Bitumen".	P. C. Neogi	V	—	89 to 102	—
12	Present-day Methods of Bituminous Road Surfacing work in Chota Nagpur, Bihar.	S. A. Amir	VI	E-39	1 (e) to 15 (e)	68
13	Light Bituminous Surfacings.	Ian A. T. Shannon	VI	G-39	1 (g) to 50 (g)	70
14	An Economical Substitute for Water-Bound Macadam.	A. L. Rao	VI	N-39	1 (h) to 10 (h) & 18 (g) to 50 (g)	71
15	Primers, their Nature and Uses.	N. Das Gupta	VII	F-40	79-86	81
16	Notes on Drag Spreading and Drag Brooming.	W. L. Murrell	VII	I-40	157 to 190 (o)	84
17	Revised Specification for Bitumen Roads in the Punjab.	Abdul Aziz	VIII	I-43	161-184 (j)	98
18	Bituminous Treatment of Wet Aggregates.	C. J. Fielder	IX Parts 1 & 4	99	7 to 54-1 & 19 to 35-4	99
19	Track Spreading.	W. J. Madden	XII Parts 2 & 5	124	241 to 253-2 & 406 to 411-5	124
20	Bituminous Treatment of Wet Aggregates.	Indian Roads Congress	XIV-3	—	360 to 382	—
21	Behaviour of Brick Metal in Tar Carpets.	K. C. De	XV Parts 3 & 4	154	393 to 414 -3 & 651 to 658-4	154
22	Treatment of Wet Aggregates with Turkey Red Oil and Slaked Lime for Bituminous Road Construction.	I. S. Uppal	XVI-1	—	144 to 147	—

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
23	An Examination of Black-top Surface Dressing laid for Field-Tests in 1945 on the Bombay-Delhi Road, Mile 736.	E. Zipkes	XVI-2	—	223 to 245	—
24	Some Observations on Air Field Runway Surfaces.	Central Road Research Institute, Delhi	XVII-1	—	153 to 172	—
25	Bituminous Treatment of Brick Metal Water-Bound Macadam Surfaces in U. P.	D. C. Chaturvedi	XIX-1 & 4	172	45 to 89-1 & 660 to 679-4	172
26	Compressive Strength as a Design Criterion for Bituminous Mixtures.	C. G. Swaminathan	XX-2 & 4	182	141 to 149-2 & 553 to 558-4	182
27	Specifications for Surface Dressing Water-Bound Macadam Roads—Critical Notes.	K. C. De & P. N. Sen Gupta	XX-2 & 4	184	219 to 228-2 & 567 to 577-4	184
28	Surface Dressing with R. T. 4.	K. C. De	XXII-1	—	77 to 88	—
29	Asphalt Paving Mixtures—Their design and Composition	N. H. Taylor	XXII-2 & 4	200	135 to 194-2 & 702 to 717-4	200
30	Adhesion between Bituminous Binders and Road Stones.	C. G. Swaminathan and K. P. Nair	XXII-2	—	299 to 310-2	—

VI. Concrete.

1	The Use of Cement Concrete for the Construction of Roads in the Bombay Presidency.	L. E. Greenings	I	7	214-216 & 236-252	9

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
2	Cement Concrete Roads.	W. J. Turnbull	I	8	217-230 & 136-258	10
3	Concrete Roads in Hyderabad (Deccan).	M. A. Zaman	I	9	231-252	11
4	Cement Bound Roads	W. J. Turnbull	II	25	117-130	20
5	Economy and Development of Bonded Brick Concrete Roads, Plain and Reinforced.	A. K. Datta	III	35	106-146	39
6	Evolution of the thin Concrete Road in the United Provinces.	W. F. Walker	VI	A-39	1(a)-31(a)	64
7	Repair and Maintenance of Cement Concrete Roads.	A.C. Mukerji	VI	B-30	1(b) to 34(b)	65
8	Trackways for Rural Road Development.	Sir K.G. Mitchell	VII	D-40	49-65(j)	79
9	Cement Concreting the Bombay-Poona Road.	W.H.E. Garrod	VIII	K-43	203 to 216(h)	95
10	Bonding a thin Wearing Coat of Cement Concrete to an old Cement Concrete Road Surface.	H.M. Surati	XI Parts 2 & 4	115	153 to 159-2 & 510 to 552-4	115
11	Standard Form for Recording Data on Cement Concrete Surfaces.	Specifications & Standards Committee	XII Parts 1 & 5	122	87 to 97-1 & 382 to 392-5	122
12	A Study of Cement Concrete Roads with Special Reference to Bombay Province.	L.T. Aminbhavi	XIII Parts 1 & 4	136	147 to 168-1 & 133 to 157-4	136

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
13	A Review on "Modern Road Construction in Concrete."	Lt. Col. W.P. Andrews	XIII-1	—	169 to 173	—
14	Cement Concrete Trackways.	Central Roads Organisation	XIII-3	—	419 to 430	—
15	Grouted Concrete Roads.	E. A. Nadirshah	XVI Parts 1 & 4	157	77 to 130-1 & 517 to 536-4	157
16	Cement-Aggregate Reaction in Concrete (A Survey of Recent Literature on the subject).	B. R. Sen, S. K. Mittal & A. C. Banerji	XVI-2	—	246 to 263	—
17	Some Observations on Air Field Runway Surfaces.	Central Road Research Institute, Delhi	XVII-1	—	153 to 172	—
18	Experimental Grouted Cement Concrete Roads in Travancore-Cochin.	E. U. Philipose	XIX-1	—	111 to 122	—
19	Cement Concrete Surfacing and Experimental Concrete Road Construction on Agra-Bombay Road.	R. J. Dhumal & M. A. Mehta	XIX-2 & 4	175	169 to 231-2 & 694 to 701-4	175
20	The Influence of a Superimposed Layer in increasing the Load Bearing Capacity of a Rigid Pavement.	S. K. Bose	XIX-3 & 4	179	499 to 549-3 & 725 to 734-4	179
21	Cement Grouted Roads.	E. A. Nadirshah	XIX-2	—	259 to 269	—
22	Resistance to Abrasion of Concrete Pavements.	P. J. Jagus & M. R. Chatterji	XXI-1 & 4	191	63 to 97-1 & 658 to 665-4	191

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
23	Influence Fields for Finite Concrete Slabs Supported Freely along Two Opposite Edges and Free at the other Two.	K. C. Ray, R. Subramoniam & S. Badaruddin	XXI-2 & 4	193	265 to 281-2 & 694 to 705-4	193
24	Prestressed Concrete Pavements.	K. K. Banerjee	XXII-1	—	89 to 106	—

VII. Miscellaneous Materials and Processes; Aggregates, Test Sizes, etc.

1	Indian "Road Aggregates" their Uses and Testing.	R. L. Sondhi	III	37	146-176	41

VIII. Bridges, Retaining Walls and other Structures.

1	Permissible Stresses in Concrete Bridge Design.	W. J. Turnbull	II	2	358-389	32
2	Submersible Bridge across Parbati at mile 231, Agra-Bombay Road.	S. N. Bhaduri	III	38	176-234	42
3	A Method of Calculating the Stability of Braced Pile Piers.	Gathlac Wilson	IV	A(i)	1(a)-16(a) & 23(a)	44
4	The Dhakuria Lake Bridge.	Gathlac Wilson	IV	A(ii)(a)	17(a)-23	4
5	Franki Pile Foundations for Bridges.	W. A. Radice	IV	B	1(b)-29(b)	46
6	Reinforced Cement Concrete Bridges of 24 ft Span constructed in Gwalior State.	S. N. Bhaduri	IV	C	1(c)-20(c)	47

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
7	Reinforced Concrete Bridge across the Godavari at Shahgadh in Hyderabad State.	Dildar Husain	IV	D	1(d)-46 (d)	4
8	Some notes on Submersible Bridges.	D. Nilsson	V	I	1(i)-45 (i)	53
9	Design of Reinforced Concrete Bridges of short span for Indian Roads.	Brij Mohanlal	V	J	1(j)-55 (j)	54
10	A serious Failure in the Painting of a Steel Highway Bridge.	W. L. Murrell	V	R	1(r)-10 (r)	63
11	The Sai Bridge.	M. A. Korni	VI	D-39	1(d)-5(d)	79
12	Intermediate Screw Piles for the Foundation of Bridges in Soft Soils.	M. S. Doraiswamy Iyengar	VII	A-40	1 & 2	76
13	Failure of a Multi-arched Masonry Bridge.	S. K. Ghosh	VII	B-40	3 to 14(g)	77
14	Sevoke Bridge.	Lt. Col. J. Chambers	VIII	G-40	27-34(h)	82
15	Boat Bridge across the Indus at Gazighat.	G. C. Khanna	VII	F-43	91-149(k)	90
16	Submersible Bridge over the Ujh River in Jammu Province.	S. B. Tayabji	VIII	H-43	157-158(j)	92
17	Masonry Arch Bridge across the Krishna at Deosagar, Hyderabad (Deccan).	Md. Farhatullah	VIII	M-43	299-303	97
18	Stable Causeways on Unstable Foundation Soils.	M. A. Mirza	IX Parts 2 & 4	100	55A to 69A-2 & 37 to 48-4	100

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
19	Ajoy Bridge—Failure of Masonry Piers—Remedial Measures adopted.	H. K. Nivas	IX Parts 2 & 4	102	101 to 104-2 & 72 to 83-4	102
20	Design and Construction of the Purnabhava Bridge.	J. Chambers	X Parts 1 & 4	103	39 to 123-1 & 655 to 696(b)-4	103
21	Standard Specifications and Code of Practice for Road Bridges—Section I.	Bridges Committee	X Parts 2 & 4	109	229 to 331-2 & 746 to 789-4	109
22	Standard Specifications and Code of Practice for Road Bridges—Section II.	Bridges Committee	X Parts 3 & 4	112	435 to 458-3 & 746 to 789-4	112
23	The Failure of a Steel Bridge in Bihar.	S. A. Amir	XI Parts 2 & 4	116	160 to 176-2 & 526 to 535-4	116
24	R. C. Bridges in Travancore State.	S. Rajaraman	XI Parts 3 & 4	118	301 to 325-3 & 569 to 576-4	118
25	Well Foundations of the Kalabagh Bridge over the Indus.	R. K. N. Iyengar	XII Parts 1 & 5	120	17 to 64-1 & 363 to 374-5	120
26	Failure of a Reinforced Concrete Bridge in the N.W.F.P.	Hardit Singh	XII Parts 2 & 5	123	211 to 239-2 & 393 to 405-5	123
27	Tables for Freely Supported Reinforced Concrete Slabs for Road Bridges and Culverts.	Bridges Committee	XII-3	—	434 to 437	—
28	The Testing of the R.C.C. Bridge over the Auranga River.	J. A. Taraporevala	XII Parts 4 & 5	129	59 to 78-4 & 434 to 441-5	129

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
29	Some Observations on Load Testing to ascertain the Foundation Bearing Pressures of Bridge Wells in Sandy Strata and on the Alterations required in the Design of a Bridge Foundation owing to one Well of a Pier having gone out of Alignment.	B. B. Gupta	XII Parts 4 & 5	130	79 to 92-4 & 442 to 443-5	130
30	Some Type Designs of Unreinforced, Hingeless Masonry Arches.	Bridges Committee	XII Parts 4 & 5	131	157 to 178 -4 and 444 to 447-5	131
31	Successive Failure of Two High Level Bridges over the Barakar.	C. D. Mitra	XII-5 & XIII-4	133	247 to 266 -5 & 95 to 111-4	133
32	Repairing & Healing of Cracks in Reinforced Concrete Bridges.	M. A. Korni	XIII Parts 3 & 4	139	321 to 346-3 and 178 to 182-4	139
33	Some Causeways on Sandy Bed.	Y. K. Lall	XIII Parts 3 & 4	140	347 to 376 -3 and 183 to 192-4	141
34	Failure of a Five Span Masonry Arch Bridge across the Bhogeswari River near Pen, District Kolaba in the Province of Bombay.	K. G. Bhate	XIV Parts 1 & 4	142	21 to 46-1 and 485 to 499-4	142
35	Well Foundations of the Kathjuri Bridge.	Sudhindra Nath Gupta	XIV Parts 2 & 4	144	153 to 192 -2 and 507 to 522-4	144
36	An Adaptable Steel Centring for R. C. Bridges.	A. Nageswara Ayyar	XIV Parts 3 & 4	147	273 to 291 -3 and 537 to 548-4	147
37	Discussions on the above Paper.	A. Nageswara Ayyar	XV Parts 3 & 4	147	449 to 468 -3 and 663 to 668-4	147

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
38	Construction of Approaches to the Malaviya Bridge at Banaras.	K. Sinha	XV Parts 2 & 4	150	207 to 235 -2 and 638 to 642-4	150
39	Construction of the Kuakhai Bridge in Orissa.	Sudhindra Nath Gupta	XV Parts 3 & 4	155	417 to 447 -3 and 659 to 662-4	155
40	Design for R. C. Pipes for Road Culverts.	A. Nageswara Ayyar	XVI-1	—	131 to 139	—
41	Causeways or Submersible Bridges.	S. P. Raju	XVI-3	—	354 to 370	—
42	A Report on Bridges and Bridge Engineering in Canada.	S. L. Bazaz	XVI-3	—	371 to 407	—
43	The Investigation, Design & Construction of the Cauvery Bridge at Pugalur.	K. K. Nambiar & K. Namasivayam	XVII Parts 1 & 4	161	68 to 134-1 and 579 to 588-4	161
44	Load Test of the Kuakhai Bridge.	S. N. Gupta	XVII-1	—	141 to 152	—
45	Some Examples of Prestressed Concrete Bridges.	A. E. Hiley, V. M. Silvera & B. B. Gupta	XVII Parts 2 & 4	162	175 to 204 -2 and 589 to 593-4	162
46	Bridging India's Rivers—An account of some of the Bridges built under the National Highway Scheme.	Indian Roads Congress	XVII-3	—	393 to 484	—
47	Testing to Destruction a 96 ft Prestressed Concrete Bridge Girder.	K.K. Nambiar & P. V. Raj	XVII Parts 3 & 4	164	345 to 392 -3 and 602 to 606-4	164
48	A New Method of Applying Kentledge by Hydraulic Jacks for Sinking Foundation Wells.	G. P. Nagarkar & M. P. Apte	XVIII Parts 1 & 4	165	23 to 39-1 and 566 to 576-4	165

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
49	The Design of Small Bridges and Culverts.	Goverdhanlal	XVIII 2 & 4	167	123 to 213 -2 and 583 to 590-4	167
50	Construction of a Submersible Bridge across River Mahanadi near Bhanjanagar (Ganjam) in Orissa.	E. V. S. Iyer & D. C. Panda	XIX-1 & 4	173	91 to 109 -1 & 680 to 688-4	173
51	Design and Construction of Prestressed Concrete Bridge across River Palar.	K.K. Nambiar	XIX-3 & 4	177	301 to 359-1 & 705 to 715-4	177
52	The Plastic Theory as applied to the Design of Mild Steel Beams & Frames.	Miss Shakuntala S. Joshi	XIX-3	—	461 to 479	—
53	Prestressed Concrete Bridge Across the Mahi River at Vasad on National Highway-Delhi-Ahmedabad-Bombay.	V. B. Manerikar & I. K. Naik	XX-2 & 4	183	151 to 217-2 & 559 to 566-4	183
54	Timber Bridges in Kashmir.	—	XX-2	—	229 to 239	—
55	Light Suspension Bridges in Himachal Pradesh.	A. J. D'Costa & T. S. Rupal	XX-3 & 4	188	359 to 413-3 & 595 to 597-4	188
56	Load Testing of the Prestressed Concrete Bridge across Bhima River at Takli on Sholapur-Bijapur Road.	S. V. Natu	XXI-1 & 4	189	25 to 48-1 & 621 to 644-4	189
57	Design and Construction of a Prestressed Concrete Bridge Across River Coleroon.	K. K. Nambiar & P. G. Nambiar	XXI-2 & 4	192	149 to 263 -2 & 666 to 693-4	192

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
58	Indian Bridges.	Y. Guyon	XXI-4	198	614 to 619 746 to 753	198
59	Construction of a Bridge across Pennar River at Nellore.	J. V. Prasad	XXII-1 & 4	199	19 to 73-1 & 685 to 701-4	199
60	Construction of Prestressed Concrete Superstructure for the Bridge over River Hindan at Ghaziabad.	A. S. Bishnoi & J. S. Mathur	XXII-2 & 4	201	197 to 259 -2 & 718 to 725-4	201

IX. Traffic Statistics; Regulation and Control of Traffic; Economics of Roads and Road Transport.

1	The Trend of Development in the United Provinces in the matter of improving Road Surfaces with special reference to recent Experiments.	C. F. Hunter	I	2	107-120& 168-182	3
2	An Analysis of Delhi Road Traffic Census.	R. L. Sondhi	II	14	7-28 & 46-62	16
3	Study of Relationship between Vehicular Traffic and Road Surface as affecting the Section of Economic Road Surface.	H. P. Sinha and A.M. Abbasi	II	15	29-39 & 46-62	17
4	Traffic Census and Road Diagrams.	Lt. Col. W. De & H. Haig	II	16	40-45 & 46-62	18
5	Economics of Road Maintenance.	S. Bashiram	II	17	63-72 & 93-104	19
6	Regulations and Control of Motor Transport in Mysore.	H. Rangachari	II	29	134-255	33

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
7	An Aspect of Traffic Statistics.	Ian A. T. Shannon	IV	H	1(h)-6 (h)	52
8	A note on the Reconstruction of Roads carried out in the U.P. with special reference to Experiments carried out and the use of Traffic Statistics.	S. N. Chakravarti	VIII	B-41	5-42(f)	86
9	Economics of Highway Types.	K. S. Raghavachary	X Parts 1 and 4	105	133 to 181 -1 & 713 to 723-4	105
10	Allocation of Road Maintenance Cost between Motor Vehicle Traffic and Non-Motor Vehicle Traffic.	Prof. K.B. Madhava	X Parts 2 and 4	108	218 to 227-2 & 734 to 745-4	108
11	Essay on "Post-war Goods and Passenger Road Transport and its Economics."	Prof. K. B. Madhava	XI-1	—	49 to 120	—
12	Essay on "Post-war Goods and Passenger Road Transport and its Economics."	N. S. Surya	XII-3	—	409 to 427	—
13	A Survey of Traffic on the New Howrah Bridge.	Prof. K. B. Madhava	XII Parts 3 and 5	127	345 to 407 -3 & 427 to 433-5	127
14	A Small Scale Traffic Survey in New Delhi.	C. S. Anantapadmanabhan	XIV Parts 1 and 4	143	47 to 121-1 and 500 to 506-4	143
15	The Design of an Experiment to Assess the Cost of Operation of Motor Vehicles on Different Types of Roads.	C. S. Anantapadmanabhan & M. K. Ganguli	XX-2 & 4	181	123 to 140-2 & 541 to 552-4	181

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
16	The Importance of Traffic Engineering in India.	R. K. N. Iyengar	XX-3 & 4	187	325 to 357-3 & 584 to 594-4	187
17	A Study of Accident Statistics and Some Aspects of Road User Behaviour in Delhi.	M. S. V. Rao & T. R. Sehgal	XXI-3	—	397-413	—
18	Scientific Aspects of the Road Traffic Problem.	Tejbir S. Khanna	XXII-3 & 4	204	395 to 423-3 & 756 to 774-4	204

X. Road Maintenance and Road Usages.

1	Ways and Means of improving the Bullock-Cart.	G.L.W. Moss	III	36	73-92	40
2	Steel Tyre Problem Unfolds.	W.L. Murrell	VII	E-40	76-77(k)	80
3	Raising the Road Rupee Ratio with a special reference to the Steel Tyre.	W. L. Murrell	VII	C-41	43 to 56 (g)	87
4	Proposals for an All-India Survey of Bullock-Carts by means of Random Sampling.	J. Vesugar	VIII	J-43	185-202 (p)	94
5	A Design for Bullock-Cart Wheels, Part I.	B. V. Vagh	XI Parts 2 and 4	101	55 to 99-2 & 49 to 70-4	101
6	Maintenance of Gravel (Moorum) Roads under Heavy Traffic.	B. B. Gupta	X Parts 2 and 4	107	211 to 217-2 & 730 to 733-4	107
7	The Effect of Road Camber on Road Maintenance and Wheel Design.	B. V. Vagh	XII Parts 1 and 5	121	65 to 85-1 & 375 to 381-5	121
8	A Design for Bullock-Cart Wheels, Part II.	Do.	XII Parts 4 and 5	128	5 to 58-4 & 375 to 381-5	128

Serial No.	Name of Paper	Name of Author	Reference to Proceedings: Volume No.	No. of Paper in Volume	Pages	Serial No. of Paper in general index
9	A Design for Bullock-Cart Wheels, Part III.	B. V. Vagh	XIII Parts 2 and 4	137	181 to 239-2 & 158 to 171-4	137
10	A Design for Bullock-Cart Wheels, Part IV.	Do.	XV Parts 1 and 4	148	65 to 154-1 and 627 to 633-4	148
11	A Design for Bullock-Cart Wheels, Part V.	Do.	XV Parts 2 and 4	151	237 to 279-2 and 627 to 633-4	151

XI. Standardisation, Designs, Loadings, Impact, Specifications.

1	The Necessity for a Reasonably Uniform Standard Loading for Design of Concrete Bridges and a suitable Loading for such and other Types of Bridges on Highways in India.	M. G. Banerjee	II	26	256 to 338 & 382 to 389	30
2	Design of Highway Bridges. The Necessity for an All-India Specification.	W. A. Radice, G. Wilson and P.F.S. Warren	II	27	338-356 & 382-389	31
3	Standardization.	D. Nilsson	VI	39	1 (k) to 16 (k)	74
4	Impact on Reinforced Concrete Road Bridges as compared to Steel Bridges.	E. P. Nicolaides	IV	L-39	1 (l) to 57 (l)	
5	Widths of Highway Pavements.	Specifications and Standards Committee	XI Parts 1 and 4	113	7 to 27-1 & 493 to 504-4	113
6	Standard Scales and Standard Sizes of Drawings for Highway Projects.	Do.	XI Parts 1 and 4	114	28 to 48-1 & 505 to 509-4	114

Serial No.	Name of Paper	Name of Author	Reference to Proceedings: Volume No.	No. of Paper in Volume	Pages	Serial No. of Paper in general index
7	Horizontal and Transition Curves for Highways.	Specifications and Standards Committee	XI Parts 3 and 4	119	327 to 392-3 & 577 to 587-4	119
8	Policy Concerning Maximum Dimensions, Weights and Speeds of Motor Vehicles in India.	Do.	XIII Parts 2 and 4	138	241 to 285-2 & 172 to 177-4	138
9	Road Boundary or Furlong Stone.	Central Roads Organisation	XIV-1	—	137 to 140	—
10	Glossary of Highway Engineering Terms.	Specifications and Standards Committee	XIV Parts 3 and 4	146	247 to 272-3 & 532 to 536-4	146
11	Do.	Do.	XVIII-3	170	371to445-3	170
12	Standards for Sight Distances for Highways.	Do.	XV Parts 1 and 4	149	155 to 181-1 and 634 to 637-4	149
13	Vertical Curves for Highways.	Do.	XVI Parts 1 and 4	156	22 to 76-1 and 506 to 515-4	156
14	Type Designs for Boundary & Furlong Stones.	Do.	XVII-1	—	135 to 140	—
15	Type Designs for Highway Milestones.	Do.	XVIII -1	—	71 to 82	—
16	Dimensions & Weights of Road-Design Vehicles.	Do.	XVIII -2	—	246 to 249	—
17	Route-Marker Signs for National Highways.	Do.	XVIII -2	—	250 to 257	—
18	Recommended Practice for Location & Layout of Road-side Motor-Fuel Filling Stations.	Do.	XVIII -3	—	447 to 451	—

Serial No.	Name of Paper	Name of Author	Reference to Proceedings: Volume No.	No. of Paper in Volume	Pages	Serial No. of Paper in general index
19	Traffic Rotaries.	Specifications and Standards Committee	XIX-3 & 4	178	367 to 421-3 & 716 to 724-4	178
20	Glossary of Highway Engineering Terms and Hindi Equivalents.	Do.	XX-3	185	243 to 296	185

XII. Research and Experiments.

1	Test Tracks—A Suggestion.	C. D. N. Meares	I	13	204-212	15
2	General Review of the Results of Recent Road Experiments in India as revealed by Modern Practice.	K.G. Mitchell	II	21	131-141 & 160-163	20
3	Road Research Results.	C. D. N. Meares	II	22	142-159 & 160-163	24
4	A Note on "Experiments with Cutbacks of Bitumen."	P. C. Neogi	V	—	89 to 102	—
5	Development and Application of Village Cement and High Silica Portland Cements for the Construction of Concrete Roads.	A. K. Datta	VI	C-39	1 (c) to 28(c)	66
6	Further Developments in Village Cements and High Silica Portland Cements for the Construction of Cement Concrete Roads.	A. K. Datta	VII	E-41	75-91 (k)	89
7	Effect of the Physico-Chemical Properties of Soils on Road Performance.	A. G. Asghar and C. L. Dhawan	XII Parts 3 and 5	126	329 to 344-3 & 425 to 426-5	126

Serial No.	Name of Paper	Name of Author	Reference to Proceedings: Volume No.	No. of Paper in Volume	Pages	Serial No. of Paper in general index
8	Cement Concrete Trackways.	Central Roads Organisation	XIII-3	—	419 to 430	—
9	Experimental Trackways for Motor Traffic on the Delhi-Meerut Road.	Do.	XIV-3	—	311 to 322	—
10	Experiments on Concrete Trackways on Black Cotton Soil.	Do.	XIV-3	—	323 to 343	—
11	Use of Stabilized Soil in Engineering Construction, Section I.	S. R. Mehra & H. L. Uppal	XIV-3	—	293 to 310	—
12	..... Do .....Do..... Sections II & III.	Do.	XV-1	—	184 to 204	—
13	.....Do.....Do..... Section IV.	Do.	XV-2	—	320 to 335	—
14	Stabilization of Gumbotil Soil for Highway Use.	O. H. Patel	XV-2	—	336 to 356	—
15	Use of Stabilized Soil in Engineering Construction, Section V.	S. R. Mehra & H. L. Uppal	XV-3	—	469 to 482	—
16	Use of Stabilized Soil in Engineering Construction, Section VI.	S. R. Mehra, H. L. Uppal & Labhu Ram	XV-3	—	483 to 491	—
17	Water-proofing of Alkaline Soil by Linseed Oil Cake.	B. R. Sen & Manohar Lal	XV-3	—	492 to 500	—
18	An Examination of Black-top Surface Dressing laid for Field Tests in 1945 on the Bombay-Delhi Road, Mile 736.	E. Zipkes	XVI-2	—	223 to 245	—

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
19	Some Observations on Air Field Runway Surfaces.	Central Road Research Institute, Okhla, Delhi	XVII-1	—	153 to 172	—
20	Compaction of Some Alluvial Soils of India.	Do.	XVII-2	—	291 to 344	—
21	An Investigation on Some Laterites.	Do.	XVIII-1	—	87 to 119	—
22	A Suggested Classification of the Black Cotton Soils of India.	Do.	XVIII-2	—	259 to 307	—
23	A Method for Estimating the Bearing Capacity of Road Crusts with Soft Materials.	Do.	XIX-1	—	123 to 163	—
24	Use of Linseed Oil-cake as a Stabilizer in Earth Construction.	Manohar Lal & B. L. Dhawan	XIX-2	—	273 to 283	—
25	Laboratory Experiments in Sand Stabilization.	H.L. Uppal	XIX-2	—	285 to 300	—
26	Shear Failure in Anisotropic Materials.	C.G. Swaminathan	XIX-2 & 4	174	167 to 188-2 & 689 to 693-4	174
27	Use of Lime in Soil Stabilization.	S.R. Mehra & L.R. Chadda	XIX-3	—	483 to 494	—
28	Laboratory Experiments on Use of Primers in Preventing Capillary Rise.	S.R. Mehra, H.L. Uppal & L.R. Chadda	XIX-3	—	495 to 498	—
29	Effect of Size on the Compressive Strength of Soil Blocks.	H. L. Uppal	XXI-1	—	129 to 147	—
30	Laboratory Investigation on the Effect of Addition of Some Surface Active Agents to Stabilized Soil Mixtures.	I. S. Uppal & O. P. Wason	XXI-2	—	307 to 320	—
31	General Report on Road Research in India.	—	XXI-2	–	355 to 377	—
32	An Investigation for Mass Production of Pozzolanic Portland Cements from Overburnt or Fused Jhama and Wellburnt Bricks by utilising Brick Kilns.	A. K. Datta	XXI-3 & 4	196	381 to 394-3 & 718 to 731-4	196
33	Further Studies on Water-proofing of Alkaline Soils by Linseed Oil-cake.	B. R. Sen, Manohar Lal and B. L. Dhawan	XXI-3	—	417 to 432	—
34	Study of Soft Aggregates from Different Parts of India with a view to their use in Low Cost Road Construction, I-Rajasthan.	H. L. Uppal & Bhupinder Singh	XXI-3	197	433 to 457-3 & 732 to 745-4	197
35	Absorptiometric Analysis of Asphaltic Bitumens.	C. G. Swaminathan & S. A. Swami	XXII-1	—	109 to 134	—
36	Study of Soft Aggregates from Different Parts of India with a view to their use in Road Construction, II-Laterites.	R. L. Nanda & R. Krishnamachari	XXII-2	—	313 to 344	—

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
37	A Laboratory Investigation on the Stripping of Bituminous Binder from a Coated Road Stone in the Presence of Water.	C. G. Swaminathan & K. P. Nair	XXII-3	—	455 to 482	—
38	General Report on Road Research in India.	—	XXII-3 & 4	—	549 to 576-3 & 784 to 800-4	—

XIII. Administration and Finance.

1	Objects and Organisation of a Permanent Indian Roads Congress.	K. G. Mitchell	I	1	11-20	1
2	Roads in India and Australia—Our Difficulties and some Suggestions.	W. L. Murrell	VI	73	1 (j) to 39 (j)	73
3	Organization of Bridging Activities.	G. R. Nangea	XV Parts 2 and 4	152	281 to 319-2 & 643 to 647-4	152
4	The Importance of Organization.	R. P. Chanda	XVI Parts 2 and 4	159	205 to 221-2 & 545 to 555-4	159

XIV. Plant, Machinery and Apparatus.

1	Notes on the Plant used for quarrying and granulating and operating costs of the Gauhati-Shillong Road, Khasi and Jaintia Hills Division, Assam.	B. F. Taylor	I	11	199-203	17

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
2	Technical Note No. 1—Selection of Plant for Collection and Loading of Shingle.	Col. R. S. Dalby	XII-2	—	273 to 276	—
3	Technical Note No. 2—A Note on Road Rollers with particular reference to Steam Road Rollers.	Central Roads Organisation	XII-4	—	107 to 155	—
4	Technical Note No. 3—Earth-Moving Machinery for Roads.	Do.	XIV-3	—	345 to 359	—
5	Technical Note No. 4—Diesel Road Rollers Manufactured in India.	R. S. Bhalla	XV-3	—	501 to 545	—
6	A New Method of Supplying India's Requirements of Bitumen for Black-topped Roads.	W. A. Griffiths	XXI-3 & 4	194	321 to 333-3 & 706 to 710-4	194
7	Earth-Moving Machinery in West Bengal.	D. N. Ghosh	XXI-3 & 4	195	335 to 354-3 & 711 to 717-4	195

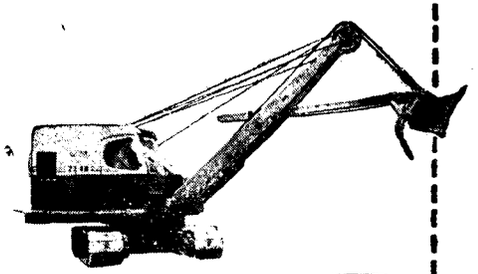
XV. Miscellaneous.

1	Lecture on "Statistics and Road Research."	Prof. K. B. Madhava	X-1	—	185 to 210	—
2	Memorandum on "Should Delhi as Capital of India be developed as a Pilot Scheme."	H. E. Ormerod	X-Parts 2 & 4	—	331 to 336-2 & 810 to 814-4	—
3	Essay on "Road Mindedness—How to create a Widespread Public Demand for more and better Roads in India."	N. M. Khan	XI-2	—	285 to 292	—

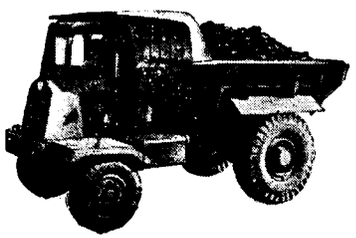
Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
4	Notes on the work and Organisation of the Road Research Laboratory (Harmondsworth), Great Britain.	G. Sriranga-chary	XI-3	—	393 to 406	—
5	Note on "A Plea for Rational Weights, Measures and Currency."	Brij Narayan	XII-5	—	456 to 470	—
6	Tentative Proposals for the establishment of the Central Road Research Institute.	Council of Scientific & Industrial Research	XIII-2	—	287 to 318	—
7	Essay on "Village Roads, their maintenance and their effects on the development of Rural India."	N. S. Surya	XIII-4	—	199 to 207	—
8	Indian Standards—Rules for Rounding off Numerical Values.	Indian Standards Institution	XVI-1	—	141 to 143	—
9	The Ninth International Road Congress, Lisbon (Sep.-Oct. 1951), Conclusions.	—	XVI-2	—	264 to 295	—
10	A Note on "A Policy on Road-Side Advertisement."	Specifications & Standards Committee.	XVII-2	—	271 to 275	—
11	Roads in Newzealand.	B. G. Naik	XVII-2	—	276 to 290	—
12	Some Observations on Airfield Runway Surfaces.	Central Road Research Institute, Delhi.	XVII-1	—	153 to 172	—
13	A Note on Experiments with Aerated Concrete.	H. Sunder Rao	XVIII-1	—	59 to 69	—

Serial No.	Name of Paper	Name of Author	Reference to Proceedings			Serial No. of Paper in general index
			Volume No.	No. of Paper in Volume	Pages	
14	Rivers & Ferries of North Bengal.	R.P. Chanda	XIX-2 & 4	176	233 to 258-2 & 702 to 704-4	176
15	Highways in Australia.	V.V. Gopala-Krishna Ayyar	XIX-3	—	425 to 459	—
16	The Tenth International Road Congress.	—	XXI-1	—	101 to 126	—
17	Surface Dressing Practice in Victoria.	Hari Dutt Gupta	XXI-2	—	285 to 304	—
18	Training Highway Engineers in the Application of Aerial surveys.	O. W. Mintzer	XXII-3	—	517 to 526	—

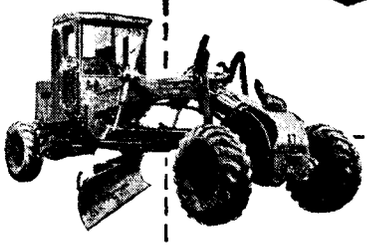
The right 'team' for building good roads



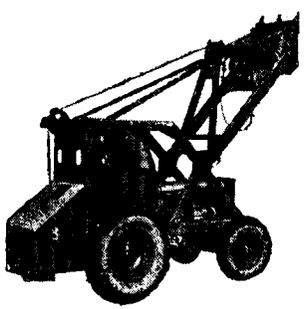
RUSTON-BUCYRUS
EXCAVATOR



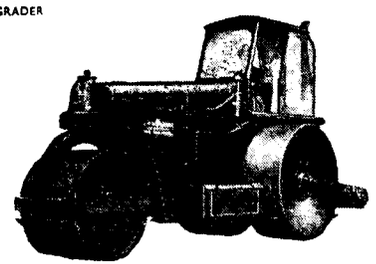
AVELING-BARFORD
SHUTTLE DUMPER



AVELING-AUSTIN
"99-H" MOTOR GRADER



AVELING-BARFORD
FRONT END LOADER



AVELING-BARFORD
TYPE 'GD' ROAD ROLLER

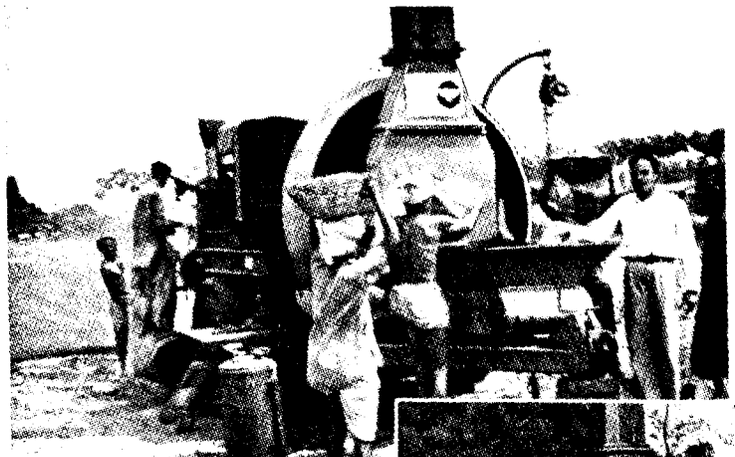
Whether it's for construction or road building, you want the best–the very best–'team', and you can get it from one source–GREAVES COTTON. Backed by 92 years of reputation and experience in the field, Greaves Cotton ensure quality and service of a consistently high standard.

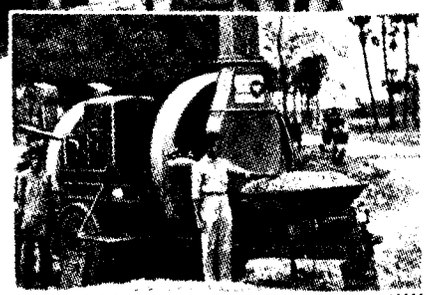
You can always depend on GREAVES.

GREAVES COTTON
& COMPANY LIMITED
1, Forbes Street, Bombay 1

Branches:
Ahmedabad • Bangalore • Calcutta
Kanpur • Madras • New Delhi

GC-7/1





Illustrations show a **Parker** 'SPOT-MIX' plant workin ; for the Patna Improvement Trust.

The 'SPOT-MIX' is a highly-mobile, single-unit plant producing 4½-9 tons of quality asphalt per hour. This self-contained plant is ideal for road maintenance and other small area surfacing projects. It can be quickly towed from site to site, behind the lorry carrying the aggregate or can be set up in a static position to supply material for several sites. A fixed model is also supplied.

Drive is by 8 h.p. diesel engine or electric motor.

PARKER

'SPOT-MIX'

ASPHALT & BITUMINOUS MIXING PLANT

4½–9 TONS PER HOUR

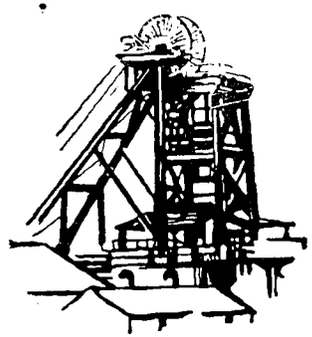
Sole Agents in India :

HEATLY & GRESHAM LIMITED

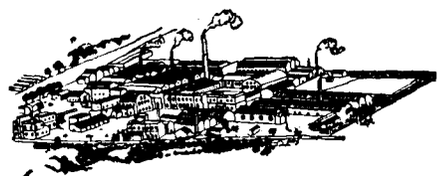
CALCUTTA · BOMBAY · MADRAS · NEW DELHI

USE 100% INDIAN ROAD TAR

FROM INDIAN COAL MINE



THROUGH INDIAN CHEMICAL INDUSTRY

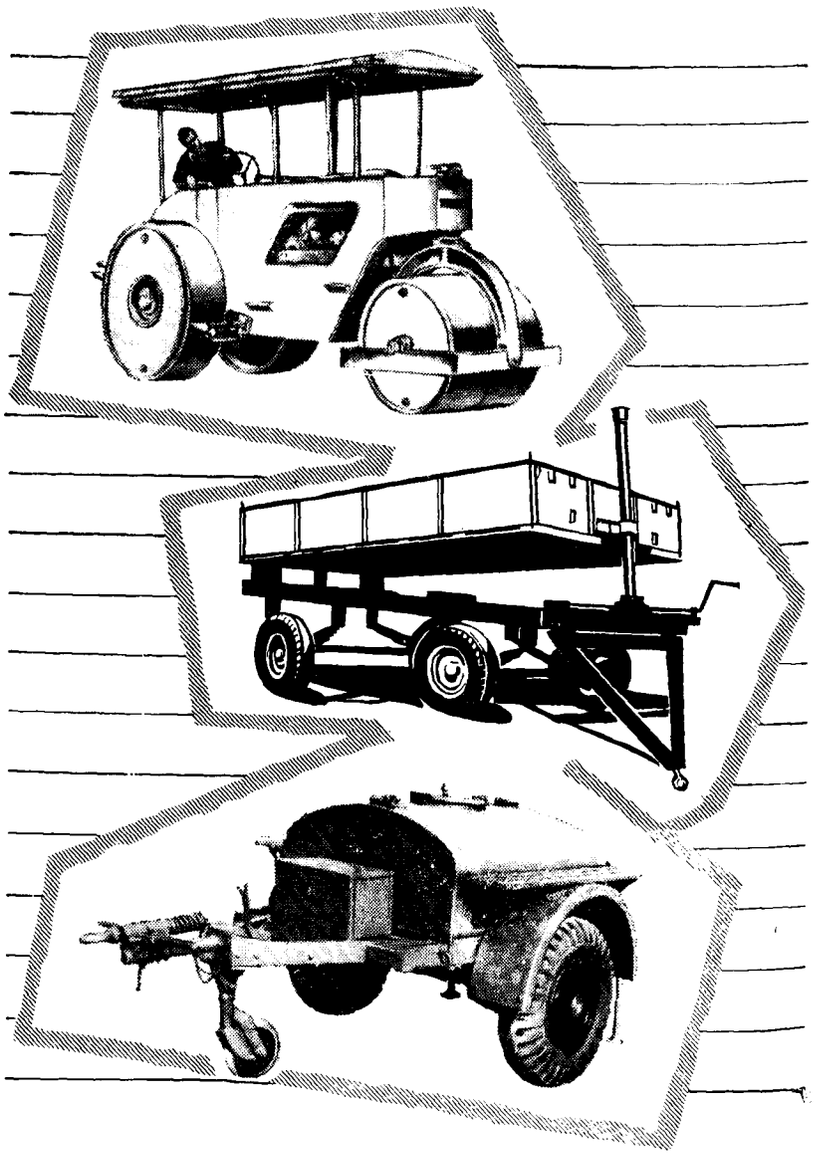


TO INDIAN ROAD

2" PREMIXED CARPET WITH ROAD TAR
LAID IN 1951 ON N. H. 34, NEAR SANTIPUR, WEST BENGAL

AND HELP THE NATIONAL ECONOMY

BENGAL CHEMICAL & PHARMACEUTICAL WORKS LTD.
6 Ganesh Chunder Avenue, Calcutta - 13

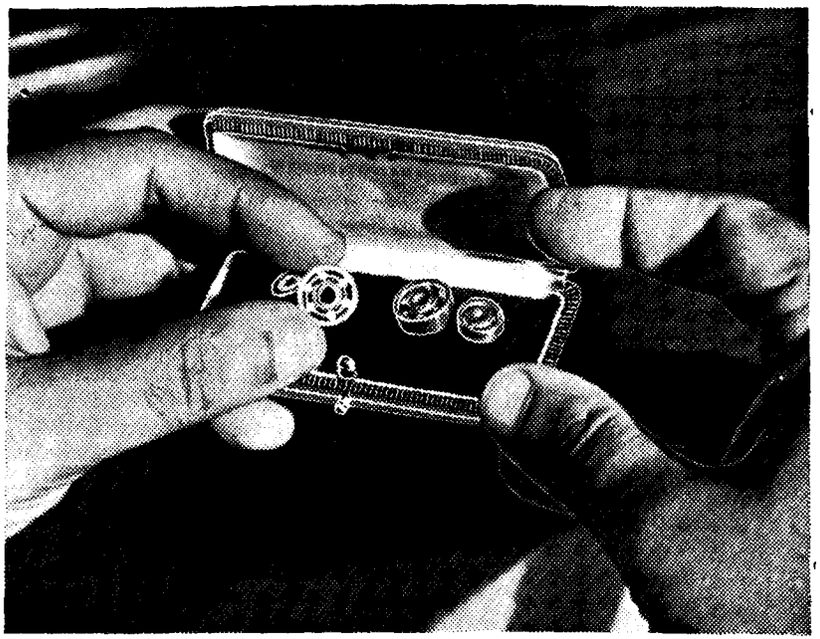


U.P.C.C
SERVING INDUSTRY AND THE FARM

Distributed By
THE UNITED PROVINCES COMMERCIAL CORPORATION
6, Ganesh Chandra Avenue, Calcutta-13

Manufactured By
AGRIND FABRICATIONS LTD

PPS|AF15|58



Ball Bearings in a Jewel Box?

THERE are times when auto spares are as precious as jewels - prices fluctuate, stocks may run out.

Dealers, whose duty it is to keep consumers happy by selling them auto spares at reasonable prices, need a constant and reliable supply. That's why, in South India, most of them insist on drawing their supplies from Madras Auto Service.

For nearly 30 years Madras Auto Service has set a standard of prices in auto spares.

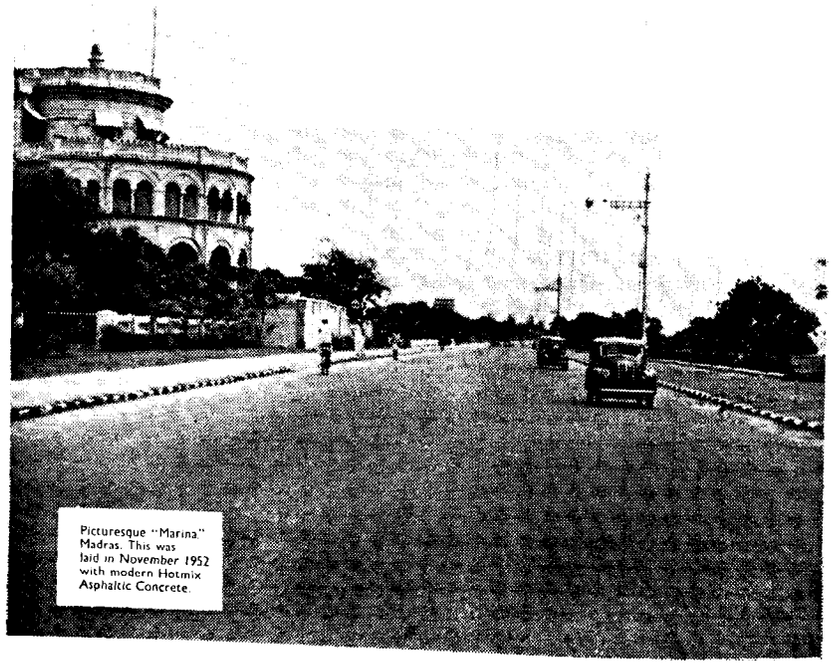
Sole Agents in South India for

Bendix Starter Drives, Bendix Hydrovac; Delco Hydraulic Brakeparts and all other products of Bendix International-Kellogg Air Compressors and Parts manufactured by The American Brakeshoe Company, New York-Stewart Warner Speedometers and panel gauges-Sudrad Wheels, Made in Germany-Wellworthy Pistons, Rings and Liners made by India Pistons Ltd., Madras-Standard Batteries: Standard Batteries Ltd., Bombay-Canara Springs & Leaves-Carter Carburetors, Fuel Filters, Mechanical pumps and all other products.

TVS

The Madras Auto Service Private Limited.
Madras — Bangalore (Unit of T. V. S.)

TVS|MAS|290A



Statement about ownership and other particulars about newspapers (JOURNAL OF THE INDIAN ROADS CONGRESS) to be published in the first issue every year after the last day of February.

FORM IV

(See Rule 8)

1.	Place of Publication	New Delhi
2.	Periodicity of its publication	QUARTERLY
3.	Printer's Name	K. S. Krishnan
	Nationality	Indian
	Address	M/s. Progressive Printers. 17,Coral Merchant Street. Madras-1.
4.	Publisher's Name	A. J. D'Costa
	Nationality	Indian
	Address	Secretary, Indian Roads Congress, Jamnagar House, Mansingh Road. New Delhi-2.
5.	Editor's Name	A. J. D'Costa
	Nationality	Indian
	Address	Secretary, Indian Roads Congress. Jamnagar House, Mansingh Road. New Delhi-2.
6.	Names and Addresses of individuals who own the newspaper and partners or shareholders holding more than one per cent of the total capital	Indian Roads Congress. Jamnagar, House, Mansingh Road, New Delhi-2.

I, A. J. D'Costa, Secretary, Indian Roads Congress, hereby declare that particulars given above are true to the best of my knowledge and belief.

(Sd.) A. J. D'Costa.

Signature of Publisher.

Date: 15—11—'58.