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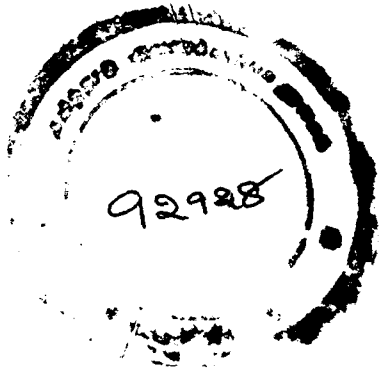
Journal of the Indian Roads Congress.

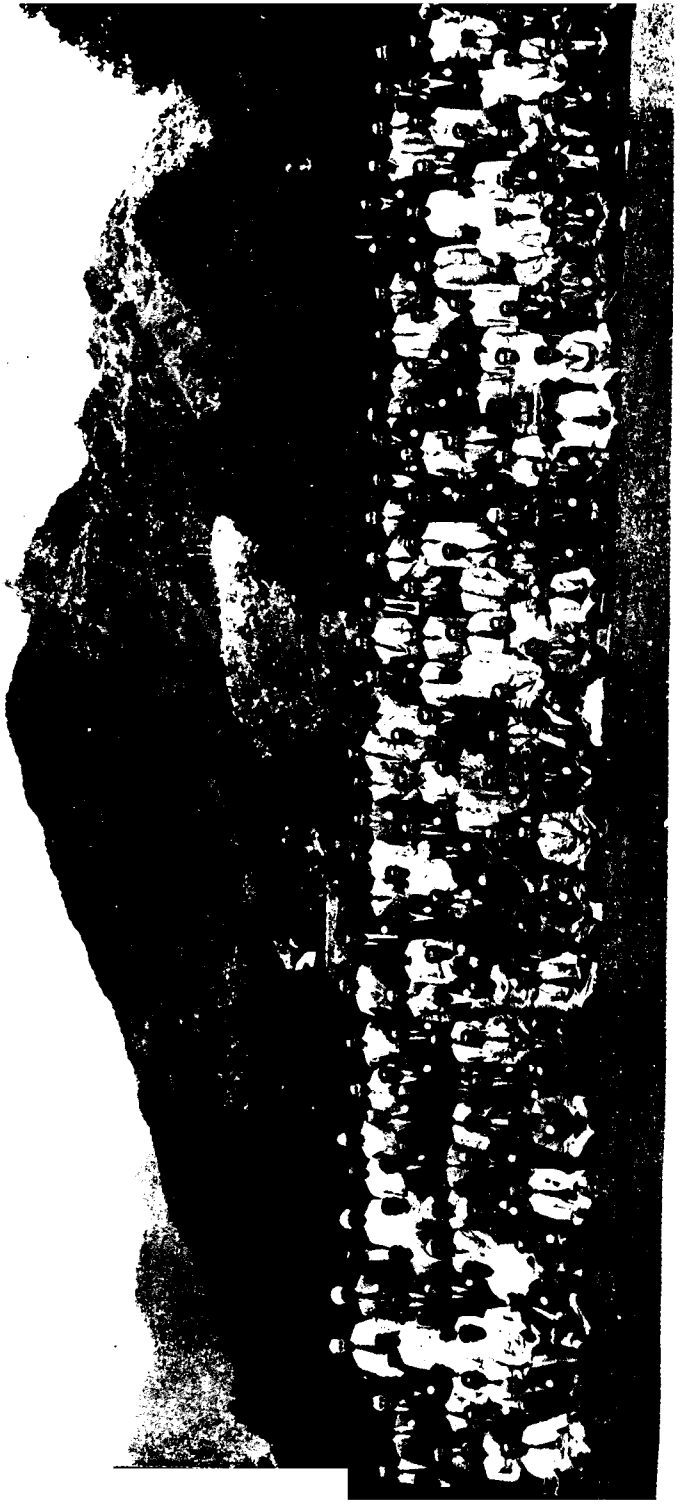
Vol. XIX — 4

1955

LIST OF MEMBERS OF THE COUNCIL FOR 1954-55

1. C. J. Fielder
2. R. N. Joshi
3. O. C. K. Krishnan
4. E. A. Nadirshah
5. L. R. Patel
6. S. N. Sinha
7. M. Meeran
8. S. N. Gupta
9. C. P. Misra
10. E. V. S. Iyer
11. S. C. Nayak
12. J. M. Frederick
13. B. Chaudhury
14. M. L. Bahl
15. R. K. Batra
16. K. K. Nambiar
17. D. P. Nayar
18. M. S. Bisht
19. T. Mitra
20. H. R. Gupta
21. D. V. Rao
22. D. N. Gupta
23. P. V. Divatia
24. Raghbir Singh
25. Kishore Lal
26. U. J. Bhatt
27. K. K. Kartha
28. Brig. K. N. Dubey
29. M. S. Mathur
30. G. M. McKelvie





INDIAN ROADS CONGRESS, NINETEENTH SESSION, SRINAGAR, JUNE, 1955.

Shri H. P. MATHRANI, I.S.E., President, 1954-55.

Shri Mathrani was born at Shikarpur (Sind) on the 12th July 1901 and received his early education there. He was educated at Edinburgh from 1921 to 1923 and passed his B.Sc. (Eng.) from Edinburgh with distinction. He was appointed to the Indian Service of Engineers in 1923. He rose to the rank of an Executive Engineer in 1927 and was promoted to the rank of Superintending Engineer in the year 1942. He specialised in Irrigation Engineering and Modern Mechanical construction methods. He was responsible for important irrigation works in Sind, particularly for diverting river Gajnai and for preliminary designs of Upper Sind and Lower Sind Barrages.

After partition he opted for service in India and in 1948 became Additional Chief Engineer, Central P.W.D. In the end of 1948 he joined the Ministry of Transport of the Government of India as Additional Consulting Engineer (Roads). In 1950 he was promoted to the rank of Consulting Engineer (Roads). In 1953 he was appointed ex-officio Joint Secretary to the Government of India, Ministry of Transport, Roads Wing.

Shri Mathrani is a member of many Institutions in India and abroad.

INDIAN ROADS CONGRESS

NOTICES AND ANNOUNCEMENTS

CONTRIBUTION OF PAPERS FOR THE TWENTIETH SESSION OF THE INDIAN ROADS CONGRESS

The next General Session of the Indian Roads Congress is likely to be held in January '56. The exact dates and programme of the Session will be communicated to Members in due course.

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.

2. **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 just before the General Session, 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 and when ready.

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

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

4. **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.

5. 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. However, only one Medal is awarded for the contribution made by more than one Author.

6. Rules and Regulations for the contribution of Technical Papers and the Award of Medals are published on pages 8 to 13 of Volume XIX-1 of the Journal of the Indian Roads Congress, April, 1955.

II. NEW ADMISSIONS

LIST OF MEMBERS OF THE INDIAN ROADS CONGRESS ENROLLED FROM 16-2-1955 TO 30-6-1955

Serial No.	*Roll No.*	*Name*	*Address*
1	1865	Vinayak Mukund Bhobe	Engineer, Roads & Bridges, P. W. D., **Cidade de Goa**, (Portuguese India).
2	1866	M. V. Virginkar	Civil Engineer, Concrete Association of India, 1-2, Queen's Road, Fort, **Bombay-1.**
3	1867	Framoz D. Mehta	Consulting Mechanical Engineer, 19-A, Cuffe Parade, Kolaba, **Bombay-5.**
4	1868	Faujdar Thakur	District Engineer, **Purnea** (Bihar).
5	1869	M. J. Padwal	Engineer, District Local Board, Prabhu Ali, Pen, Dist. **Kolaba**, (Bombay).
6	1870	A. C. Malhotra	Chief Engineer & Secretary to the Govt. of PEPSU, P. W. D., **Patiala.**
7	1871	V. S. Goel	Senior Scientific Officer, P. O. C. R. R. I., Okhla, **New Delhi.**
8	1872	Labh Singh Bassi	Assistant Engineer Designs, Planning Circle, P. W. D., B & R., **Chandigarh** (Punjab).
9	1873	P. R. Aramadhu	Executive Engineer, P. W. D., 71/1, Katol Road, **Nagpur** (Madhya Pradesh).
10	1874	Som Nath Kaul	Assistant Engineer, P. W. D., Sathu Bala, Kotcha Bala, **Srinagar** (J. & K. State).
11	1875	Sardar Hussain	District Engineer, P. W. D., 1, Marris Road, **Aligarh** (Uttar Pradesh).
12	1876	Mrigendranath Ray	Junior Engineer, P. W. D., Aijal Lungleh Road Sub Division, **P. O. Aijal**, Distt. Mizo (Assam).
13	1877	D. P. R. Cassad	Shirin Lodge, Byramji Town, **Nagpur-1.**

Serial No.	Roll No.	Name	Address
14	1878	M. K. Navaney	Assistant Engineer, Ministry of Transport, Roads Wing, Jamnagar House, Shahjahan Road, **New Delhi-2.**
15	1879	Gostu Venkatesulu	Assistant Engineer, Ministry of Transport, Roads Wing, Jamnagar House, Shahjahan Road, **New Delhi-2.**
16	1880	S. L. Kathuria	Assistant Engineer, Ministry of Transport, Roads Wing, Jamnagar House, Shahjahan Road, **New Delhi-2.**
17	1881	K. Sreenivasa Rao	Assistant Engineer (Highways), Palar Bridge Construction, **Chingleput,** Via Madras.
18	1882	B. Y. Bhonsale	Bituminous Engineer, Burmah-Shell Oil Co., East Street, **Camp Poona-1.**
19	1883	O. P. Dubey	Sub-Divisional Officer, P. W. D., **P.O. Dathua** (J. & K. State).
20	1884	Amrit Lal	Sub Divisional Officer, P. W. D., **Reasi** (J. & K. State).
21	1885	K. B. Carnac	City Engineer, Mercantile Bank Building, 5th Floor, Mahatma Gandhi Road, Fort, **Bombay-1.**
22	1886	B. N. Talukdar	Assistant Engineer, P. W. D., **Nowgong** (Assam).
23	1887	Kishan Chand S. Kanungo	Assistant Valuation Officer, Govt. of India, Ministry of Rehabilitation, Office of the Assistant Valuation Officer, 75 D. L. F. Colony, **Rohtak.**
24	1888	N. Chakraverty	Municipal Engineer, Delhi Municipal Committee, **Delhi.**
25	1889	Satish Prasad	Bituman Engineer, 21/125, Lodhi Road, **New Delhi.**
26	1890	K. Subba Rao	Assistant Engineer, **Kakinada** (East Godavari Distt.), (Andhra).
27	1891	C. H. Gandhi	Consulting Engineer & Architect, M/s. C. H. Gandhi & Co., Mehta Building, Medows Street, Fort, **Bombay.**

Serial No.	Roll No.	Name	Address
28	1892	K. M. Chandiramani	Assistant Engineer, Ministry of Transport, (Roads Wing), **New Delhi.**
29	1893	K. D. Bhatia	Executive Engineer, Madhopur Central Division, C. P. W. D., **Madhopur,** Distt. Gurdaspur.
30	1894	U. N. Parameshwar Rao	Technical Assistant to the Chief Engineer (Hlghways), Chepauk, **Madras-1.**
31	1895	Sitaram Das	Sub Divisional Officer, P. W. D., Gauhati, Panchabuti Lane, Chenikothi, **Gauhati,** (Assam).
32	1896	C. Seshavatharam	Chief Engineer (Highways), Andhra, **Kurnool.**
33	1897	D. C. Panda	Assistant Engineer, P. W. D., **Parlakimedi,** Distt. Ganjam (Orissa).
34	1898	D. N. Tekchandani	Assistant Engineer, Sikkim Sub Division No. I, Central P. W. D., **Gangtok** (Sikkim).
35	1899	U. N. Rynjah	Sub Divisional Officer, P. W. D., S. J. Road Sub Division, **P. O. Jowai,** (Assam).
36	1900	T. S. Lamba	Sub Divisional Officer, Bridge Sub Division, **Dera Gopipur,** Distt. Kangra.
37	1901	M. R. Malya	C/o. Burmah Shell, Esplanade, **Madras-1.**
38	1902	S. P. Sinha	District Engineer, **Gaya.**
39	1903	S. N. Toshakhani	Divisional Engineer, Sopare Hydraulic Division, **Srinagar** (J. & K. State).
40	1904	Avtar Singh Sachdev	Assistant Engineer, P. W. D., (B & R), Sangrur Sub Division, **Sangrur** (PEPSU).
41	1905	Arjan Singh	Depty Chief Engineer, J.& K.H. Q., **C/o. 56 A. P. O.**
42	1906	Ghulam Rasool	Assistant Engineer, Irrigation Deptt., **Srinagar** (J. & K. State).

Serial No.	Roll No.	Name	Address
43	1907	B. C. Mazumdar	Junior Scientific Officer, Central Road Research Institute, Okhla, **New Delhi.**
44	1908	S. K. Hanumantha	Assistant Engineer, **Thirthahally P. O.** (Mysore State).
45	1909	H. Channiah	Assistant Engineer, P. W. D., Old Public Office, **Bangalore-1.**
46	1910	John A. Green	Burmah Shell, **Calcutta.**
47	1911	P. C. Roy	Executive Engineer, W. & B. Department, Burdwan Division, **P. O. & Distt. Hooghly.**
48	1912	Om Parkash Sabhlok	Sub Divisional Officer, (B & R), **Dalmia Dadri** (PEPSU).
49	1913	N. Mohan Rao	Junior Scientific Officer, Central Road Research Institute, P. O. CRRI, Okhla, **New Delhi.**
50	1914	Y. C. Gokhale	Junior Scientific Officer, Central Road Research Institute, P. O. CRRI, Okhla, **New Delhi.**
51	1915	D. K. Goyal	District Engineer, Uttar Pradesh P. W. D., B/R., **Fatehpur.**
52	1916	K. Ramanna	Assistant Engineer, Corporation of Madras, 99, Shenoy Nagar, **Madras-30.**
53	1917	Amiya Kumar Mukherjee	Assistant Engineer, Dev. (Roads) Department, Armbagh Construction Sub Division, **P. O. Armbagh,** Distt. Hooghly (West Bengal).
54	1918	C. P. Srivastava	Executive Engineer, P. W. D., Vindhya Pradesh, **Rewa.**
55	1919	K. G. Salvi	Junior Scientific Officer, Central Road Research Institute, P. O. CRRI, Okhla, **New Delhi.**
56	1920	Madan Mohan Lal	Superintending Engineer, **Raipur,** (Madhya Pradesh).
57	1921	S. N. Tripathi	Superintending Engineer, P. W. D., **Nagpur** (Madhya Pradesh).
58	1922	Bala Prashad	Superintending Engineer, P. W. D., Kailas, Malakpet, **Hyderabad.**

Serial No.	Roll No.	Name	Address
59	1923	J. C. Gauba	Trust Engineer, Improvement Trust, **Banaras.**
60	1924	J. M. Gupte	Engineer, District Local Board, **Surat.**
61	1925	J. N. Mitra	Principal Engineering Officer, **Rewa,** (Vindhya Pradesh).
62	1926	B. Kala	Engineer, District Board, **Rae Barelly** (Uttar Pradesh).
63	1927	M. C. Antin	Engineer, District Local Board, **Bijapur** (Bombay State).
64	1928	Som Nath Kaul	Sub Divisional Officer, P.W.D., R. & B., Patlipora, Chhattabal, **Srinagar** (J. & K. State).
65	1929	Dina Nath Bhan	Sub Divisional Officer, P. W. D., Planning & Project Division, Kashmir State, Bana Mohal la, IInd Bridge, **Srinagar.** (J. & K. State).
66	1930	B. S. Katti	Deputy Engineer, Local Board, **Chikodi,** Distt. Belgaum.
67	1931	R. P. Barman	Chief Engineer, Central P. W. D., **New Delhi.**
68	1932	S. D. Gogai	Sub Divisional Officer, P. W. D., **Gauhati P. O.** (Assam).
69	1933	D. Mojumdar	Sub Divisional Officer, Barrackpore Construction Sub Dvn., Govt. House-Compound, **P.O. Barrackpore** (W. Bengal).
70	1934	A. Lakshman Das	Assistant Engineer, P.A. to Principal Engineering Officer, **Rewa** (Vindhya Pradesh).
71	1935	L. V. Hingorani	Assistant Engineer, P. W. D., **Bhuj** (Kutch).
72	1936	Ninan Kurian	Assistant Engineer, Periyar Bridge, **Alwaye** (T. & C. State).
73	1937	P. T. Reddy	Assistant Chief Engineer, P. W. D., R. & B., **Hyderabad.**
74	1938	Satnarayan Singh	Assistant Engineer, P.W.D., Road Surveys, Office of the Chief Engineer, P.W.D., R. & B., **Hyderabad,**

Serial No.	*Roll No.*	*Name*	*Address*
75	1939	L. M. Contractor	Deputy Engineer, Baroda Borough Municipality, Wadi Chhelli Pole, **Baroda.**
76	1940	Sumair Chand	Executive Engineer, Provincial Division, **Lucknow** (Uttar Pradesh).
77	1941	Asutosh Guha	Assistant Engineer, (W & B), West Bengal, 23/1, Jadavpur East Road, **Calcutta-32.**
78	1942	D. K. Ghosh	Sub Divisional Officer, (W & B), **Asansol,** Distt. Burdwan (W. Bengal).
79	1943	Jagannath Mitra	Assistant Engineer, (W & B), Govt. of West Bengal, 171, Pramenick Ghat Road, **Calcutta-36.**
80	1944	V. Raju	Engineer, District Local Board, **Mehsana,** (North Gujerat).
81	1945	K. Venkateswara Rao	Municipal Engineer, **Rajahmundry** (Andhra).
82	1946	W. X. Mascarenhas	Chief Engineer, R. & B., P. W. D. Secretariat, **Bombay.**
83	1947	B. L. Chaku	Sub Divisional Officer, P. W. D. Karan Nagar, **Srinagar** (J. & K. State).
84	1948	Rattan Kumar Singh Marya	C/o. Lt.-Col. R.S.Marya, Raghomajra, **Patiala,** (PEPSU).
85	1949	K. C. Pathak	Sub Divisional Officer, P.W.D., (E & D), **Sibsagar,** (Assam).
86	1950	Hansraj Sharma	Sub Divisional Officer, P. W. D., **Udhampur,** (Near Post Office), (J. & K. State).

ASSOCIATE MEMBERS

1	55	The Burmah Oil Co. (India Trading) Limited	Distributor for M/s. Assam Oil Co. Ltd., **Digboi** (Assam).
2	56	Mool Raj Kaura	21, Bara Khamba Road, **New Delhi.**
3	57	A. P. Desai	C/o. Associated Exports Imports Corporation, 8-B, Lal Bazar Street, **Calcutta-1.**
4	58	The Indian Standards Institution	19, University Road, **Delhi-8.**

III. DEATHS

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

Serial No.	*Roll No.*	*Name*	*Address*
1	94	J. W. Edwin	34, St. Johns Church Road, Civil Station, **Bangalore Cantt.**
2	27	L. K. Gupta	Sales Manager, C/o. Messrs McLeod & Co. Ltd, Calfix Dept., 3, Netaji Subhas Road, **Calcutta.**
3	217	O. C. K. Krishnan	Chief Engineer, Asphalt Dept., Standard Vacuum Oil Co., India Dn., Post Box 355, **Bombay.**
4	862	P. Veeriah	Divisional Engineer (H), No. 10, Dr. Guruswamy Mudaliar St., Kilpauk, **Madras-10.**

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	452	Ajwani, J. M.	C/o. Shri Moti G. Ajwani, No. 56, Bhagwandas Chawl, Bhavani Peth, Poona.
2	778	Laha, K. P.	Assistant Engineer (Civil), Construction Division, I. B. & I. D. V. C., Burdwan.

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	1468	T. H. Dhanokar.
2	1394	R. M. Anand.

PROCEEDINGS OF THE NINETEENTH SESSION OF THE INDIAN ROADS CONGRESS

Vol. XIX - Part 4 SRINAGAR June 1955

PRESIDENTIAL ADDRESS

The Nineteenth Session of the Indian Roads Congrrss was held at Srinagar from the 18th to the 25th June, 1955, and was formally opened by Yuvraj Karan Singh, Sadar-i-Riyasat, Jammu & Kashmir at 11-00 a.m. on the 19th June, 1955. The proceedings opened with an address by Shri H. P. Mathrani, the President, the full text of which is given below :

As President of the Indian Roads Congress, it is my most pleasant duty and privilege to express our gratitude for your having kindly consented to inaugurate this the 19th Session of the Indian Roads Congress.

I extend a cordial welcome to our distinguished guests, ladies and gentlemen, who have so graciously responded to our invitation and spared time to attend this function. A Society like ours derives inspiration from, and grows on the interest, which you, the representatives of the public, take in its activities. Though the technical details of our work may be complicated and not easy for lay people to understand, every citizen can appreciate good planning and good execution of roads. It is your lively interest, judicious appreciation, and constructive criticism that help a great deal to keep us on even keel. It is in the course of contacts like this that our plans and problems are presented in their proper perspective before you with a view to evoking your understanding and co-operation.

To members and delegates who have assembled here, my hearty congratulations on yet another year's successes, through hard and intelligent work, in your endeavour to improve and expand the country's road system. We are here to pick up again the threads of our discussions from where we left, and go forward gathering and disseminating knowledge and perfecting techniques through which we hope to play no mean part in the nation's march to prosperity.

I am very glad to announce that we have received messages of encouragements from our Prime Minister, Shri Jawaharlal Nehru and from Shri Alagesan, Deputy Minister of Transport, Government of India. Before I proceed further I shall read these messages.

We are deeply indebted to the Government of Jammu and Kashmir for inviting us to hold this Session at Srinagar, the ancient city founded by Asoka, who was also the founder of high-ways in this country and which is surrounded by beautiful lakes and fine Mughal gardens. They have been inviting us so graciously for the past several years and, although the lure of the beautiful Kashmir was tantalising the minds of all of us, we had to restrain our feelings and to postpone the holding of a Session here to a time when we could see the construction of the Banihal Tunnel.

A sincere word of thanks is also due from us to the local officers who have taken much pains and devoted considerable time to the making of excellent arrangements for our stay and work.

Lying in the lap of the lofty and hoary Himalayas, this valley of Kashmir is incomparable in beauty : the world has nothing more fair to show. Before proceeding to the business part of my address, I pay my homage to this jewel among the valleys of the world. Though many poets have paid eloquent tributes to the eternal charms of this Paradise on Earth, I cannot restrain the urge of making a humble offering, artless but straight from the heart. Nature must have fashioned this land, with its legends and mythology going back to the epic past, as a sporting ground for gods and passed it on to man when he inherited this Earth.

The people of this valley are not only handsome of form and features, they are also intellectually a great race. The process of Evolution, by which Life is for ever straining to achieve physical and intellectual perfection, must indeed have reached rare heights in this race, from whom descends our beloved Prime Minister, that man of destiny who is trying ever so earnestly to prevent the human race from annihilating itself.

Srinagar is famous for its art and craftsmanship. We shall have some opportunities between our deliberations to see and appreciate its carpets, shawls, embroidery, wood and silver work. And I am sure every one of us will carry home some of these things as souvenirs.

The crisp and bracing climate of this place and the fascinations around us have already, within the short time we have been here toned up the body and mind. The spirit is now eager to get down to the work that lies ahead of us.

Kashmir, like the rest of India, is determined to push forward on the path of progress and, peacefully but unswervingly, reconstruct a stable and prosperous regime for herself. She is conscious of what is good or bad for her aspirations and we wish her Godspeed.

President delivering the Address.

Development of highways, as part of the essential programmes of a Welfare State, is not a new conception. In India, Emperor Asoka recognised, even in the 4th century B.C., the importance of highways for building up the strength and prosperity of his realms. He gave the country, as we know it, a good network of roads. Thereafter, over the centuries that rolled past, road development was slow and chequered, depending chiefly on the spurts of energy of some rulers who, in between their preoccupation with wars realised that roads were essential for promoting agriculture, stimulating trade, facilitating pilgrimage, warding off famines, and retaining control over the country.

In comparatively recent times, the invention of the steam engine gave impetus to the construction of railways and development of roads was neglected. But this did not provoke any public protest because the bad condition of our roads did not

seem to matter seriously to the bullock cart and the pack animal which remained, until recently, our only means of road transport.

With the advent of the automobile, however, quickly arose an urgent and insistent demand for well surfaced and fully bridged all-weather roads. It was then that the development of roads came in for serious consideration at the hands of Government.

The Jayakar Committee was appointed in 1927 to look into the requirements of the situation. As a result of their recommendations, the Central Road Fund was created in 1929. A part of the customs and excise duty on petral began to be credited to the Fund. Grants from this Fund were given to States for road development, particularly in rural areas. But much work could not be done under this scheme as the annual contributions to the Fund amounted to Rs 1½ crores only. With the growth in petrol consumption and increase in the rate of contribution to the Fund from two annas to two annas six pies, the revenues of this Fund increased from Rs 1.5 crores to Rs 4.5 crores. Although this amount is very small compared with the needs of the country, a fair amount of work reckoned over a number of years has been carried out in the country by the resources provided by this Fund.

The Jayakar Committee also stressed the need for creating a forum for bringing together road engineers in the country, so that they should discuss the science and practice of road construction and maintenance. In pursuance of this recommendation, the Indian Roads Congress came into being in 1934 when the Central Road Fund was placed on a permanent footing by the Central Legislature.

Before the Indian Roads Congress was created, it was not possible for road engineers in India to get together and discuss questions relating to the administration, planning, design, construction, operation, use and maintenance of roads. Very little of experimental or testing work was undertaken with a view to improve the technique of road construction, and that little was seldom correlated in an effective way. On policy matters, the Provincial and Central Governments had no organized way of obtaining the collective opinion of road engineers in the country. No standards of road and bridge design existed for uniform application throughout the country. The Indian Roads Congress was created to make up these deficiencies.

In the limited time at my disposal, it is not possible for me to give a complete picture of the useful work done by the Congress in the fulfilment of its objects. So I will be brief.

In the course of the last 21 years, it has done very valuable work. Its activities are many and have been enumerated on similar occasions in the past. I wish to mention that, working through its technical committees and subcommittees, it has prepared and published many useful standards for road and bridge design. It has sponsored and correlated research and disseminated knowledge gained through research. In its Journals, it has published 170 technical Papers which have been discussed freely during its annual sessions.

The Congress has taken a very active hand in guiding Government in regard to questions connected with the road development policy and administration. For instance, it has been stressing the need for provincialising District Board Engineering Services concerned with roads, and has also been pressing for drawing up comprehensive road development plans and for providing assured finance for them. In matters like this, the Congress has frequently assembled conferences of all the chief Engineers of the county to deliberate and make their recommendations to Government.

The most important of the Chief Engineers' conferences sponsored by the Indian Roads Congress was the one assembled in Nagpur in 1943. The well-known historic document on road development, known as the Nagpur Plan, emerged from the deliberations of that conference.

In the year 1943, the second World War had come to our own door and our railways were not able, by themselves, to cope with the large-scale movement of men and materials required by the exigencies of the war. Transport by railways had to be supplemented by road transport. During those days, frantic efforts were made to build many roads for the defence of the country and this was a forceful reminder to us of the woeful inadequacy of our roads *vis-a-vis* the nation's needs of defence and trade. This awakened us to the imperative necessity of undertaking a comprehensive and well integrated country-wide programme of developing road communications.

The outcome was the Nagpur Plan which provided for balanced development of all classes of roads and laid down sound principles for determining priorities and phasing out execution of road projects essential for the immediate needs of the country.

This Plan provided for increasing the length of hard surfaced roads from 83,000 miles to approximately 1,23,000 miles, and the earthen roads from 1,32,000 miles to 2,08,000 miles, in the area of the Indian Union.

During the last war, there was considerable activity in respect of road development, but this slackened off immediately the war was over, and not much progress was made before we embarked on the first Five-Year Plan.

At the commencement of the Plan, tbe country had 97,000 miles of hard surfaced roads and 1,47,000 miles of unsurfaced roads. The Plan provides for an addition of 10,000 miles of hard surfaced roads and 20,000 miles of unsurfaced roads. Thus, at the end of the Plan period, we expect 1,07,000 miles of hard surfaced and 1,67,000 miles of unsurfaced roads.

The main deficiency in our roads was the lack of bridges, particularly across major rivers. The increase in the milage of roads, by itself, does not give an adequate idea of the magnitude of work involved in developing road communications in the country at the present stage, when almost all the big rivers have to be newly bridged. We are constructing thousands of culverts and small bridges and scores of very big bridges, varying in length from 500 ft to 7,000 ft, to give the country an all-weather road system. The mighty rivers of India present a number of difficult problems to the bridge engineer. These rivers meander about freely in alluvial beds and scour very deeply in high floods. In some of these rivers, the floods rise more than a 100 feet. Bridging them requires careful selection of sites where they meander least and elaborate calculations to determine the probable high flood discharges, the depth of possible scour, and the suitable type of construction. It is these problems that require all the ingenuity and skill the road engineer can muster.

On National Highways alone we have taken in hand the construction of 75 major bridges and hope to complete about half of them during the current Plan period. Considering the difficulties that we have met, this is not a small achievement.

In building a big bridge across the Katjuri river near Cuttack, we met with artesian conditions. Here, as soon as the wells that were being sunk for the foundations of the bridge, pierced through the impervious strata, the impounded water from below began to rush out through the wells. This, in turn, made the wells unstable and they began to sink rapidly by their own weight. It was an engineering feat to prevent them from going down indefinitely and to make them hold the weight of the bridge amounting to 1,200 tons per pier.

Coming to the progress of projects included in the first Five-Year Plan, we have, speaking broadly, been able to keep up to our programme of work and we hope to achieve the targets by the

end of the Plan period. In fact, I have every hope that improvement of road surfaces, particularly of National Highways, will progress ahead of the Plan.

Road engineers are now busy preparing a second Five-Year Plan and the Planning Commission have tentatively approved the proposals in respect of roads in the Central sector. This Plan is likely to provide roughly Rs 60 crores for development of National Highways and Rs 44 crores for other roads like the West Coast Road for the development of which the Central Government have agreed to give financial assistance, and other roads of special economic and inter-State importance. This amount of Rs 104 crores will be further supplemented by grants from the Central Road Fund to the extent of about Rs 22 crores. Thus, the Central expenditure on road development in the second Five-Year Plan will amount to about Rs 125 crores against the total expenditure of approximately Rs 60 crores in the first Five-Year Plan period.

As regards the States sector, the plans are in the course of preparation and it is expected that the development expenditure on roads in this sector will be of the order of Rs 225 crores, against a provision of Rs 90 crores in the first Five-Year Plan.

Possibly at the rate now envisaged, the Nagpur Plan targets in respect of length of roads, metalled and unmetalled, will be nearly reached in the second Five-Year Plan. Targets in respect of bridges may, however, take one more plan to attain. The stage will then be set for bolder planning and greater achievement in the years to follow.

Mention must be made here of the highlights of road development in Jammu and Kashmir. For the hilly State of Jammu and Kashmir, roads are its life line as there are no railways or navigable streams, and roads provide practically the only means of communication. It was to provide the main artery of life that Pathankot-Jammu road was constructed in recent years at a cost of about Rs 3.3 crores. In view of the very rapid development of traffic on this road, widening of its carriageway to provide for two lane traffic and replacing its causeways with bridges, have been taken in hand and are now in progress. The construction of Udhampur-Dalhousie road, which is required for the economic development of a large area of the State, has also been recently taken in hand at the estimated cost of Rs 3.0 crores. The Pathankot-Jammu-Srinagar-Uri road has been (provisionally) classified as a National Highway and will now be maintained and improved from Central funds. The State started participating the Central Road Fund in May 1954. It is gratifying to note that

the State Government, too, has of late been going ahead with its own programme of road works. During the last two years, two hundred and nineteen miles of existing roads have been improved and developed, 4,500 ft of bridging has been nearly completed, and 225 miles of new roads and tracks have been added to the State's road system. By the end of 1955-56, 200 miles more of new roads and another 2,500 ft of major bridging are expected to be constructed, and 263 miles of existing roads upgraded, and all this is in addition to the 400 miles of roads maintained by the Army.

The most important feature of road development in the State is going to be the construction of the Bannihal Tunnel through the Pir Panjal range at an altitude of 7,300 ft, which is more or less the snowline. At present, the Jammu-Srinagar-Uri road, the main artery of the State, crosses the Pir Panjal at an altitude of about 9,000 ft and this part of the road remains snowbound for over four months in the year. Since this road is the only means of communication between the State and the rest of the country, it is essential to make it an all-weather road. With that object, the construction of the Bannihal Tunnel has been started. This tunnel will be over a mile and a half long and will be one of the longest road tunnels in the world, there being less than half a dozen road tunnels that can claim to be as long or a little longer. There exist several long railway tunnels, but the problems which a road tunnel presents are much more difficult than those of a railway tunnel. Motor vehicles using the road tunnel generate a considerable amount of carbon monoxide and until and unless this poisonous gas is sufficiently diluted, there is danger to human life in long road tunnels. Apart from the problem of ventilation, there are other problems in long road tunnels, namely, fires, accidents to motor vehicles, lighting, etc., which have to be carefully tackled and necessary safety devices provided. After a study of many existing road tunnels of the world, it has been decided that it would be cheaper and safer to construct a two-tube tunnel, each tube for traffic in one direction, and to ventilate the two tubes by the forced longitudinal system of ventilation to dilute carbon monoxide in the tunnels sufficiently to make them safe for human beings. The two tubes will be interconnected by cross links through which pedestrians could cross from the footpath of one tunnel to that of the other in case of fire or some other emergency. It is estimated that this tunnel, including its ventilation and safety devices, will cost about Rs 3 crores. This cost is being borne by the Central Government, as the Jammu-Srinagar-Uri road is a National Highway. The project is expected to be completed in all respects in about three years. It is, however, proposed to have one of the two

tubes completed and brought into use in the cold weather of 1956—57 for regulated one-way traffic. I have not come across a single road tunnel of comparable length in the world which was designed and constructed in a period of less than six years from the date of conception of the idea to build the tunnel as will be the case in respect of this tunnel. In fact, I am not aware of any tunnel of corresponding magnitude, the completion of which took less than a quarter of a century from the date of conception of the idea to construct the tunnel. The idea of constructing the Bannihal Tunnel came from the Jammu and Kashmir Government in the beginning of 1952. At that time no detailed ground or geological surveys were available, nor was any information available about the meteorological conditions at the site. The ground and geological surveys were completed in the remarkably quick time of about eight months. Meteorological data is still being collected as these observations have to be made over a long period to get reliable data for designing artificial ventilation of the proper magnitude. This tunnel, when completed, will have very far reaching effects on the development of the Kashmir Valley. It is not possible today properly to appraise the role this tunnel will play in shaping the future of this part of our country. We, engineers, could be rightly proud of such an achievement.

We are now spending enormous sums of money on road development and have to aim at getting the best out of the country's money. This can be done by improving our standards and specifications so that the construction cost is lowered and the life of structures increased. These improvements have to be based on research—research inside the laboratory followed by experiments on models and then by trials on the field scale.

Research workers are busy throughout the world making valuable additions to our knowledge. We must also redouble our efforts in this field so that, in the context of our own requirements, we can claim that our theories of design and our processes of construction are not irrational and out-dated. It is not enough merely to assimilate what others are discovering and apply it to our conditions by chopping and changing here and there. We must find our own original solutions of the problems that face us.

Highway engineers require a rational theory for designing road pavement. Tremendous effort is being made all over the world to understand the mechanics of soil and its relation to the design of road pavements. I appeal to research workers in this country to take a hand in that effort. I am conscious

that in matters of research, we have had to start from scratch and all I wish to point out is that we must keep alive the desire to make up the leeway and come abreast of our requirements arising out of our colossal road development programmes.

It is not only essential to build more and better roads but we must also ensure that the roads we build remain free from haphazard growth of building called "ribbon development" along them and from encroachments. This can be done by improving the working of the present laws and enacting new Highway Laws. A beginning has been made in respect of the latter in some States but we must step up the progress, as otherwise there is risk of our beautiful new roads being ruined, paricularly near towns and cities by the unregulated growth of buildings along them. At present road engineers have no powers to get encroachments within highway limits removed. All that they can do is to request the local revenue authorities to do so. In this respect, our experience is sad, with the result that encroachments are increasing and highways being built at tremendous cost are being spoiled. Indeed, the present system is working so adversely against road interests that new legislation giving necessary powers to the road authorities to remove encroachments should have preceded our embarking on large road development programmes.

I cannot over-emphasize the imperative need for passing Highway Laws, if we wish to derive the maximum benefit from our roads. The traffic must flow freely along them. You are all aware of the congestion and risk of accidents that exist on roads in built-up areas. It costs colossal amounts of money and yet it is not always possible to improve roads, once they get built upon, to meet the increasing needs of traffic and to ensure safety of life. I may mention that the Government of India are seriously concerned with the problem of improving existing links of through roads in urban areas, constructing by-passes round towns, replacing level crossings with over-bridges, and so on. The benefit that these measures are intended to give can be made permanent only if encroachments are rigorously stopped and ribbon development is prevented.

We, Road Engineers, are happy at the road development but we have to be prepared to shoulder much greater responsibilities and put in much harder work than ever before. For the successful implementation of our big plans, engineers will require not only expert knowledge but also have to cultivate many other intellectual and moral qualities, such as honesty, courage, independence of thought, sound judgment, fairness and good sense. A practical engineer must have all these qualities

to be successful in his professional and technical work. And, when he has them, his responsibilities will no longer be confined to the tendering of technical advice only; he will inevitably be called upon to take an active part in framing policies on economic and administrative problems associated with his projects.

I thank you, Ladies and Gentlemen, for your giving me a patient hearing. I request you, Sir, to declare open this Nineteenth Session of the Indian Roads Congress.

INAUGURAL ADDRESS

In declaring the Session open, Sadar Riyasat, Yuvaraj Karan Sigh said:

Ladies and Gentlemen,

I am happy to welcome you all to Kashmir. If the venue of a conference has any effect upon its deliberations I am sure your holding this session amidst such charming and inspiring surroundings will add greatly to the success of your work. For many of you I expect this is your first visit to the Valley, and I hope that your stay here will be comfortable and pleasant.

Roads can truly be described as the lifelines of Civilization. Ever since the dawn of recorded history men have travelled over the face of the earth, and as the primary means of locomotion available to us are our legs, the paths whereby man travelled from one place to another took on great importance. Through the centuries forests were cut, mighty rivers spanned and mountains bored until today we see that over a larger part of the world's land mass there is an extensive system of roads. Here

Yuvraj Karan Singhji delivering the Inaugural Address.

in India we have a tradition of road-building going back several thousand years and some of our greatest emperors were keen road-builders. Nevertheless, keeping in view the vast land space that our country occupies and our huge population, it has to be admitted that our road development is still far behind our requirements.

Until recently the economic development of our country had been proceeding upon a somewhat haphazard basis and roads also did not come under any really co-ordinated system of national development. With the advent of freedom, however, came the realization that if we are to rapidly and substantially improve the living standards of our people and add to the national wealth of our country it was essential that our economic development should be properly planned, so that we could use our resources in a balanced and co-ordinated manner to bring about the best possible results in the shortest possible time. The first step towards this was our first Five-Year Plan which is now drawing to a close. Keeping in view the tremendous difficulties involved in planning with very limited resources and without adequate statistics or experience, I think we have no reason to be ashamed of what has been achieved. Nevertheless this represents only a beginning in tackling the huge problem of national economic reconstruction that from now on is bound to be our predominant concern. In this great adventure the development of communications will play an invaluable part and, as roads are still by and large the main arteries of travel, it is clear that the development of roads in our country has an importance that cannot be overestimated. Obviously the concept of the Welfare State will not become a reality if large sections of our population remain cut off from the main streams of progress.

There are to my mind several aspects which bring out this great importance. To begin with it is hardly necessary to repeat that economic progress will be greatly hastened by an improvement and expansion in the network of roads. The age-old concept of the self-sufficient village has, for better or for worse, broken down and it is now essential that even the remotest village in India should be incorporated in the national economy. This can only be done if every village is connected with a motorable road and, however staggering the implication of this may be, it is surely the goal towards which we must look forward. Secondly, there is the question of defence. We are a nation pledged to peace and we are doing all we can in the international sphere to contribute towards harmony and a lessening of tensions. Nevertheless, we must always be prepared to defend aggression against our country, and for this purpose a well-developed system of roads takes on considerable significance.

PRESIDENT'S CONCLUDING REMARKS

Sadar-i-Riyasat, Ladies and Gentlemen,

I thank you, Sir, for inaugurating this the 19th Session of the Indian Roads Congress and for your message of encouragement.

Road engineers are conscious of the great need of developing roads in the submontane region on the north of our country, which has been neglected in the past. Development of these roads has, recently, been taken up in right earnest under the directive of our Prime Minister, and you will be glad to hear that in this region construction of about 5,000 miles of roads, motorable roads, jeepable roads, and improved bridle paths has been or is about to be commenced. We also hope that a substantial additional length of these roads will be taken in hand as a part of the Second Five-Year Plan.

Now, Sir, may I request you to present the " Indian Roads Congress Medal " to Shri Goverdhan Lal for his Paper on " The Design of Small Bridges and Culverts ". May I also request you to announce that the Paper on " Stabilization of Certain Clayey Soils in India " by Col. S. K. Bose is commended.

MESSAGES

to

the Nineteenth Session of

The Indian Roads Congress

held at Srinagar from 18th to 25th June, 1955.

Shri Jawahar Lal Nehru, Prime Minister of India.

I send my good wishes to the Annual Session of the Indian Roads Congress, which is going to meet in Srinagar next month. Communications of all kinds are essential in any system of planning. There is grave danger that while we produce goods, we cannot transport them easily.

In particular, communications have to be developed in our hill areas which have been largely neglected in the past.

Dr. S. Radhakrishnan, the Vice-President of India.

I am glad to know that the next session of the Indian Roads Congress is scheduled to be held at Srinagar from the 18th to 25th June. I send my best wishes for the success of the session.

Shri O. V. Alagesan,

Deputy Minister for Transport & Railways, Government of India.

I have great pleasure in sending my greetings and good wishes to the 19th Session of the Indian Roads Congress which is meeting at Srinagar in beautiful Kashmir.

Srinagar is more than 200 miles away from the nearest railhead and as such, you could not have chosen a better place in order to emphasise the importance of road communication. Kashmir provides the proper setting for your annual confabulations. I have no doubt you will be inspired by its divine beauty. You are doubly fortunate in that the young and progressive Sadar-i-Riyasat of Jammu & Kashmir has consented to open your Conference. I personally know the great interest he is taking in the development of road communication in his State, and you will profit by his lead.

You are meeting in the last year of our First Five-Year Plan and on the eve of the Second Plan. You may have the quiet satisfaction of having achieved the targets set in the First Plan. The size of the Second Plan is going to be much bigger than the first one. You will be called upon to achieve much more during the Second Plan period. Rural communication is bound to claim a greater share of our attention and resources. It should not be said at the end of the Second Plan that any village in India is left without a road. I have no doubt that both the country and the Engineers of the country will rise to the occasion.

I wish every success to the Srinagar Session.

Bakhshi Ghulam Mohammad,

Prime Minister of Jammu & Kashmir.

It was a good thought to hold the session of the Indian Roads Congress in Kashmir this year. There is no doubt that in the sphere of social reconstruction of India, engineers have to play increasingly a vital role. Progress in the modern world is a race for mastery of up-to-date technological methods.

It is urgently important for the economic development of our country that we should have a wide net-work of dependable and cheap roads so that greater economic activity is stimulated and accelerated in all parts. Lack of a good system of communications is a sign of backwardness and it should be the concern of all that the entire length and breadth of India is welded together in a corporate way with common social and economic pursuits and collective endeavour for their accomplishment.

Messages of Good Wishes and Success of the Session have also been received from Shri G. M. McKelvie, and the following Technical Institutions from Australia, U. S. A., and U. K.

(i) Country Roads Board, Australia.

(ii) Highway Research Board, U. S. A.

(iii) The Institution of Engineers, Australia.

(iv) The Institution of Civil Engineers, U. K.

(v) American Association of State Highway Officials, U. S. A.

(vi) American Society of Civil Engineers.

(vii) Bureau of Public Roads, U. S. A.

(viii) Queensland Main Roads Commission, Australia.

INDIAN ROADS CONGRESS
NINETEENTH SESSION—SRINAGAR 1955

The Indian Roads Congress held its Nineteenth Annual Session from the 18th to 25th of June 1955 at Srinagar, the summer capital of Jammu & Kashmir State.

The Session was inaugurated by Yuvaraj Karan Singhji, Sadar-i-Riyasat, Jammu and Kashmir State, on the 19th June, 1955. 233 delegates from all parts of India attended the Session. This was the first meeting of the Congress in the State.

The "Indian Roads Congress Medal" was awarded to Shri Goverdhanlal for his Paper on "The Design of Small Bridges and Culverts." Also, the Paper on "The Stabilization of Certain Clayey Soils in India by Heat Treatment" by Col. S. K. Bose was commended.

Nine Papers were discussed. About 70 speakers took part in the discussion.

The Panel discussion on "Surface Dressing with Bituminous Binders" was also arranged.

The following Committees held meetings during the Session :

(1) Specifications & Standards Committee.

(2) Research Organization Division.

(3) Education Subcommittee.

(4) Soil Research Subcommittee.

(5) Manufacture of Road Making Machinery & Mechanization Subcommittee.

(6) Road Transport Operation Cost Committee.

(7) Papers Subcommittee.

(8) Cement Concrete Road Surface Dressing Subcommittee.

(9) Provincialization of Local Bodies Engineering Services Subcommittee.

The Council held its 44th and 45th meetings. The Council reviewed the work done by the various committees and appointed a Road Transport Development Committee to study the transport

problems of the country and to make recommendations. At the 45th Council meeting, Shri K. K. Nambiar, Chief Engineer (Highways), Madras, was elected President. The Vice-Presidents, elected were Shri M. S. Bisht, Chief Engineer, P. W. D., B & R Uttar Pradesh, Shri D. N. Gupta, Chief Engineer, P. W. D., B & R Jammu & Kashmir, and Shri W. A. Griffiths of Messrs Burmah-Shell Co., Ltd., Madras.

On the 19th evening, Bakhshi Ghulam Mohammad, Prime Minister, Jammu & Kashmir State, opened the Technical Exhibition arranged by the Indian Roads Congress. He visited every stall and showed keen interest in the exhibits.

Many State P. W. Ds. and engineering firms participated in the exhibition. A list of Government Departments and firms, who participated in the exhibition, is given at page 583.

Trips to Gulmarg and Veerinag—the source of river Jhelum, were arranged. The inspection of Bannihal Tunnel under progress, the Sind Hydro-electric Works and the Government Joinery Mill was also arranged.

The Prime Minister, Jammu and Kashmir State was also 'At Home' to the delegates. He congratulated the Indian Roads Congress for its fine work and stressed on the role of engineers in Five-Year Plans. The construction of the road from Pathankot to Srinagar was a fine achievement to the credit of engineers. Bannihal tunnel will be a further step towards the progress of Kashmir. But more and more roads and tunnels will be required to develop Kashmir.

The Session which commenced on the 18th June concluded on the 25th June, 1955.

Shri Goverdhanlal receiving the I. R. C. Medal.

Bakshi Ghulam Mohammad declaring the exhibition open.

Bakshi Ghulam Mohammad at the exhibition.

Yuvraj Karan Singhj visiting the exhibition.

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

GOVERNMENT OF INDIA

Central Public Works Department
Central Road Research Institute
Ministry of Transport, Roads Wing

STATES

Andhra - Highways Department
Bombay—P. W. D.
Bombay State Road Transport Corporation
Bhopal—P. W. D.
Bihar - P. W. D.
Jammu and Kashmir - P. W. D.
Jammu and Kashmir—Agriculture Department
Jammu and Kashmir—Forests Department
Jammu and Kashmir—Publicity Department
Jammu and Kashmir—Tourist Department
Madras—Highways Department
Punjab - P. W. D., B. & R. Laboratory, Karnal
Uttar Pradesh—P. W. D., B. & R.
West Bengal—Road Development Department

ENGINEERING FIRMS

M/s. Associated Imports and Exports Limited
M/s. Burmah-Shell Oil Distributing & Storage Co., Ltd.
M/s. Caltex (India) Ltd.
M/s. Concrete Association of India Ltd.
M/s. Greaves Cotton & Co., Ltd.
M/s. Standard Vacuum Oil Co.
M/s. Willcox Buckwell-India Ltd.
M/s. William Jacks & Co., Ltd.

Minutes of the 44th Council Meeting of the INDIAN ROADS CONGRESS

Held at Srinagar on the 18th June 1955.

Present :

H. P. Mathrani — President

F. P. Antia
M. L. Bahl
K. Barua
C. M. Bennett
U. J. Bhatt
M. S. Bisht
D. B. Chopra, Brig.
R. J. Dhumal
Goverdhan Lal
D. N. Gupta
S. N. Gupta
H. R. Gupta
E. V. S. Iyer
R. N. Joshi
K. K. Kartha
C. P. Misra
T. Mitra
E. A. Nadirshah
K. K. Nambiar
D. P. Nayar

J. Subrahmanyam — Secretary

The following co-opted Members attended :

R. C. Roy
C. Seshavatharam
P. L. Varma

The following attenytab idedinvtion :

K. F. Antia
D. G. Bhagat
R. S. Bhalla
J. N. Mitra
J. M. Trehan
Qazi Mohd. Afzal
W. A. Griffiths
Sujan Singh
B. V. Vagh.

The Council placed on record their sorrow at the loss suffered y the Council in the premature death of Shri O. C. K. Krishnan nd directed that their condolence be conveyed to his family on ıeir bereavement.

1. Confirmation of the Minutes of the 43rd Council Meeting.

The Minutes of the 43rd Council meeting held at Bhubaneswar on the 9th February 1954 as published at pages 550 to 552 of Volume XVIII-4 of the Journal of the Indian Hoads Congress were confirmed.

Resolution Passed Unanimously By the Council of The Indian Roads Congress on 4th February 1954

"The Council of the Indian Roads Congress places on record their great appreciation of the services rendered by Shri J M Mckelvie to the cause of road development in general and the Indian Roads Congress in particular. With his retirement from the service of the Government of India in May 1953, the Indian Roads Congress lost the services of an able engineer and an ardent worker for this Society. His association with the Congress started in 1934 as one of the founder members of the Society. Under his fostering care as the Honorary Treasurer and later as the President, the Society was able to stabilize its finances. He was responsible for starting the publication of the "Transport-Communications Monthly Review". His great ability as an engineer won him the admiration and respect of all who knew him. He was always ready to place his long experience and great technical ability at the disposal of the Congress. Under his initiative and guidance the Indian Roads Congress undertook to lay down road standards and draft the Indian Roads Congress Bridge Code. His genial but firm personality and burning enthusiasm will be greatly missed at the future meetings of the Society."

President
Indian Roads Congress

Shri G. M. McKelvie receiving the Salver.
[By Courtesy of the 'Scotsman' Edinburgh]

Shri G. M. McKelvie (seated centre), with the silver salver and scroll. The group also includes (seated) Shri R. B. Carnegie, President of the Institution of Highway Engineers and Shri T. McCallum, Chairman of the Scottish Branch. Looking on are Shri W. F. Munro, Montrose, Honorary Secretary, Scottish Branch and Shri D. B. Waters.

[By Courtesy of the 'Scotsman' Edinburgh]

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

The minutes of the meetings of the Executive Committee held at New Delhi on the 4th September 1954 and the 23rd April 1955 were approved.

3. **Audit Report for the year 1953-54.**

The Report of the auditors for the year 1953-54 was recorded.

4. **Draft Report of the Council to the General Body of Members for the period 1st January to the 31st December 1954.**

The draft report was approved.

5. **Amendment to Rules and Regulations.**

The Council agreed to amend Rule 6 to read as under :

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

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

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

6. **Budget.**

The budget estimate for 1954-55 was approved.

7. **Rail concession to delegates of the Indian Roads Congress.**

The Council greatly appreciated the rail concession extended to the delegates by the Railway and passed the following resolution :

"The Council of the Indian Roads Congress express their thanks to the Railway Board for granting travel concession to the delegates attending the Indian Roads Congress. While more than 200 delegates participate in the sessions of the Congress, many of the delegates being deputed by Governments or Local Bodies are not eligible for the concession and only about fifty

delegates will be able to avail of this concession each year. The Council hope that the number of members availing of Railway concession will increase in course of time and request the Railway Board to continue the concession even if the member availing of the concession is less than 100, particularly as the total number of delegates coming by Rail exceeds 100.

8. **Presentation of a salver and a scroll containing a resolution of thanks to Shri G. M. McKelvie.**

The Council passed the following resolutions :

(i) " The Indian Roads Congress thank the Institution of Highway Engineers, United Kingdom for kindly presenting, on behalf of the Indian Roads Congress, a salver and a scroll containing the resolution passed by the Congress to Shri G. M. McKelvie at the Annual Luncheon of the Scottish Branch of their Institution ".

(ii) " The Council of the Indian Roads Congress thank the Custom and Excise authorities, United Kingdom, for admitting the import of a silver salver free of customs duty and purchase tax presented to Shri G. M. McKelvie by the Institution of Highway Engineers, United Kingdom, on behalf of the Indian Roads Congress ".

9. **Miscellaneous.**

(i) The Council decided that the Committees and Subcommittees should meet more frequently than at present and that as far as possible, the work of the Commitees should be carried out by correspondence. To enable these Committees being held, T. A. may be paid from Indian Roads Congress funds to those Committee members who cannot get the same from their employers.

(ii) The Council decided that the Sections I & II of the I. R. C. Bridge Code should be published as early as possible.

(iii) The Council decided to appoint a Committee called Road Transport Development Committee to study the road transport problems of the country and to make recommendations. The present Road Transport Subcommittee will be abolished.

Minutes of the Business Meeting of the

INDIAN ROADS CONGRESS

Held at Srinagar on the 22nd June 1955.

The Nineteenth Annual General Meeting of Members was held at Srinagar on Wednesday, the 22nd June, 1955 at 10-30 A. M. In all 224 Members and 9 invitees (names and particulars (pages 594-601) attended the Session.

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

The minutes of the last Business Meeting held at Bhubaneswar on the 8th February 1954, as printed at pages 515 to 549 of the Journal—Volume XVIII-Part 603-605-4-March 1955 were confirmed.

3. **Audit Report.**

(i) The Audit Report for the period 1st October, 1953 to the 30th September, 1954 pages 603–605 was recorded.

(ii) It was decided to re-appoint M/s. Walkers, Chandiok & 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 607–628) was taken as read and approved.

5. **Resolutions of thanks.**

The following resolutions were passed :

(i) The Indian Roads Congress thank the Government of Jammu & Kashmir for their kind invitation to hold the Nineteenth Session of the Indian Roads Congress and for the very efficient arrangements made in connection therewith.

(ii) The Indian Roads Congress thank Yuvaraj Karan Singhji, Sadar-i-Riyasat, Jammu & Kashmir State, for inaugurating the Nineteenth Session of the Indian Roads Congress and for his permission to print his

very inspiring Address in the Journal of the Indian Roads Congress.

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

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

(v) The Indian Roads Congress thank Bakshi Ghulam Mohd., Prime Minister, Jammu and Kashmir State for his message and for kindly declaring open the Technical Exhibition organized by the Indian Roads Congress on the occasion of the Session.

(vi) The Indian Roads Congress thank Sardar Swaran Singh, Minister for Works, Housing and Supply for his best wishes for the success of the Session.

(vii) The Indian Roads Congress thank Shri O. V. Alagesan, Dy. Minister for Transport and Railways, Govt. of India, for his inspiring message to the members of the Indian Roads Congress.

(viii) The Indian Roads Congress thank Shri K. Santhanam, Lieutenant Governor of Vindhya Pradesh, for his very inspiring message and good wishes to the members of the Indian Roads Congress.

(ix) The Indian Roads Congress thank Shri Abdulqaiy Ansari, Minister for Public Works, Bihar for wishing the Conference success.

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

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

(xii) The Indian Roads Congress thank Shri D. N. Gupta, Chief Engineer, Qazi Mohd. Afzal, Local Organizing Secretary, Indian Roads Congress, Shri P. N. Wanchoo, Shri S. Narboo, Shri D. P. Malhotra, Divisional Engineers, Shri Dina Nath Bhan, S. D. O., other officers and staff of the Public Works Department of Jammu and Kashmir State for the excellent arrangements made by them for the Session and for the convenience of the delegates.

(xiii) The Indian Roads Congress thank the Public Relations Officer, Government of India in Jammu and Kashmir State for giving wide publicity to the proceedings of the Session.

(xiv) The Indian Roads Congress thank the Secretary, Information and Field Publicity Office and the Transport Controller, Jammu & Kashmir State for the facilities provided by them for the delegates and the assistance they extended to the Local Organizing Secretary in making the function a success.

(xv) The Indian Roads Congress thank the firms and Govt. Departments who participated in the Technical Exhibition and offered technical films for being screened.

(xvi) The Indian Roads Congress thank the Departments of the Forest, Agriculture, Tourism, Electricity and Transport of Jammu & Kashmir Government, the Srinagar Municipality and Government College for Women for the co-operation they extended to the Local Organizing Secretary for the success of the Session.

(xvii) The Indian Roads Congress thank the management of Nedou's Hotel, Srinagar, for placing their hall at the disposal of the Indian Roads Congress for their meetings.

(xviii) The Indian Roads Congress thank the Press for giving wide publicity to the proceedings of the Session.

6. Scrutineers for the Election of Council Members.

Messrs. Goverdhan Lal, B. V. Vagh, K. F. Antia, and W. A. Griffiths were appointed scrutineers for the election to the Council under rule 9-i of the Rules and Regulations of the Indian Roads Congress.

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

9-f. (i) Representatives of Associate Members other than Public servants.

F. P. Antia
M. P. Apte
C. J. Fielder
W. A. Griffiths
E. A. Nadirshah
Sujan Singh

g. Representative of District Board Engineers.

Fateh Chand

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

K. Subba Rao

i. Representative elected by the General Body.

H. S. Batliwala
S. N. Gupta
M. N. Kamath
C. P. Misra

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

9-a. Name of participating Administration	Name of representative
Andhra	C. Seshavatharam
Assam	B. Choudhury
Bihar	M. L. Bahl
Bombay	W. X. Manscarenhas
Madhya Pradesh	H. R. Gupta
Madras	K. K. Nambiar
Orissa	C. M. Bennett
Punjab	D. P. Nayar
Uttar Pradesh	M. S. Bisht
West Bengal	R. C. Roy
Hyderabad-Deccan	M. A. Khayyum Khan

9-a. Name of participating Administration	Name of representative
Jammu and Kashmir	D. N. Gupta
Madhya Bharat	P. V. Divatia
Mysore	H. Ananthachar
PEPSU	A. C. Malhotra
Rajasthan	Kishori Lal
Saurashtra	U. J. Bhatt
Travancore-Cochin	K. K. Kartha
9-b Engineer-in-Chief, Army Headquarters	Brig. D. B. Chopra
9-c Central P. W. D.	N. G. Dewan
9-d Consulting Engineer (Road Development)	H. P. Mathrani

10. **Past Presidents:**

9-e

T. Mitra

Annexure I

LIST OF MEMBERS WHO ATTENDED THE NINETEENTH SESSION OF THE INDIAN ROADS CONGRESS HELD AT SRINAGAR IN June, 1955.

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, Roads Wing ...	21
	(b) Engineer-in-Chief's Branch ...	4
	(c) Central P. W. D. ...	3
	(d) Railway Board ...	1
2.	**Council of Scientific and Industrial Research** ...	8
3.	**Planning Commission** ...	1
4.	**Andhra** ...	7
5.	**Assam** ...	4
6.	**Bihar** ...	20
7.	**Bombay** ...	36
8.	**Madhya Pradesh** ...	8
9.	**Madras** ...	12
10.	**Orissa** ...	3
11.	**Punjab** ...	6
12.	**Uttar Pradesh** ...	16
13.	**West Bengal** ...	26
14.	**Hyderabad-Deccan** ...	5
15.	**Jammu & Kashmir** ...	18
16.	**Madhya Bharat** ...	2
17.	**Mysore** ...	4
18.	**Rajasthan** ...	2
19.	**Saurashtra** ...	2
20.	**Travancore-Cochin** ...	2
21.	**Tripura** ...	1
22.	**Patiala & East Punjab States Union** ...	4
23.	**Vindhya Pradesh** ...	3
24.	**Delhi** ...	10
25.	**Bhopal** ...	1
26.	**Kutch** ...	2
27.	**Pakistan** ...	1
	Total ...	**233**

LIST OF MEMBERS WHO ATTENDED THE NINETEENTH SESSION OF THE INDIAN ROADS CONGRESS HELD AT SRINAGAR IN JUNE 1955.

S. No.	Roll No.	Name.
	1. GOVERNMENT OF INDIA	
	(a) Ministry of Transport (Roads Wing)	
1	Invitee	Anantapadmanabhan, C. S.
2	1446	Bhalla, R. S.
3	266	Bhagat, D. G.
4	1892	Chandiramani, K. M.
5	1078	Gursahani, R. L.
6	879	Goverdhan Lal
7	Invitee	Gopalan, P. V.
8	785	Hardyal
9	1275	Jaswant Singh
10	1880	Kathuria, S. L.
11	1146	Menon, M. D.
12	1288	Mathrani, H. P.
13	1878	Navaney, M. K.
14	790	Oza, M. G.
15	885	Poonen, P. C.
16	Invitee	Ranganathan, K.
17	1280	Sadarangani, T. G.
18	723	Subrahmanyam, J.
19	1532	Sehra, P. T.
20	918	Trehan, J. M.
21	1879	Venkatesulu, Gostu
	(b) Engineer-in-Chief's Branch	
22	1905	Arjan Singh, Col.
23	1818	Bose, Col. S. K.
24	16	Chopra, Brig. D. B.
25	Invitee	Deb, A. K.
	(c) Central P. W. D.	
26	658	Bhatia, M. S.
27	1931	Barman, R. Ps
28	738	Vaish, V. R.
	(d) Railway Board	
29	Invitee	Kumar, S. L.
	2. COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH	
30	Invitee	Puri, B. D.

S. No.	Roll No.	Name.
		Madras (*contd.*)
117	268	Nambiar, K. K.
118	1732	Namasivayam, K.
119	1581	Pillai, V. Govindaswamy
120	1881	Rao, K. Sreenivasa
121	1894	Rao, U. N. Parameshwar
122	347	Reddy, K. Ramaswami
123	1916	Ramanna, K.
124	1795	Subbayya, K. B.
125	1775	Selvam, T. T.
		10. ORISSA
126	204	Bennett, C. M.
127	292	Iyer, E. V. S.
128	1897	Panda, D. C.
		11. PUNJAB
129	1638	Gill, A. S.
130	154	Nayar, D. P.
131	376	Sandhawalia, N. S.
132	Invitee	Uppal, Dr. I. S.
133	491	Varma, P. L.
134	1832	Varma, D. R.
		12. UTTAR PRADESH
135	205	Bisht, M. S.
136	1926	Bachaspati Kala
137	1525	Chaturvedi, D. C.
138	222	Fateh Chand
139	1915	Goyal, D. K.
140	1923	Gauba, J. C.
141	1398	Johorey, M. C.
142	1182	Kochhar, R. K.
143	1199	Laroia, D. K.
144	1217	Misra, P. N.
145	759	Mathur, S. B.
146	1391	Saxena, J. K.
147	1940	Sumair Chand
148	960	Sinha, K.
149	115	Sharma, H. S.
150	1085	Wadhwani, G. B.
		13. WEST BENGAL
151	1628	Bose, A. K.
152	1413	Bhattacharjee, S. P.
153	1324	Chanda, R. P.
154	1348	Chatterjee, M. K.
155	1496	Chattopadhyay, K. P.
156	41	De, K. C.
157	57	Desai, A. P.

S. No.	Roll No.	Name.
		West Bengal (*contd.*)
158	Invitee	Mrs. Desai, Jyoti A.
159	1505	Das, Tulsi Madhab
160	231	Fielder, C. J.
161	936	Gupta, S. N.
162	1030	Ghosh, A. K.
163	1942	Ghose, Deb Kumar
164	1941	Guha, Asutosh
165	1424	Ghosal, P. K.
166	1910	Green, John A.
167	316	Mitra, T.
168	1309	Mazumdar, Sailendra Nath
169	1933	Majumdar, Debabrata
170	1943	Mitra Jagannath
171	1917	Mukherjee, A. K.
172	1231	Pal, S.
173	1630	Paul, N.
174	766	Roy, R. C.
175	1911	Roy, P. C.
176	1544	Ray, S. N.
		14. HYDERABAD-DECCAN
177	1922	Bala Pershad
178	249	Katrak, M. M.
179	29	Narasimham, J. S.
180	1937	Reddy, P. T.
181	1938	Satnarayanan Singh
		15. JAMMU AND KASHMIR
182	1929	Bhan, D. N.
183	1947	Chaku, B. L.
184	1457	Gandotra, H. K.
185	1580	Grewal, R. S.
186	1624	Gupta, D. N.
187	1695	Gurdip Singh
188	337	Khan, G. H.
189	1928	Kaul, S. N.
190	1696	Laharwal, G. R.
191	974	Malhotra, D. P.
192	1445	Nanda, J. D.
193	60	Nanda, B. D.
194	1552	Narboo, S.
195	1672	Qazi Mohd. Afzal
196	1585	Shah, S. R.
197	1821	Sheikh Abdul Salam
198	1733	Vaidya, G. H.
199	1583	Wanchoo, P. N.
		16. MADHYA BHARAT
200	567	Dhumal, R. J.
201	1575	Ghatpande, G. S.

S. No.	Roll No.	Name.
		17. MYSORE
202	1909	Channiah, H.
203	1668	Manchigiah, M. H.
204	1356	Mudaliar, C. R. Krishnaswami
205	1908	Reddy, S. K. Hanumantha
		18. RAJASTHAN
206	331	Mathur, Kishore Lal
207	1714	Mital, K. C.
		19. SAURASHTRA
208	214	Bhatt, U. J.
209	1858	Ghia, R. T.
		20. TRAVANCORE-COCHIN
210	1654	Kartha, K. K.
211	1936	Ninan Kurian
		21. TRIPURA
212	307	Sen, A. K.
		22. PATIALA AND EAST PUNJAB STATES UNION
213	1338	Dhillon, Arjan Singh
214	1134	Khanna, P. N.
215	1904	Sachdev, Avtar Singh
216	1912	Sabhlok, Om Parkash
		23. VINDHYA PRADESH
217	1934	Das, A. Lakshman
218	1925	Mitra, J. N.
219	1918	Srivastava, C. P.
		24. DELHI
220	1183	Nazarath, C. V.
221	883	Nanda, M. L.
222	1776	Prinja, K. C.
223	1432	Sujan Singh
224	39	Shenoy, B. N.
225	40	Shahani, T. C.
226	1889	Satish Prasad
227	Invitee	Sehan, Surjan S.
228	1314	Sani, G. H.
229	58	Verman, Dr. Lal C.

S. No.	Roll No.	Name.
		25. BHOPAL
230	444	Fahim Beg
		26. KUTCH
231	1935	Hingorani, L. V.
232	1471	Vora, P. K.
		27. PAKISTAN
233	1549	Doctor, P. K.

BALANCE SHEET

(Excluding Transpor

	Rs A. P.	R	Rs A. P.	Rs A. P.
...	4,101 1 9	...	6,395 6 3	
...	127 12 0	...	1,192 6 0	
'und ...	430 0 0		7,587 12 3	
	4,658 13 9	...	745 10 9	6,842 1 6
		...	1,618 8 0	
		...	459 9 3	
			2,078 1 3	
		...	207 13 0	1,870 4 3
...	419 3 0	5, ...	24 12 0	
ontra) ...		2, ...	1 9 0	23 3 0
D				
...	1,26,896 14 9	...	46,192 11 0	
...	140 0 0	...	4,808 1 0	51,000 12 0
...	14,218 13 3	1,41, ...	9,270 0 0	
		...	417 8 0	
...	20,052 6 4			
...	373 12 0	20, ...	31,000 0 0	
Γ		...	1,535 4 0	
		5,		
S		10, ...	390 0 0	
		...	3,770 0 0	
		...	142 7 0	
...	1,18,102 1 10	...	18 0 0	46,543 3 0
...	2,652 7 0			6,155 0 9
	1,20,754 8 10			126 0 0
pendi-				
ne &		...	6,000 0 0	
...	16,912 2 4	...	54,000 0 0	
	1,37,666 11 2	...	50,000 0 0	
		...	20,271 10 0	
000 0 0		...	10,984 2 0	141,255 12 0
218 13 3	24,218 13 3	1,13,		
		...	3,167 6 6	
Total ...		2,98 ...	692 1 0	
		...	72 5 0	3,931 12 6
		...	15,700 0 0	
		...	730 0 0	
		...	168 4 4	
		...	3,283 0 0	19,881 4 4
		...	1,652 14 11	
		...	16 0 0	
		...	390 9 1	2,059 8 0
		...	18,465 9 8	
		...	4 6 6	18,470 0 2
		...		2,98,158 13 6

(Sd.) J. SUBRAHMANYAM.
Secretar

the INDIAN ROADS CONGRESS
at 30th September, 1954, above
lanations we have required.
t set forth gives a true and correc
rding to the best of our informa
ks.

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

INDIAN ROADS CONGRESS

INCOME AND EXPENDITURE FOR THE YEAR ENDED 30TH SEPTEMBER, 1954.

(Excluding Transport-Communications Monthly Review)

EXPENDITURE		Rs A. P.	Rs A. P.	INCOME		Rs A. P.	Rs A. P.
To Opening Stock of Journals as on 1st October, 1953	...	33,755 6 0		By Subscriptions :			
,, Paper Consumed	...	10,608 11 6		Ordinary Members	...	23,865 0 0	
,, Printing Charges	...	15,900 5 6		Associate Members	...	2,855 0 0	
		60,264 7 0		Members restored	...	395 0 0	
				Life Members	...	40 0 0	27,155 0 0
Less : Closing Stock of Journals as on 30th September, 1954	...	46,192 11 0	14,071 12 0	,, Entrance Fees :			
				Ordinary Members	...	2,000 0 0	
			35,324 11 6	Associate Members	...	360 0 0	2,360 0 0
,, Establishment	...		16,950 12 6				
,, Local & other Allowances	...		1,200 0 0	,, Sale of Publications	...	8,937 15 0	
,, Honorarium to Secretary	...			,, Advertisements	...	7,309 8 0	16,247 7 0
			152 8 0				
,, T. A. to Staff for attending Meetings	...		202 15 3				50,000 0 0
,, Bank Charges	...		1,767 5 2	,, Subsidies (including arrears.)	...		4,500 4 0
,, Provident Fund Contribution	...			,, Interest on Government Securities etc.	...		
			450 0 0				
,, Audit Fee	...		4,695 1 0	,, Receipts on account of :	...	7,660 0 0	
,, Postage & Telegrams	...		2,417 5 6	Delegation Fees	...	1,847 8 0	9,507 8 0
,, General Printing & Stationery	...			Transport Charges etc.			
			425 10 0				52 4 0
,, Uniforms to Class IV Servants	...		1,340 1 3	,, Donation from Shri McKelvie	...		295 14 0
,, Miscellaneous Expenses	...		600 0 0	,, Miscellaneous Income			
,, Publicity Account	...						
			7,980 8 9				
,, 18th Session Expenses	...		403 7 0				
,, Subscriptions to other Societies	...		4,269 0 0				
,, Bad Debts written off	...						
			955 0 9				
,, Depreciation written off	...						
,, Balance being Excess of Income over Expenditure carried to Balance Sheet	...		16,912 2 4				
Total			1,10,118 5 0	Total			1,10,118 5 0

Kashmere Gate,
Delhi.
Dated, this 3rd day of December 1954.

(Sd.) J. SUBRAHMANYAM,
Secretary.

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

PENDITURE ACCOUNT FOR T

		Rs A. P.			Rs A. P.
	...	3,919 4 0		...	2,718 12 0
	...	5,968 11 9		...	10,687 5 6
	...	1,232 10 6		...	210 10 0
	...	6 12 0	been		
	...	20 11 6			
ried to	...	2,468 9 9			
Total	...	13,616 11 6	Total	...	13,616 11 6

BALANCE SHEET AS AT

	Rs A. P.	Rs A. P.	Rs A. P.	Rs A. P.
			1,549 8 0	
	50 4 0		1,062 1 0	2,611 9 0
	641 4 6	691 8 6		
				14 0 0
	7,007 0 9			5,668 8 6
				1,868 13 0
	2,468 9 9	9,475 10 6		4 4 6
		10,167 3 0		10,167 3 0

found correct.

Sd.) J. SUBRAHMANYAM,
Secretary.

. Chandiok,
and & Wales), F.C.A.,
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 1954

[The report covers the period from the 1st January to the 31st December, 1954, though a few matters referred to in it are carried beyond the latter date for convenience and completeness of record.]

1. GENERAL

The Eighteenth Session of the Indian Roads Congress was held at Bhubaneswar in February 1954 when 197 members and 4 invitees attended the Session. The 5 Papers published in the Journal of the Indian Roads Congress, Volume XVIII-parts 1 to 3, were read and discussed. Three Committees and seven Subcommittees were reconstituted to deal with various engineering and administrative problems. A new committee was also appointed to draft answers to the questions on Cement Concrete Road Surfacing discussed at the last three sessions of the Indian Roads Congress. The Executive Committee held two meetings at New Delhi on the 4th September 1954 and the 23rd April 1955.

2. ADMINISTRATION

Shri H. P. Mathrani, Consulting Engineer (Road Development) and Joint Secretary to the Government of India, Ministry of Transport, was elected President of the Indian Roads Congress at the Bhubaneswar Session. He continued also as Honorary Treasurer. Shri Goverdhan Lal, Deputy Consulting Engineer to the Government of India (Roads) continued as Honorary Deputy Treasurer.

Shri J. Subrahmanyam continued as Honorary Secretary. Shri A. Mukerjee continued as Honorary Assistant Secretary till the 30th April 1954, when he took service under the Government of West Bengal.

Shri B. N. Shenoy continued as Technical Secretary.

3. OFFICE

The office continued to function in New Delhi. It disposed of 7,963 receipts and issued 17,126 letters during the period under report.

The staff worked statisfactorily.

4. MEMBERSHIP

(1) The number of members on the rolls on the 30th September 1954 was 1270 (1242 Ordinary and 28 Associate). During the year there were 86 new admissions and 70 removals from the rolls. The removals were the result of resignations (22), deaths (7) and non-payment of arrears of subscription (41) by members who had retired from service, left India or failed to respond in spite of a prolonged effort.

(2) **Life Membership**:—During the Congress year from the 1st October 1953 to the 30th September 1954, 4 members enrolled themselves as Life members and the name of one member was removed from the rolls due to death. The number of life members on the 30th September 1954 was 124. This number is, however, included in the total number of ordinary members. The fees received from them have been transferred to a separate reserve (Building, Museum and Technical Fund) after deducting Rs 10 per member for initial expenses.

5. DEATHS

It is with deep regret that the Council record the deaths of the following Members:

Brinda Roy	S. B. Tyabji
Mohd. Abu Tarab	L. U. Prosad
J. C. Sahney	C. N. Thirupuvanam
A. Burns Lawson	M. N. Bhuyan

M. N. Patni

6. BUDGET

The budget for the year 1954—55 and the "Actuals" for 1953—54 were approved by the Executive Committee at their meeting held on the 23rd April 1955. The estimates have been placed before the Council at its 44th meeting. The actuals for 1953—54 show a surplus of Rs 24,547 against an estimated deficit of Rs 6,364. The improvement in budgetary position resulted from economy in expenditure, better realization of subscription, Grants-in-aid, Delegation fee and a good sale of publications.

The total contribution received from the States during the year ending the 30th September 1954 was 49,000. The outstandings from the Central and State Governments on the 30th September 1954 amounted to Rs 31,000. The States concerned 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, amounting to Rs 24,000 and intimations sanctioning contributions amounting to Rs 2,000 have been received after the 30th September 1954.

As decided by the Executive Committee, the Governments of Himachal Pradesh and Vindhya Pradesh were requested to contribute towards the funds of the Indian Roads Congress. The former has agreed to contribute Rs 1,000 per annum and the reply from the latter is awaited.

Part 'A' States were approached in 1949 to sanction annual contributions 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.

As the period of sanction of many States is due to expire with the year 1954-55, the question of approaching them for fresh sanctions in the light of increased tempo of road development work and consequent increase in the activities of the Indian Roads Congress has been examined and necessary requests will be made to the States.

The arrears of subcriptions at the beginning of the Congress year 1953-54 were Rs 10,601 due from 197 members. The names of 70 members who had retired from service, died or failed to pay were removed from the rolls. Consequently, a sum of Rs 3,955 standing as arrears against these members was written off by the Executive Committee during the year 1953-54.

A sum of Rs 2,006 was realized from 47 members.

After adding the arrears for 1953-54, the total of arrears on the 1st October 1954 stood at Rs 9,270 due from 187 Members. Action has been taken regarding this and some more members have been removed from the rolls by the Executive Committee at its meeting on 23-4-55. Details of the action that is being taken will be reported in the next annual report.

7. AUDIT

At the Eighteenth Session at Bhubaneswar it was decided to appoint Messrs. Walker, Chandiok and Co., Chartered Accountants and Auditors, Delhi to audit the Accounts of the

Congress for 1953-54. The report was examined by the Executive Committee on the 23rd April 1955. It was also placed before the Council at their 44th meeting on the 18th June 1955.

8. PUBLICATIONS

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

The following new publications were made available for sale.

(1) Bound Volume XVII.

(2) Type Designs for Boundary and Furlong Stones.

(3) Route-Marker Signs for National Highways.

(4) Dimensions and Weight of Road-Design Vehicles.

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

(6) Road Research Bulletin No. 2—Report on Experimental Surfacings Tested on the Road Test Track at Majherhat, Alipore, Calcutta (1942–1947).

Circulars were issued to all State Governments, other Administrations, and engineering firms bringing to their notice the publications. Announcements regarding the publications were also made in the Journal and the Transport-Communications Monthly Review. As a result, these publications received sufficient publicity and had a brisk sale.

Copies of the booklet "Bridging India's Rivers" issued by the Indian Roads Congress last year were supplied to Ministers at Centre and certain important persons. Nearly 200 copies were given to the Government of India for distribution among the Indian Embassies abroad.

The balance of the publications on the 31st December 1954 was as under:

Name of Proceedings	*Volume*	*Balance*
I.R.C. Proceedings	I to VII-part 1 & VIII	Sold out
Do.	VII-part 2	46
Do.	IX-part 4	122
Do.	IX (Bound)	144
Do.	X-parts 1, 2 & 3	Sold out

Name of Proceedings	*Volume*	*Balance*
I. R. C. Proceedings	X-part 4	244
Do.	X (Bound)	Sold out
Do.	XI-parts 1 & 2	Sold out
Do.	XI-parts 3 & 4	180
Do.	XI-part 4	Sold out
Do.	XII-part 1	409
Do.	XII-part 2	403
Do.	XII-part 3	496
Do.	XII-part 4	427
Do.	XII-part 5	415
Do.	XII-parts 1 to 3 (Bound)	224
Do.	XII-parts 4 & 5 (Bound)	290
Do.	XIII-part 1	369
Do.	XIII-part 2	720
Do.	XIII-part 3	Sold out
Do.	XIII-part 4	576
Do.	XIII-parts 1 & 2 (Bound)	153
Do.	XIII-parts 3 & 4 (Bound)	295
Do.	XIV-part 1	385
Do.	XIV-part 2	308
Do.	XIV-part 3	422
Do.	XIV-part 4	517
Do.	XIV-parts 1 to 4 (Bound)	771
Do.	XV-part 1	336
Do.	XV-part 2	375
Do.	XV-part 3	411
Do.	XV-part 4	561
Do.	XV-parts 1 to 4 (Bound)	Sold out
Do.	XVI-part 1	114
Do.	XVI-part 2	156
Do.	XVI-part 3	166
Do.	XVI-part 4	723
Do.	XVI-parts 1 to 4 (Bound)	66
Do.	XVII-part 1	152
Do.	XVII-part 2	59
Do.	XVII-part 3	172
Do.	XVII-part 4	790
Do.	XVII-parts 1 to 4 (Bound)	Sold out
Do.	XVIII-part 1	Sold out
Do.	XVIII-part 2	126
Do.	XVIII-part 3	

Road Research Bulletin No. 1	229
Road Research Bulletin No. 2	595
Bridge Code (1937)	Sold out
Nagpur Report	176
Lecture by Prof. K. B. Madhava	Sold out
Paper on "Water-Bound Macadam"	23
Booklet "Bridging India's Rivers"	Sold out
Type Designs for Boundary and Furlong Stones	331
Route-Marker Signs for National Highways	343
Dimensions and Weight of Road-Design Vehicles	101
Recommended Practice for the Location and Layout of Roadside Motor-Fuel Filling Stations ...	Sold out

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

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

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

The Transport-Communications Monthly Review. The Indian Roads Congress is popularising modern ideas on Road Development and Road Engineering for the benefit of executive staff who, owing to their whole-time preoccupation with their official duties are not able to keep abreast of the latest advance in the science of road engineering. Original articles on various road and bridge works are also being published in this 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.

Complimentary copies of the Review are being issued as usual to important persons in India. Also complimentary copies of the issue for March 1954 were given to all the 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. Some of the subjects on which information was sought are given below:

(1) Basis of fixing the expected age of a bridge.
(2) Bituminous treatment of wet aggregates.
(3) Cylinder and cube strength of concrete.
(4) Design of bullock-cart wheels.
(5) Design of a drag spreader.
(6) Design of the rotaries and intersections of roads.
(7) Design of truss bridges.
(8) Designs of cement concrete arch bridges of sho spans.
(9) Glossary of Highway Engineering Terms.
(10) Hair pin bends.
(11) Hill road alignments and half tunnels.
(12) I. R. C. Standard Specifications & Code of Practice Road Bridges in India.
(13) Marking of road bridges with their weight classifi tion.
(14) Road milage statistics in India and in foreign countr
(15) Road traffic signs.
(16) Sizes of road aggregates & tolerances to be permitted
(17) Specification of natural asphalt.
(18) Specification for village roads.
(19) Stabilized soil and soil cement road construction.
(20) Type designs of highway milestones.
(21) Standard layouts for roundabouts.

(22) Standards for road gradients, widths, and horizontal curves.

(23) Use of mechanical equipment for rock cutting on hill roads.

(24) Vertical curves.

(25) Water-bound macadam specification.

(26) Well foundation for bridges and their testing.

10. LIBRARY

A large number of technical journals of Institutions in India and abroad were received in exchange for the Indian Roads Congress publications. Some new books and standards of the British, Swiss, German and the Indian Standards Institutions were added to the library of the Congress. Members can borrow books from the libraries of the Congress and Consulting Engineer (Road Development) by writing to Secretary, Indian Roads Congress. The rules regarding the loan of books are published in Vol. XIX-part 1 of the Journal of the Congress.

Lists of additions to the library are published monthly in the "Transport-Communications Monthly Review". Further, lists of selected literature classified according to subjects are being published for information of Members. Abstracts of more important books and articles are also published. Members are requested to make free use of the library. 125 books were issued on loan during the year under report. This is a very small number considering that the Society has a membership of nearly 1,300. **It is urged that members should make more use of these libraries.** Photostat copies of any articles can be supplied on payment.

11. MEDALS AND PRIZES

The Council at its 42nd meeting held at Bhubaneswar on the 4th February 1954 considered the recommendations of the Papers Subcommittee for the award of Medals for Papers read at the Seventeenth Session and announced the following award :

> "The Indian Roads Congress Medal" to Shri K. K. Nambiar and Shri K. Namasivayam for their Paper No. 161 "The Investigation, Design and Construction of the Cauvery Bridge at Pugalur" published in Vol. XVII-1 of the Journal.

Further, the Council laid down the policy that only one medal should be awarded for contributions made by more than one Author.

12. COLLECTION OF PARTICULARS OF BRIDGES

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

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, representative of the Indian Roads Congress is the President of that Society for the current year.

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

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

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 ,,	—	Shri H. P. Sinha

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

EDC:	2-Cement	... Shri E. P. Nicolaides
EDC:	20-Drawings	... Shri H. P. Sinha
CDC:	7-Bitumen & Tar Products	Shri K. K. Nambiar Shri Brijmohan Lal
BDC:	1-Terminology Notations & Drawings Sectional Committee	Shri H. Sundar Rao (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 the Road Tar Subcommittee of the Indian Standards Institution.

Principal representative	...	Shri R. N. Chatterjee
Alternative representative	...	Shri G. C. Khanna

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

(4) Shri H. Sundar Rao continued to represent the Indian Roads Congress on the Road Research Committee set up by the Council of Scientific and Industrial Research.

14. REPRESENTATION ON THE BOARD OF ENGINEERING RESEARCH

The Prime Minister in his capacity as President of the Council of Scientific and Industrial Research set up this Board to co-ordinate research in various branches of engineering. The President of the Indian Roads Congress is a member of this board.

TECHNICAL ACTIVITIES

15. SPECIFICATIONS AND STANDARDS COMMITTEE

The Committee held meetings on the 4th and 8th February and the 29th November, 1954. The following subjects were discussed :

(1) A Preliminary Note on the Design of Road Intersections at Grade.

(2) Standards on Road-Rail Level Crossing.

(3) Specifications for Road Stone and Chippings.

(4) Classification and General Standards for Roads in India.

(5) Glossary of Highway Engineering Terms.

The note referred to at item (1) above has been drafted as a Paper and is expected to be published in the Journal for discussion at the 1956 session of the Indian Roads Congress.

The standards on road-rail level crossing referred to at item (2) were discussed by the Committee. They have decided that these standards should be re-drafted in the light of the discussion and the revised draft should be passed on to the Ministry of Transport, Roads Wing who would finalize it in consultation with the Railway Board. Accordingly the note has been finalized.

The specification for road stone and chippings referred to at item (3) were discussed by the Committee. They approved the specification for $\frac{3}{8}$ in. broken road stone. But they decided that the tolerances to be permitted for the various sizes of stones should be investigated and fixed.

The specifications for $\frac{3}{4}$ in. light chipping bitumen carpet was issued.

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

While discussing a note on classification and general standards for roads in India referred to at item (4) the Committee expressed the view that the definitions of the different classes of roads as given in the Nagpur Plan were satisfactory. The general standards for the design of various classes of roads will be published in the form of a pamphlet.

Item (5) Glossary of Highway Engineering Terms. A small subcommittee has been appointed to finalize the definitions. The definitions when finalized will be published as a separate book.

In addition to the four standards issued last year, one more standard on Furlong and Boundary Stones is under print.

As recommended by the Indian Roads Congress, the Government of India have brought the standards to the notice of the State administrations and have recommended their adoption.

A book on Horizontal and Transition Curves for Highways is under preparation. The book contains :

(i) Tables which enable the selection of the best possible curve suited to any particular site for deviation angles from 6 to 120 degreess.

(ii) Tables giving the elements for setting out Spiral Transitions of various lengths and radii by offsets and by a theodolite.

(iii) Tables giving the various elements of unit transition length for different angles consumed by the transition. These will enable one to design curves in tight locations.

(iv) Worked out examples.

These Tables are under print and the book is expected to be put on sale shortly.

The following subjects have been under study of the Committee.

(1) Rotaries.

(2) Testing Road Aggregates.

(3) Tables on Vertical Curves.

(4) Standard Form for Recording Traffic Census.

(5) Specification for Water-Bound Macadam.

A Paper on item (1) above has been published in Volume XIX-part 3 of the Journal and it will be discussed during the current session.

16. BRIDGES COMMITTEE

The 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.

17. TECHNICAL SUBCOMMITTEE

(i) Test Track Division

The Subcommittee held meetings on the 8th January, 6th February and the 15th December 1954. The progress of work done at the Road Test Track, Calcutta, was discussed and the programme for the next series of tests was drawn up. The 1952-54 series of tests were carried out to determine the comparative performance of the soil stabilized base courses of different thicknesses under adverse conditions.

The members of the Division after inspecting the surfaces concluded that the stabilized bases did not fail under the test

conditions. They also observed that 7-in. thick soil-sand stabilized base compared favourably with the two layers of brick soling. It was also decided that for future tests, data about humidity and temperature for the period during which tests were carried out should be collected.

The Subcommittee also decided that the usual test load at the test track should be so increased as to represent the actual loads on the roads and that the manner of loading should be so remodelled as to utilize the maximum width of the test sections. The details of this scheme will be worked out by the Convenor. In the meantime, however, the load on the existing test carts will be increased as far as possible.

The following programme was drawn up for the next series of tests.

1st section — soil-sand stabilized base.

2nd section — soil-sand cement stabilized base.

3rd section — soil-sand bitumen stabilized base.

4th section — sand-sand moorum stabilized base.

All these base courses will have 9 in. depth.

The sub-grades under these sections would be of the same type of soil preferably clay. The wearing course will consist of $1\frac{1}{2}$ in. tar carpet. A detailed specification will be considered by the Subcommittee after carrying out the laboratory tests.

It was also resolved by the Committee that similar tests should be conducted on actual road and proposals regarding this will be submitted to the Government of India.

Tests on surface dressings laid on the Delhi-Mathura Road near the Central Road Research Institute, Okhla (Delhi) are in progress.

The Road Research Bulletin No. 2 containing reports of work done at the Road Test Track at Calcutta from 1942-1947 has been issued.

(ii) Research Organization Division

At the meeting held on the 4th February 1954, the Subcommittee discussed the following reports:

(i) Report on "Curing of Concrete by the Membrane Method" by the College of Military Engineering Kirkee.

(ii) Abstracts from the Report for 1950-51 of Research Laboratory, West Bengal.

(iii) Abstracts from the Report for 1950 of the Irrigation Research Institute, Amritsar.

Later at their meeting held on the 30th November 1954, the Subcommittee discussed the following subjects:

(i) List of Research Problems.

(ii) A report on "Stabilized Earth Bricks and Tiles for Buildings," Hyderabad Engineering Research Station.

(iii) Report of the work done at the Roads and Buildings Laboratory, Karnal from July 1952 to June 1953.

The list of Research problems referred to at item (i) above was discussed and approved with certain changes. The Member-Secretary would suggest the priorities for the problems approved and circulate them to members of the Committee.

Items (ii) and (iii). The work done at the Roads and Buildings Laboratory, Karnal and Hyderabad Engineering Research Station was noted. It was decided that a suggestion should be made to the Karnal Laboratory to study detrimental effects of magnesium sulphate on various properties of soils.

18. SOIL RESEARCH SUBCOMMITTEE

The Subcommittee held a meeting on the 7th February 1954.

On the request of the Indian Roads Congress, the Government of India had agreed to provide funds for carrying out experiments on surface dressing with tar on stabilised roads with and without tack coat in the Punjab and Madras. The Subcommittee considered that, wherever possible, both Bitumen and Tar should be used, for the purposes of comparison and that the Madras light-chipping carpet specifications may be taken as equivalent to two-coat surface dressing.

The Punjab P.W.D. has already taken up the work in hand and the experiments are being carried out on Sonepat-Gohana Road and on village road from 30/3 of Grand Trunk Road to village Bigham in Rohtak District.

The Highways Department, Madras will also take up the work in hand shortly.

On the recommendation of the Indian Roads Congress, the Government of India have suggested to the Chief Engineers of all States that the use of stabilized soil for base courses in various road projects should be encouraged where stone, bricks, gravel, etc. are not available and climatic conditions are favourable for the use of stabilized soil.

At the meeting held on the 28th October 1953, the Subcommittee considered the proposal for a special test track for research on the use of soil for village road construction and recommended that inexpensive low speed test tracks should be set up in each State for testing different specifications for soil stabilized road construction. Preferably these should be on diversion of roads. The matter was placed before the Executive Committee who have agreed with the views expressed by the Subcommittee and decided to recommend to the State P. W. Ds. that, where conditions permit, inexpensive test tracks for testing different specifications of stabilized road construction be set up alongside roads.

The Subcommittee at their meeting held on the 28th October 1953 decided that a detailed note on the use of machinery in the soil stabilization work done on Ramnad-Mandapam Road should be placed before the Subcommittee. The note was to include information on the possibilities and effectiveness of the use of machinery. As Shri G. Srirangachary to whom this work was entrusted had left the Highways Department, Madras, the Chief Engineer (Highways) Madras was requested to entrust this work to another officer. Shri R. N. Dogra of Punjab has also promised to send a detailed report on a similar work done in a community project near Jullunder.

19. EDUCATION SUBCOMMITTEE

The Subcommittee held a meeting on the 5th February 1954.

They discussed the draft syllabus for Highway Engineering in the degree course. The syllabus will be considered further at the next meeting of the Subcommittee.

The Subcommittee also considered the details of the Refresher Courses for engineers working in Highways Departments. The details will be considered further at the next meeting of the Subcommittee. It was, however, decided by the Subcommittee and by the Council that it was not necessary for the Indian Roads Congress to work out details of Refresher Courses for subordinates for the present.

20. PROVINCIALIZATION OF LOCAL BODIES ENGINEERING SERVICES SUBCOMMITTEE

The Subcommittee held a meeting on the 7th February 1954. They were of the opinion that better organization of the technical personnel of local bodies will result in more efficient execution of public warks under the 5-Year Plan. The Executive Committee, decided that the recommendations of the Indian Roads Congress should be forwarded to the Planning Commission and they be requested to advise the State Government to provincialize the Engineering Services of their Local Bodies as the State of Madras had done with excellent results. The Planning Commission have been addressed in the matter.

21. MANUFACTURE OF ROAD MAKING MACHINERY AND MACHANIZATION SUBCOMMITTEE

The Subcommittee held a meeting on the 7th February 1954.

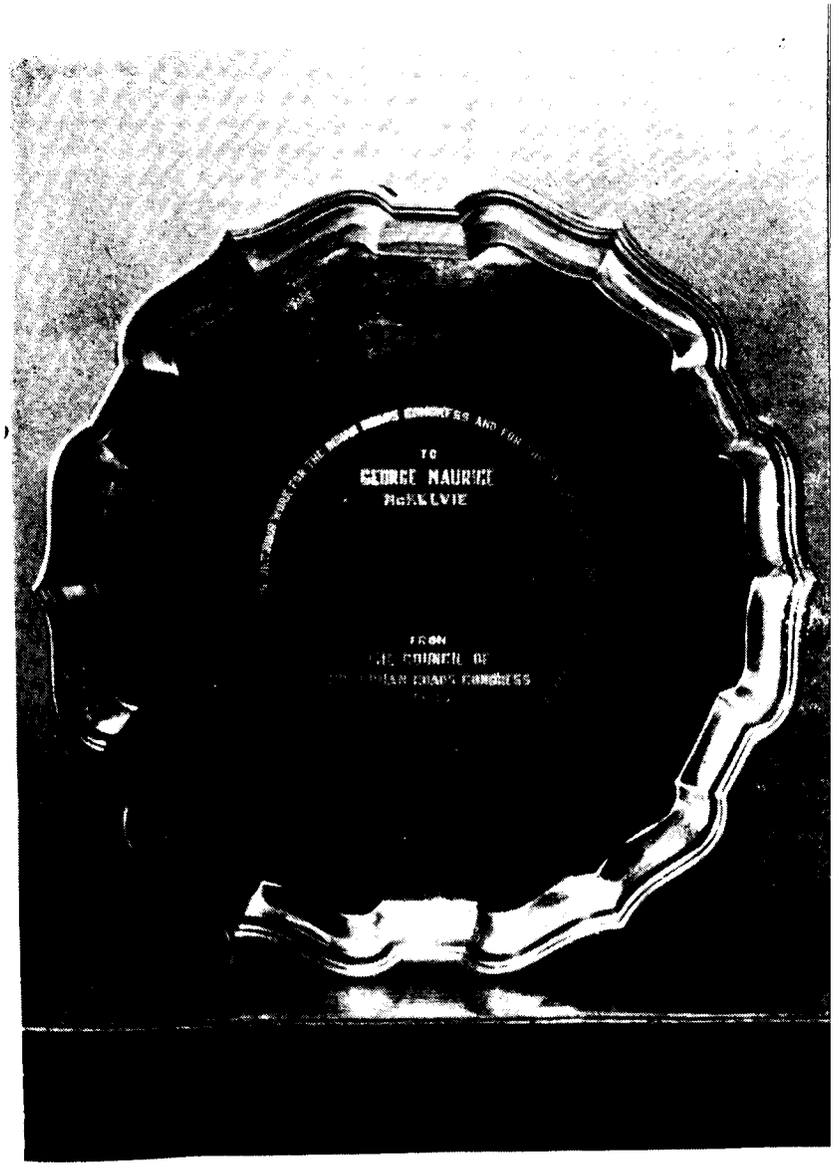
The minutes of the meeting were considered by the Executive Committee in their meeting held on the 4th September 1954. They noted the progress made in regard to the manufacture of certain items of road making machinery in India. They also noted that efforts made by the Government of India towards the establishment of diesel road rollers industry in India have not been successful so far. It was, however, expected that steam road rollers industry would shortly be established in India on a permanent basis.

22. ROAD TRANSPORT SUBCOMMITTEE

The Subcommittee in their meeting held on the 4th February 1954 reviewed the question of the formation of an Indian Road Transport Congress. Members of the Subcommittee considered that there was a need for the formation of an Indian Road Transport Congress and it was decided that before the Government of India were requested to review the recommendation, the matter should be examined by the Executive Committee in the light of the present condition of transport in the country.

23. ROAD OPERATION COSTS COMMITTEE

At the instance of the Government of India, the Indian Roads Congress appointed a Committee of experts to study (i) the cost of operation of motor vehicles on different classes of roads ; and (ii) the economy resulting from road improvements. The Committee held its first meeting at Delhi on the 25th September 1953. The questionnaire prepared by the Committee was circulated to various operators. Some data has been



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collected. As soon as more information is received, the final report of the Subcommittee will be compiled.

MISCELLANEOUS

24. PAPERS FOR THE 19th SESSION

14 Papers were received during the year, 4 were already lying pending. Out of these 18 Papers, 9 were accepted for publication, 4 were rejected, and 5 are under consideration for the next session.

25. TEST VALUES OF ROAD STONES

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

26. APPRECIATION OF THE SERVICES RENDERED BY SHRI G. M. MCKELVIE

The Council of the Indian Roads Congress at their meetings held at Bhubaneswar in February 1954 unanimously passed a resolution greatly appreciating the services rendered by Shri G. M. McKelvie to the Indian Roads Congress. They also decided to present him a silver salver and contributed towards its cost.

As Shri McKelvie was in Scotland, the Institution of Highway Engineers, United Kingdom was requested to present, on behalf of the Indian Roads Congress, the salver to Shri McKelvie at one of the meetings of their Scottish Branch. This proposal was accepted by the Institution and the salver was presented to Shri McKelvie on the occasion of the Annual Luncheon at Edinburgh on the 25th March 1955.

Shri McKelvie has greatly appreciated the present and thanked the Indian Roads Congress for it.

27. The Council desires to express appreciation of the continued interest shown by the members in advancing the activities of the Society. They also wish to draw the attention of members to the need for writing Papers or Notes on anything of interest to Road Engineers that they observe or experience in the course of their professional activities.

Appendix

LIST OF JOURNALS

1. American Foundryman.
2. American Highways.
3. Annual Reports of the Institution of Engineers (India), Bombay Centre.
4. Automobile News.
5. Better Roads.
6. Bitumen Teere Asphate Peche und Verwandte Stoffe (in German).
7. British Constructional Engineer.
8. British Road Federation (Bulletin).
9. Bulletin Technique De la Suissee Romande (in French).
10. Bulletin of Central Building Research Institute, (India).
11. Bulletin of the Institution of Engineers, (India).
12. Bulletin of the International Association of Road Congresses.
13. Burmah Shell News.
14. Central Board of Irrigation Abstracts.
15. Commenwealth Today.
16. Conerete Quarterly.
17. Contractors Record and Municipal Engineering, U. K.
18. Cement (In Dutch).
19. De Ingenieur in Indonesia (In Dutch).
20. De I 'Institute Technique Du Batiment et Des Travaux Publics (in French).
21. Engineering News of India.
22. Highways and Bridges and Engineering Works.
23. Highway Current Literature.
24. Highway Research Abstracts.
25. Indian Journal of Power and River Valley Developments.
26. Indian Minerals.

27. Indoc 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 Indian Institute of Science.
41. Journal of the Japan Society of Civil Engineers (In Japanese).
42. Link Belt Speeder News.
43. Magazine of Concrete Research.
44. Main Roads.
45. News Letter of I. R. T. D. A.
46. Motor Transport.
47. Municipal Gazette.
48. Premier Automobile Journal.
49. Proceedings of the Institution of Civil Engineers, London.
50. Power Engineer.
51. Public Roads.
52. Quarterly Technical Bulletin (Indian), (Ministry of Railways).
53. Reinforced Concrete Review, U. K.
54. Road Abstracts, Road Research Laboratory, U. K.
55. Road Builders News.
56. Road International.
57. Roads and Road Construction.

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

Minutes of the 45th Council Meeting of the INDIAN ROADS CONGRESS held at Gulmarg on the 23rd June 1955

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

Present:

F. P. Antia, Dr.
M. P. Apte
K. Barua
M. L. Bahl
H. S. Batliwala
C. M. Bennett
U. J. Bhatt
M. S. Bisht
D. B. Chopra, Brig.
A. S. Dhillon, Major
R. J. Dhumal
Fateh Chand
Goverdhan Lal
W. A. Griffiths
D. N. Gupta
H. R. Gupta
S. N. Gupta
M. N. Kamath
K. K. Kartha
Kishore Lal
C. P. Misra
C. R. K. Mudaliar
E. A. Nadirshah
K. K. Nambiar
D. P. Nayar
R. C. Roy
C. Seshavatharam
T. Mitra
K. Subba Rao
Sujan Singh
J. Subrahmanyam, Secretary

The following co-opted Members attended:

K. F. Antia
R. K. N. Iyengar, Dr.
S. L. Kumar
M. N. Majumdar
L. C. Verman, Dr.

The following attended by invitation:

M. F. Beg
R. S. Bhalla
D. G. Bhagat
Qazi Mohd. Afzal
B. N. Roy
A. K. Sen
J. M. Trehan
B. V. Vagh

1. Co-options and Invitations.

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

2. Confirmation of the Minutes of the 44th Council Meeting.

The Minutes of 44th Council meeting held at Srinagar on the 18th June 1955 were confirmed.

3. **Office Bearers.**

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

President	...	K. K. Nambiar
Vice-Presidents	...	M. S. Bisht
		D. N. Gupta
		W. A. Griffiths
Hony. Secretary	...	J. Subrahmanyam

At this stage, the newly elected President, Shri K. K. Nambiar, took the chair.

4. **Venue of the next General Session.**

The Council accepted with thanks the invitation of the Government of Madhya Pradesh to hold the next Session of the Indian Roads Congress at Nagpur early in the year 1956.

The Council also recorded their thanks to the Government of Uttar Pradesh for extending invitation to the Indian Roads Congress to hold their next Session at Lucknow. The Council agreed to avail of their invitation for a later session of the Indian Roads Congress.

5. **Committees and Subcommittees.**

The Convenors of Committees and Subcommittees were appointed as under :

(1)	Specifications & Standards Committee	... Goverdhan Lal
(2)	Bridges Committee	... H. P. Mathrani
(3)	Technical Subcommittee :	
	(i) Test Track Division	... T. Mitra
	(ii) Research Organization Division	... H. P. Sinha
(4)	Soil Research Subcommittee	... S. R. Mehra
(5)	Education Subcommittee	... E. A. Nadirshah
(6)	Road Transport Development Committee	... F. P. Antia
(7)	Provincialization of Local Bodies Engineering Services Subcommittee	... B. N. Roy

(8)	Papers Subcommittee	... H. P. Mathrani
(9)	Manufacture of Road Making Machinery & Mechanization Subcommittee	... R. S. Bhalla
(10)	Organization Committee	... H. P. Mathrani
(11)	Road Operation Cost Committee	... H. P. Mathrani
(12)	Cement Concrete Road Surfacing Subcommittee	... E. A. Nadirshah

6. **Inclusion of Highway Engineering Course in the Curricula of Engineering Colleges in India.**

The Council approved the syllabus for Highway Engineering course prepared by the Education Subcommittee and decided to recommend to the All-India Council of Technical Education its inclusion in the curricula of Engineering Colleges in India.

7. **Miscellaneous.**

The Council decided that written comments be invited on Col. S. K. Bose's Paper entitled "The Influence of a Superimposed Layer in Increasing the Load Bearing Capacity of a Rigid Pavement" published in Volume XIX-Part 3 of the Journal of the Indian Roads Congress.

It was further decided that this Paper should be referred to the Rigid Pavements Division of the Specifications and Standards Committee.

Inspection Tour Notes

INDIAN ROADS CONGRESS—NINETEENTH SESSION 1955.

BANNIHAL TUNNEL

At present, entry into the Kashmir Valley is through the Bannihal Pass which is at a height of 8,989 feet. Because of this elevation the pass remains snowbound for four months in a year and Srinagar cannot be reached by road during the winter. Therefore, in the beginning of 1952, the Jammu & Kashmir Government recommended the construction of a low level tunnel near Bannihal to make the Jammu-Srinagar road motorable throughout the year.

After a study of over 25 road tunnels in Europe and America the design for work was finalized. The tunnel as proposed will be 1.6 miles long and will consist of two tubes. Each of the tubes will have a carriageway 10 ft 6 in. wide with two footpaths 4 ft 1 in. and 1 ft 11 in. wide, one on each side. The tunnel will have an upward gradient of 3 in 1,000 from both sides, that is, there will be a hump in the centre. A cross-section and longitudinal section of the proposed tunnel is shown in Fig. at page 633.

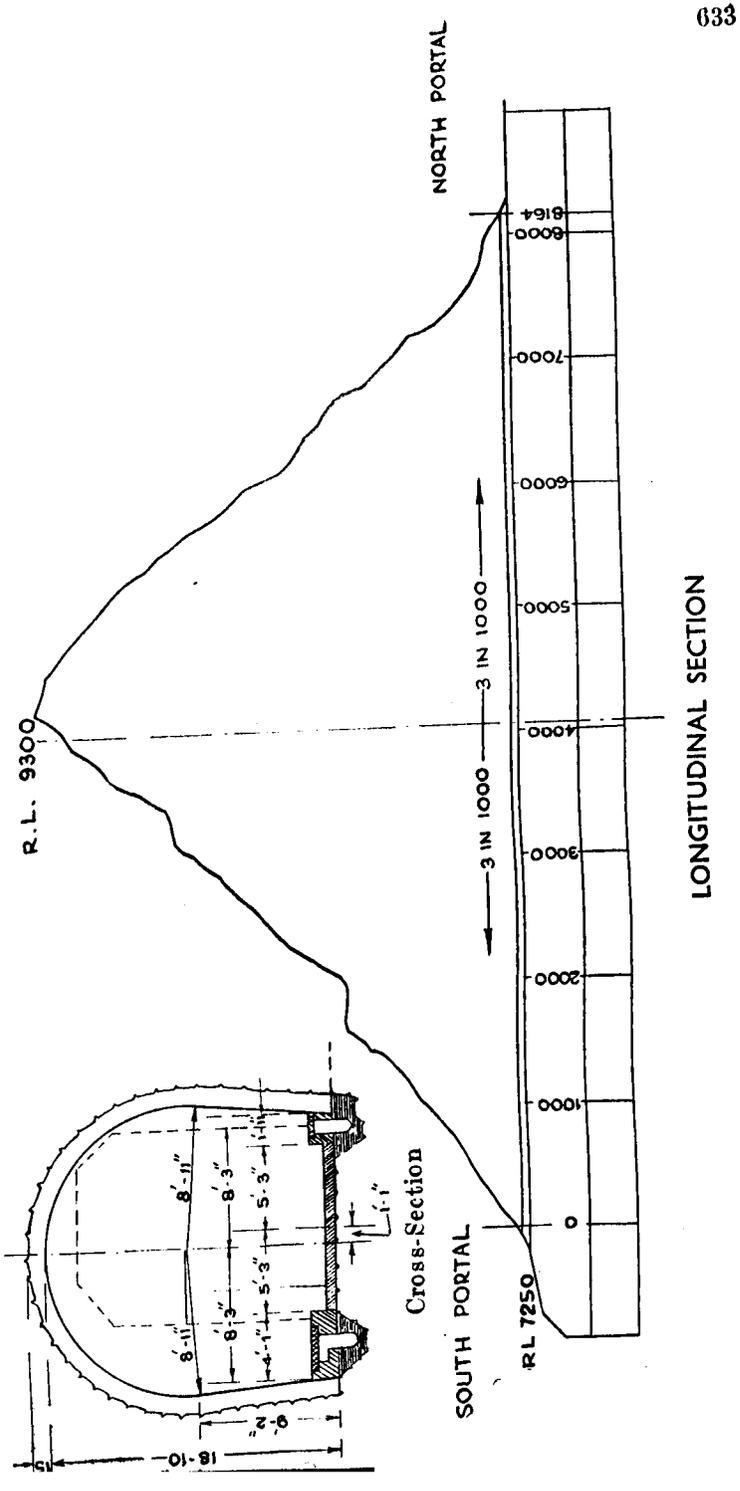
The tunnel has been designed for a normal traffic of 250 vehicles per hour in each direction and can accommodate 400 vehilcles per hour in each direction during peak traffic periods.

Four passing places, each 200 ft long, will be provided in each tube. The width of the carriageway will be 18 ft 6 in. at these places.

In the design, the carbon monoxide content has been limited to 2.5 parts in 10,000 when the tunnel is dealing with normal traffic. (This limit of 0.25 parts has been found to be safe if inhaled for long periods by human beings). The carbon monoxide concentration is likely to increase to 4.0 parts in 10,000 during peak periods. During the periods of this peak motor traffic, pedestrian traffic through the tunnel will have to be stopped as this proportion of carbon monoxide is safe for short periods only.

VENTILATION

The tunnel will have forced longitudinal ventilation system, in which fresh air will be blown into the tunnel in the direction of and behind the traffic moving in the tube. This system of ventilation was found to be the most economical for the length of



the tunnel, the height of rock over it, and the intensity of traffic expected.

The velocity of the air will be limited to 10 ft per second as greater velocities will be uncomfortable for pedestrians using the tunnel. The machinery for forcing the fresh air will consist of a ring of blowers round the entry portal.

For a short length near the portals there will be blasts of air which will be uncomfortable for pedestrians. To get over this, separate short tunnels have been provided for the entry of pedestrians. These will join the main tunnel at about 300 ft beyond the portals. Incidentally, these could be used as emergency exits in case the main portals are blocked for any reason.

LIGHTING

It is proposed to have ceiling lights 80 ft apart in the major part of the tunnel. Near the portals the distance between the lights will be gradually reduced to 10 ft so that the transition from relatively dark tunnel to bright outside in daytime may be gradual. The type of lights to be used, has not yet been decided. The lights will be connected to three separate circuits, two for alternate lights and third one for every tenth light. The first two circuits will be fed only by the power house while the circuit for every tenth light will be connected not only to the power house but also to a series of storage batteries which will automatically come into operation if the power house fails at any time. The storage batteries will be capable of supplying current to the traffic light and every tenth light for three hours.

SAFETY DEVICES

Fire stations equipped with water hydrants, chemical fire extinguishers, sandbins, telephones and alarm signals will be provided 400 ft apart. Carbon monoxide measuring instruments will also be provided. All the fire stations, carbon monoxide measuring instruments, traffic signals and ventilating blowers will be connected to the control room that will be provided at one end.

The carbon monoxide gauges will be connected with alarm bells which will ring when the ratio of this gas exceeds the safe limit.

Electric traffic counters, anemometers for measuring the velocity and direction of the wind, sand and salt bins for de-frosting the road surface are also proposed to be provided.

The following auxiliary buildings are proposed to be constructed :

South Portal: Garages, workshop, office, control room and 4 one-room quarters.

North Portal: Garages, workshop, control room and one one-room quarter.

Parking places 175 ft wide each will be provided at the portals.

Details of the proposed lining are given below :

(a) In non-self-supporting section, 1 : 2 : 4 cement concrete of thickness 12 in., 15 in., or 18 in. depending on pressures from above and on sides.

(b) Where the bottom is not on hard strata, reinforced cement concrete invert will be provided jointed with lining which will also be reinforced. The thickness will vary according to conditions.

(c) At by-passes, the thickness of lining will vary from 12 in. to 22 in. depending on the pressures.

(d) Where there is seepage of water, insulation will be provided which will be supported by an inner vault concrete of 8 in. uniform thickness.

The insulation will consist of a priming coat, a hot bitumen coat sufficient to cover the surface, and two layers of bitumen paper laid with hot bitumen coat between the layers and over it.

Details of machinery used in the tunnel are given below.

1. **Compressors :** Run by diesel engine of 90 h. p. and working at a pressure of 70—80 lb per sq. in. and having a capacity of 200 cu. ft. per minute each. In all four compressors will be installed on each portal. At present two have been installed on the north side and three on the south side.

2. **Generating sets :** Diesel generating sets of different capacities (10, 40 and 60 K. V. A.) for power supply to workshop, tunnel lighting, area lighting and other purposes.

3. **Shovel loaders :** Universal type, operated by compressed air with hopper capacity of 11 cu. ft. One on each side and one standby.

4. **Ventilators:** Reversible units—one on each side with a capacity of about 75 cu. ft. per minute. These can supply fresh air and extract bad gasses as required.

5. **Drills:** Pneumatic drills of varying lengths.

6. **Tipping wagons:** Capacity 70 cu. ft. each, used for removing muck. At present 9 wagons are working on each side but eventually there will be 20 wagons on each side.

7. **Locomotives:** Operated by diesel engines of 60 h. p. which can haul up to 12 wagons on level. One unit is working on each side at present but one more will be required on each side at a later stage.

8. **Concrete mixer:** One of 14/17 cu. ft. capacity on each side—operated by diesel engines.

9. **Stone breaker:** Two operated by diesel engines – one of them has a capacity of about 225 cu. ft. per hour and the other about 350 cu. ft. per hour. Both these stone breakers have screening and washing arrangements.

10. **Stone mill:** One on each side to produce sand from stone. These have not yet arrived at site.

11. **Concrete pump:** One on each side to pump concrete for roof lining. These have not yet arrived.

12. **Engine-driven winches:** For lifting concrete for side walls and other purposes.

13. **Tipper Wagons:** Eight on each side for carrying material to concrete mixers and carrying mixed concrete for lining. Capacity of each about 28 cu. ft.

14. **Trolley lines:** Rails weighing 55—60 lb laid for 2 ft gauge.

15. **Trucks:** (a) Five Mercedes Benz trucks operated by 120 h. p. diesel engines are already in use and 15 more are on order. Each one can haul 4½ tons of material.

    (b) One special truck for carrying explosives of the same make and capacity as above which is allowed to carry only 3 tons of explosives at a time.

SINDH VALLEY HYDRO ELECTRIC PROJECT

At present electric power supply to Srinagar is generated at Mohora, 54 miles away from Srinagar, where the generating station was built in 1904–07. The present generating capacity of about 2,500 K. W. is inadequate to meet the present demand of Srinagar town. The use of the waters of Sindh Nallah for generation of hydro electric power was first thought of in 1946 and work was started after 1948.

The Sindh Nallah has been tapped at the convex at Prang 22 miles from Srinagar, page 639. The power channel which skirts the mountains detours a length of nearly ten miles through rugged country for about four miles, yielding a head of 462 ft at Ganderbal, the power station site, which is situated 13 miles from Srinagar. A balancing reservoir has been provided two miles upstream of forebay tank to store 86.1 acre-feet of water.

The generating station has been built for four units of 3,000 K. W. each. At present, however, only two units have been installed. The generation is 6.6 KV, 50-cycle, 3-phase and two 33-K. V. lines are run to two receiving stations at Khanyar and Karannagar (Srinagar). A network of 63 sub-stations 6.6-K. V., 400-230 volts, supplies the distribution system. The installed capacity of the station is expected to be increased to 15,000 or 18,000 K. W. to meet the eventual demand.

An irrigation channel carrying 135 cusecs of water, meant to irrigate an area of 2,500 acres, takes off from the forebay tank. Besides irrigation, the water from this canal will supplement the water supply to Srinagar town.

Diversion Weir at Headworks

A rock-fill weir, 160 ft long at the crest, with a 20-ft scour channel fitted with a wheel-type gate, has been provided, abutting upon about 50 per cent waterway of the Sindh River. The weir, as built, is insufficient to cope up with the full flow discharge which empirically works out as 50,000 cusecs. An extension of the weir over the other half of the waterway remains to be done. The head regulator, Photo 1, with a 20 ft × 3 ft opening, will discharge 600 cusecs at a pond level of 5,711, which is the crest level of the weir. Regulation of headworks will be done by sliding gates.

Three tunnels, 3 ft × 1 ft, have been provided for shingle exclusion in front of the head regulator. Fish ladder and a long bay have also been provided in the weir.

Power Channel

The power channel, after its off-take from the headworks, traverses a steep and rugged terrain for the first four miles, Photo 2. The strata in this reach comprises conglomerate, hard rock, fissured at places and interspersed with shingle and boulders. The maximum cutting is about 110 ft in the hard conglomerate reach. The hillside above the canal is thickly wooded. About two dozen small and big ravines are intercepting the canal alignment. Aqueducts and super-passages have been provided for these.

In the next two miles the canal passes through easier terrain, where the strata varies from earth to shingle and boulders. Three major drainage crossings, two super-passages and one aqueduct, have been provided in this reach.

For miles 6 & 7, the hillside is again steep and consists of hard rock, shingle and boulders, which appear geologically loose formations. The depth of cutting in this reach is about 60 feet. In the eighth mile, the terrain becomes easy and the balancing reservoir has been provided in this reach. Herein the strata comprises of individual big boulders and shingle and boulder.

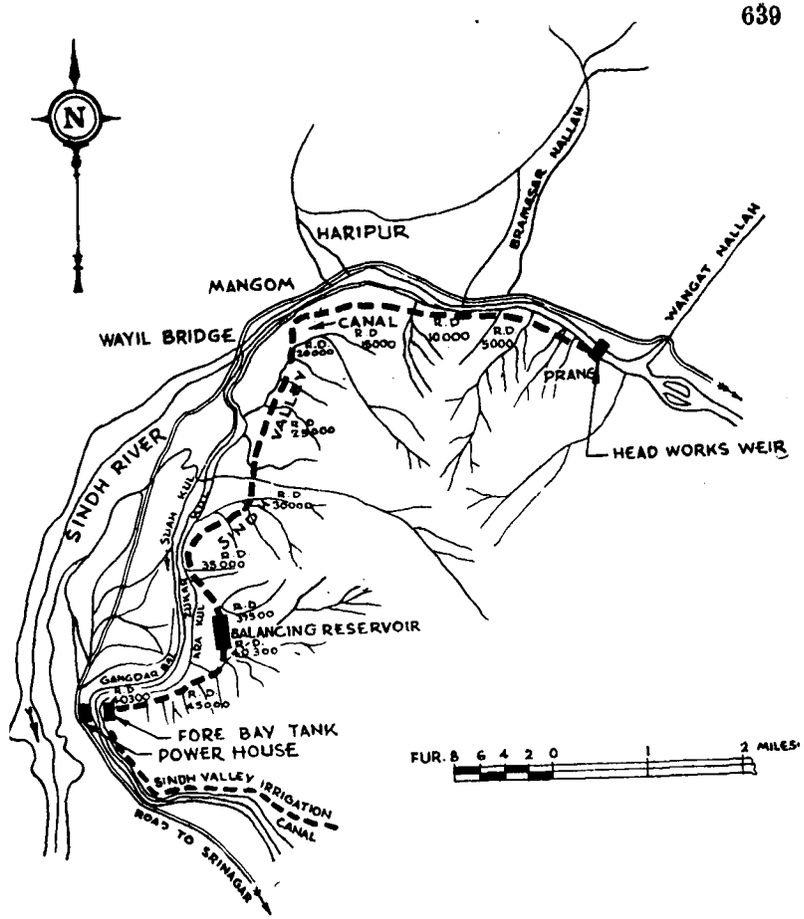
In the last two miles, the canal passes through earth with stratified rock formations. Sufficient setting-back of the hillside had to be done at places where oozings from the hillside interfered with the canal excavation. Particulars of the canal are given on page 648.

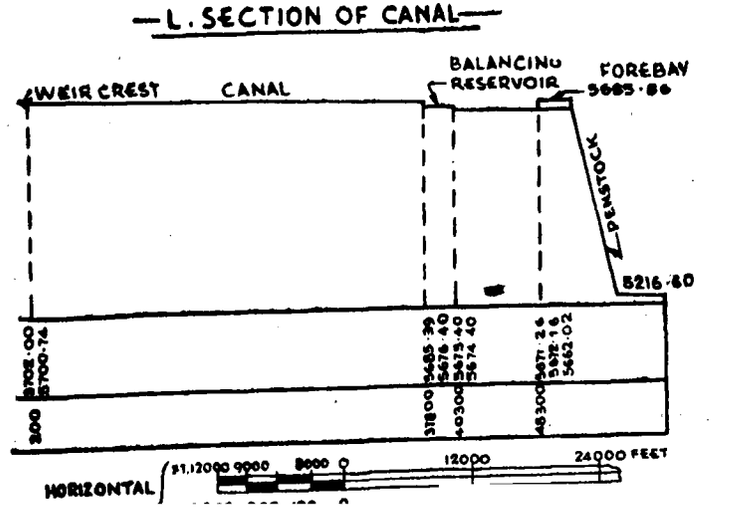
Balancing Reservoir

In order to increase the power potential of the generating station, a balancing reservoir has been provided with a capacity of 86.1 acre-ft. It is 2,500 ft in length and about 200 ft in width at full supply level with a bed width of 187 feet. A spillway capable of discharging 475 cusecs has been provided in the middle of the reservoir tank. At the lower end, an exit gate has also been provided which will regulate supply of water into the forebay tank.

Forebay Tank

The full supply level of the forebay tank which is 100 ft × 76 ft × 24 ft, is 5376.04. It has three cut-water bays feeding into three penstocks, of which only one has been built. The bed level of the forebay is at R. L. 5662.16. A wash-out has been provided at R. D. 5659.78 and the floor slopped towards the wash-out. The freeboard at full supply level is 3.4 ft, Photo 3.





The floor of the tank consists of 12 to 15 in. of cement concrete laid over one foot of soil cement on compacted soil. The walls are of rubble stone masonry in lime with lime concrete backing. The cut-water masonry has been done in cement concrete with brick facing cement plastered. The inside of the tank has been cement plastered 2 in. to 3 in. thick reinforced with G. I. netting. The face wall of the tank is in mass cement concrete. Between anchor one and the face wall of tank, a chamber has been constructed for the butterfly valve and associated gear.

The control gear on the butterfly valve is set for 20 per cent more than normal intake and the balance weight closes the valve automatically, stopping the flow of water, should any pipe fracture or any excessive leakage of the penstock occur. An air-valve has also been provided on the penstock immediately after the first anchor block.

Penstock

The penstock is about 1,350 ft long, made up of 15 ft long pieces joined with butt-type rivetted joints with a strap on top. Five anchor blocks have been provided with expansion joints in each length between the blocks. The penstock bifurcates into two pieces at the lower end, supplying two turbines. The discharge carried by each penstock is 200 cusecs, Photo 4.

The diameter of the penstock varies from 5 ft 1 in. at the top to 4 ft $8\frac{1}{8}$ in. near the bifurcation piece. The bifurcation pieces are 3 ft 4 in. in diameter. The plate thickness of the pipe varies from 5/16 in. at the top to 5/8 in. at the lower end. Manholes have been provided near the expansion joints between two anchor blocks.

Between the anchor blocks the penstock is supported on saddle blocks spaced about 30 ft apart. Pads have been welded on the penstock at these saddle points and bearing plates provided. The surfaces, between the saddle plates and the pads have been lubricated with graphitised tallow.

Power House

The power house, 165 ft × 28 ft, has been built in three sections to allow for differential settlement. The tail-race runs lower down in line with the penstock channel after negotiating a curve behind the power house, Photo 5.

The main building is supported on an R. C. raft at R.L. 5200. Vertical stanchions have been constructed on the R.C. raft which carry R. C. gantry beams on which a 8/3-ton crane is carried.

Photo 1. Head Regulator

Photo 2. The Canal

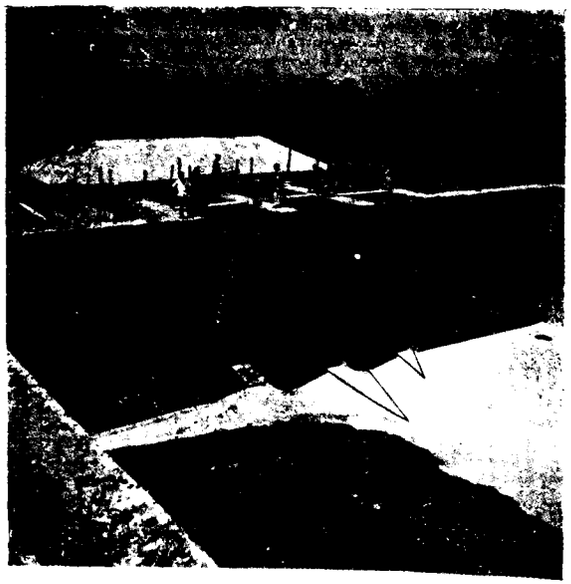


Photo 3. **Forebay Tank**

Photo 4. **Penstock**

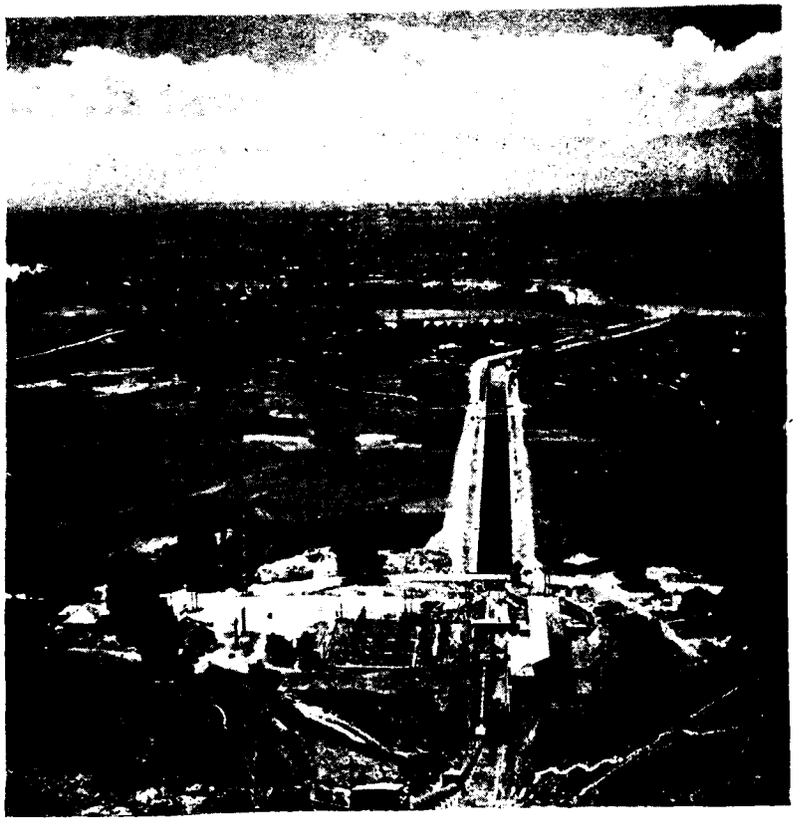


Photo 5. **General view of Power House & Outdoor Station**

Photo 6. Outdoor Transformer Station

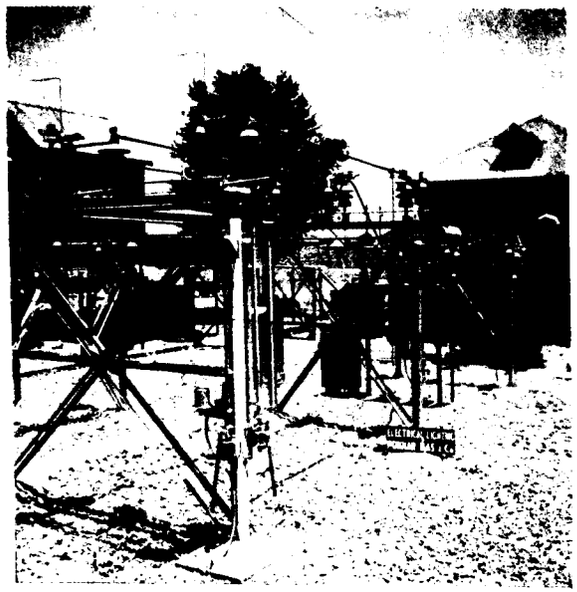


Photo 7. Receiving Station, Khanyar

Control room has been constructed on the east side of the power house adjacent to the extension bays for units 3 and 4 likely to be installed within next few years. The top of machinery foundations is at R. L. 5212. The bed of the exit channel is at R. L. 5204.3 in which water will rise to 5107 for two turbines. The H. F. L. from the back-water of river Sindh, which is the outfall of tail-race channel, will be 5207.6.

The power house has been built for four units. Two Escher-Wyss reaction turbines, rated at 4,365 horse power, 1000 r.p.m. 97 cusecs at 460 ft head have been installed.

A house set rated at 25 K. W. has been provided in the power house. It is a pelton-wheel supplied by a 4-in. pipe which has been tapped-off the 40 in. inlet pipe to No. 1 machine. The house set is run-up to start with and it supplies power to the motors driving the governor and bearing oil pumps. An actuator governor has been provided on the unit and the generation is at 400 volt.

Metropolitan-Vickers generators, transformers, switches, gear and protective-gear have been installed. The generators are rated at 3,000 K. W., 6.0 K. V. 3-phase, 50 cycle, 1000 r.p.m. and are directly coupled to the turbines.

Automatic voltage-regulators, with parallel running compensation for load sharing, have been fitted on each generator control panel. These are quick acting type and are capable of maintaining the voltage of the generators within $\pm$ 1 per cent.

The step-up transformer and high voltage switch-gear have been erected in the yard immediately outside the power house, Photo 6. This yard has six bays, comprising two generator-transformer units, two station auxiliary transformers and two outgoing 33 K.V. lines. The oil circuit breakers are rated at 250 M. V. A. and the transformers at 300 KVA, 33-KV/400-230-Volt for the auxiliary ones. The neutrals of the 33 KV transformers are solidly earthed.

Electric heaters have been provided in the oil circuit breaker tanks, the marshalling kiosks and transformer oil conservator tanks. These tanks are meant to maintain temperatures in the equipments in which they are fitted at a minimum level during winter.

On the outgoing lines two Metrosil surge diverters have been mounted on the structures. These are meant to protect the outdoor station from lightning and other waves that may strike the 13 mile long transmission lines. The lines are,

however protected by two earth wires running along their lengths. An earth conductor has also been strung over the outdoor station.

The direct current supply is from a 165-volt battery with a tap at 110-volt. It provides power for the oil circuit breaker closing and tripping circuits, indicating and alarms circuit and for the mimic diagrams. There is, however, a change-over switch from the D. C. to A. C. for the indicating circuit. The emergency lights in the power house and yard outside are also supplied from this battery. A motor generator set has been provided for the battery charging purpose.

The control of the system is remote and is exercised from the control room.

A workshop with a lathe, drilling machines, grinders, power hacksaw and shaping machines, has been provided. A diesel-electric unit has also been erected in the workshop for supplying power during construction and breakdowns.

Receiving Stations - Karannagar & Khanyar

Each of the two receiving stations, Photo 7, has been equipped with one 3760-KVA, 33-KV/6.6-KV delta/star main and a 100-KVA, 6.6-K.V./400-230 volt station auxiliary transformers. There are five 6.6-KV., 3-phase outgoing feeders. At present, however, only four feeders have been connected up to each receiving station feeding a network of 63, 6.6-KV/400-230 volt distribution sub-stations.

Cost

The total cost of the project is estimated to be Rs 227.82 lakhs. Details are given on page 650.

General Data

Length of canal	48,300 ft
Minimum discharge of River Sindh in winter	325 cusecs
Maximum discharge	56,000 cusecs
Normal discharge during summer	5,000 cusecs
Average bed grade of river	1 : 100

Bed soil at headworks	Big boulders, stones and shingle

Headworks at Prang

Length of rockfill weir	160 ft
Bed level of river	5702.00
Crest level	5711.00
Maximum H. F. level over crest	5727.00
Maximum H. F. level before construction of weir	5713.00
Top level of end abutments	5730.00

Scouring Sluice Channel

Width of scouring channel at gate	20 ft
Width of supply channel in front of head gate	20 ft
Bed level of scouring channel under gate & above	5702.00
Bed level of scouring channel below gates	5698.00
Size of gate	20 ft × 9 ft

Head Gate

Clear width of gate	20 ft
Clear height of gate	3 ft
Maximum discharge required through head gate	600 cusecs
Bed level of river in front of head gate	5702.00
Crest level of head gate	5708.64
Top level of head gates	5708.64
High flood level of river	5727.00
Free board	3 ft
Bed level of canal at headworks	5700.74

CANAL DATA

Canal section R.D.	Bed level	Bed width ft	Side slopes	Full supply depth ft	Free-board ft	Maximum discharge cusecs	Bed grade
0– 800	5700.74	11	1 : 1	7.9	1.5	600	1 : 2500
800–16600	5695.39	9	1 : 1	7.9	1.5	475	1 : 2500
18100–37800							
16600–18100		14.5	1 : 8	—	1.5	475	1 : 2500
40300–48300		9	1 : 1	7.9	1.5	600	1 : 2500

Balancing Reservoir R. D. 37800 to 40300

Length of tank	2500 ft
Bed width	187 ft
Full supply depth	7.64 ft
Hillside slope	1 : 1
Downstream slope	1½ : 1
Storage capacity	86.1 acre-ft
Bed width of canal trench	9 ft
Side slope	1 : 1
Full supply depth	7.9 ft
Bed grade	1 : 2500
Discharge capacity for 100 cusecs	Hr. Min. Sec. 10 25 31

Spillway Balancing Reservoir

Length of crest	190 ft
Crest level	5691.44
Full supply depth	1.9 ft
Full supply level	5694.34
Free board	1.5 ft
Bank top level	5694.79
Maximum discharge	475 cusecs

Forebay Tank

Bed level of canal at entry	5671.26
Crest level	5672.16
Bed level of forebay	5682.02
Fall in Forebay from canal	10.04
Minimum full supply level in forebay	5674.04
Maximum full supply level in forebay	5682.26
Centre level of forebay tank	5664.90
Free board	3.4 ft
Bed level of wash-out	5659.78
Bed level of extension canal at R. D. O. below forebay	5654.78

COSTS

Particulars	Amount in lakhs Rs	Particulars	Amount in lakhs Rs
Civil		**Electrical**	
Preliminaries	1.32	Preliminaries	0.50
Headworks	6.60	Power house and outdoor station and receiving station machinery	28.50
Earthwork	38.09	Pipe line	2.60
Silt ejectors	0.50	Erection charges	1.75
Lining of power channel	22.30	Workshop equipment and tools and plant	3.25
Approach roads	2.47	Two 13-mile long 33-KV. lines, telephone line and tie line	7.80
Balancing reservoir	5.53	Two receiving station buildings	1.70
Forebay tank	2.05	6.6 K.V. 3-phase, H. T. line	9.00
Penstock and anchor block	2.43	Sub-stations 6.6/KV/400-230 volt plus land	14.50
Buildings	5.78	L.T. distribution	11.00
Power house	5.47	Service lines and change-over	17.00
Escapes & escape channels	2.70	Overheads: Establishment T.A.	3.50
Masonry works	9.18	Miscellaneous	1.00
Tools and plant	2.40		
Supervision & miscellaneous	40.8		
Extension of irrigation canal	12.00		
Total	127.22		102.10
Deduct: Salvage value of tools & plant	0.50		
Total	125.72		

Total for the project: Rs 227.82 lakhs.

Discussion on Paper No. 171*

"A New Approach to the Analysis of Stability of Slopes"

By

P. C. VARGHESE

Sunday, June 19, 1955

Shri U. J. Bhatt (Chairman) called upon Shri E. C. Chandrasekharan, in the absence of the Author, to introduce the Paper.

Shri E. C. Chandrasekharan, in introducing the Paper, said that different procedures could be used for the determination of the average normal force and average shear resistance used in deriving the resistance curve. The Author had sent a note describing two methods for determining $\overline{S}$ and $\overline{N}$ mentioned in para 2.3 of the Paper. The first method was based on the assumption that the shear resistance was uniform along arc of the assumed circle of failure. The[2] second one was based on the simplifying assumption that the forces on the side vertical faces of the strip under consideration might be neglected.

Method I. Consider the mass *abc*, Fig. 1 bounded by an assumed cylindrical siding surface. This mass is in equilibrium under the action of three forces W, S and N. W is the total weight of the mass and acts through its centre of gravity. The direction and line of action of S depends on the actual distribution of the shear stress along the arc *ab*. If we introduce the assumption that the shear resistance is distributed uniformly along the arc *ab* (and investigation of cases where different probable positions and direction of S are assumed, indicate the above simple assumption as satisfactory in arriving at the resistance curve), then the line of the resultant S is parallel to the chord *ab* and acts at a distance of $\frac{R^2\theta}{L}$ from O, the centre of the assumed failure circle. The

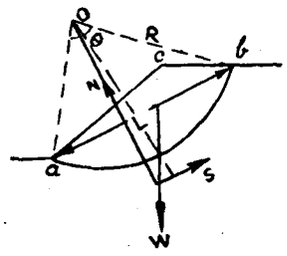


Fig. 1

* Published at pages 24 to 43 of the Journal of the Indian Roads Congress, Volume XIX-1, April 1955.

direction of N was fixed by the condition that it must pass through the point of intersection of W and S and also through the centre 0 of the assumed failure circle. Hence a force polygon will determine the magnitude of N and S. The dimensionless quantities N and S were then defined by the equation :

$$\overline{N} = \frac{N}{\gamma_m HL} \text{ and } \overline{S} = \frac{S}{\gamma_m HL}$$

Method 2. Consider an element of the mass of width dx as shown in Fig. 2. Assume that the stresses on the vertical boundaries of the slices can be disregarded: then the total reaction on the base of the slice is equal to the weight of the slice.

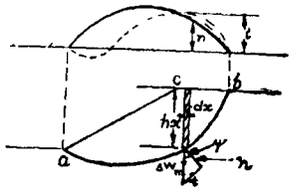


Fig. 2

Weight of slice $= \triangle w_m = \gamma_m h_x d_x$

The component of the weight in the direction normal to the slice $= \gamma_m h_x \cos \psi d_x$

The total normal load on $AB = N' = \int \gamma_m h_x \cos \psi d_x$

Thus the value of N' can be obtained graphically by plotting the curve of $\gamma_m h_x \cos \psi$ against x and obtaining the area under the curve. The average normal pressure along the arc is thus obtained by dividing the total normal load by the length of arc $R\theta$. Dividing this average normal load by $\gamma_m H$ we get the dimensionless number $\overline{N}' = \frac{N'}{\gamma_m HR\theta}$

Similarly, the value of T, the total resistance along the arc ab can be obtained by plotting the curve $\gamma_m h_x \sin \psi$ against x. Then the average shear resistance along arc ab is obtained by dividing the total shear by the length of arc $R\theta$. Thus,

$$S' = \frac{T}{\gamma_m HR\theta}$$

The values of N' and $\overline{S}'$ obtained may be used for plotting the resistance envelope.

The two methods described would not give identical results. This was due to the different assumptions involved in the two methods. For the first method the calculation of the total weight and centre of gravity of the sliding mass, and the position of the line of action of S were required. In the second one, the quantities required for the computation could be obtained graphically by use of a planimeter. In practice, the second method gave slightly more conservative results than the first one.

Shri N. Mohan Rao observed that the method advocated by the Author reduced calculations where site conditions were such that investigation of stability was required for varying values of ϕ and c. Where stability was to be checked for only one set of shear constants, the methods currently in use were satisfactory.

Fellinius had proved that the vertical drawn through the mid-point of the slope passed through the centre of the critical circle for base failure. The Author had shown, Plate II of the Paper, that the centres of the circles for toe failures lay on a curve asymptotically approaching the perpendicular bisector of the slope. These two findings served as a good guides in selecting the probable circles of failure.

The heterogeneous character of the soils met with in practice resulted in invalidating the computations made on the assumption that the soil mass was homogeneous. Another assumption was that the shearing stress in the idealised mass was uniformly distributed and that failure occurred simultaneously along the whole length. Krynine had said "This assumption is completely unwarranted. In the case of actual earth masses since both shearing stress and shearing strength of earth material are not constant along a failure line, equilibrium will only be broken at one or more points of the line." These assumptions were unavoidable if simplification was required. It was, therefore, very essential that the implications involved in the assumptions were understood and proper judgment used in the application of the theory to field conditions.

He had occasion to design slopes in a clay whose angle of internal friction varied from 8° to 12° as revealed by laboratory tests. The critical factor of safety was worked out by the Swedish method for $\phi = 0$ and one value of cohesion. Study of existing slopes and in situ shear tests led him to believe that the $\phi = 0$ analysis was conservative. So the factor of safety for various values of ϕ and c had to be worked out and each alternative meant many trials for getting at the critical value. In his opinion, the Author's method of resistance envelopes did reduce the amount of work and was a welcome addition to the knowledge on the analysis of stability of slopes.

Shri R. N. Joshi observed that he had occasion to discuss the subject matter of the Paper with one having considerable experience of analysis of slopes, who found that the Paper was a valuable one. The method suggested in the Paper reduced the amount of work involved in stability analysis.

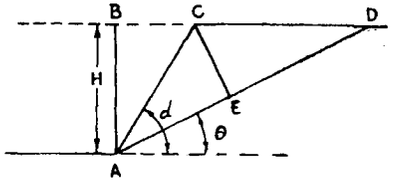


Fig. 3

Considering a bank of slope α and assuming for the sake of simplicity that the slip occurred along a plane with an inclination θ, Fig. 3, even though slips occurred along arcs of circles,

$$AC = \frac{H}{\sin \alpha} \; ; \; CE = \frac{H}{\sin \alpha} \cdot \text{Sin} (\alpha - \theta)$$

$$AD = \frac{H}{\sin \theta} = L$$

$$\text{Area of } \triangle ACD = \tfrac{1}{2} \cdot \frac{H}{\sin \theta} \cdot \frac{H}{\sin \alpha} \cdot \sin (\alpha - \theta)$$

Weight of triangular prism of soil per foot run =

$$Wc = \frac{\gamma_m}{2} \cdot \frac{H}{\sin \theta} \cdot \frac{H}{\sin \alpha} \cdot \sin (\alpha - \theta)$$

where γ_m is the density of the soil.

Considering the action along the inclined plane AD,

$$\text{Activating shear} = W \sin \theta$$

$$\text{Normal force} = W \cos \theta$$

$$\bar{S} = \frac{S}{L \cdot \gamma_m H} = \frac{W \sin \theta}{\frac{H}{\sin \theta} \times \gamma_m \times H}$$

$$= \frac{\frac{\gamma_m}{2} \cdot \frac{H}{\sin \theta} \cdot \frac{H}{\sin \alpha} \cdot \sin (\alpha - \theta) \cdot \sin \theta}{H^2 \cdot \gamma_m} \times \sin \theta$$

$$= \frac{\sin \theta \cdot \sin (\alpha - \theta)}{2 \sin \alpha}$$

To find out the maximum value of $\bar{S}$,

$$\frac{d\bar{S}}{d\theta} = 0 = \frac{d}{d\theta} \cdot \frac{1}{2 \sin \alpha} \left[\sin \theta \cdot \sin \alpha \cos \theta - \cos \alpha \cdot \sin 2\theta\right]$$

$$= \frac{1}{2 \sin \alpha} \left[\frac{\sin \alpha \cdot \sin 2\theta}{2} - \cos \alpha \cdot \sin 2\theta\right]$$

$$\frac{1}{2 \sin \alpha} \left[\sin \alpha \cdot \cos 2\theta - \cos \alpha \cdot \sin 2\theta\right]$$

$$= 0$$

$\therefore$ For S to be maximum

$$\sin \alpha \cos 2\theta = \cos \alpha \cdot \sin 2\theta$$

$$\text{i.e., } \tan \alpha = \tan 2\theta \text{ or } \theta = \frac{\alpha}{2}$$

$$\text{For } \theta = \frac{\alpha}{2}, \; \frac{\bar{S}}{\bar{N}} = \frac{W \sin \theta}{W \cos \theta} = \tan \theta = \tan \frac{\alpha}{2}.$$

$$\text{i.e., For } \bar{S} \text{ to be max. } \frac{\bar{S}}{\bar{N}} = \tan \frac{\alpha}{2}.$$

Therefore, on the assumption that slip occurred along a plane, the activating shear stress was maximum along the plane inclined at an angle equal to half the inclination of the slope ($\theta = \frac{\alpha}{2}$). The critical value of $\frac{\bar{S}}{\bar{N}}$, for such value of θ was $\tan \frac{\alpha}{2}$. Study of Plate I of thePaper confirmed the above. For all shear resistance envelopes of slopes $\alpha = 15^\circ$ to 90°, $\frac{S}{\bar{N}}$ for the maximum value of $\bar{S}$ worked out to be nearly equal to $\tan \frac{\alpha}{2}$. The resultant of the sliding forces acting along an arc might be considered to act parallel to the closing chord accompanied by a moment, as diagrammatically explained in Fig. 4. So con-

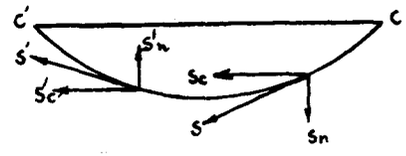


Fig. 4

sidering the failure along a plane did not introduce an error in the value of θ, the inclination of the sliding plane.

In the equation for S, W_c, the weight of the sliding prism of earth had been taken as that due to that section of bank bounded by the chord, whereas W, the weight of earth of the sector of the bank bounded by the arc of failure, was the correct one. That introduced some approximation. It was seen from Plate II, that for values of θ in the neighbourhood of α, R, the radius of curvature of the critical slip arc was large, with the result that $(W - Wc)$ was small. For values of θ in the neighbourhood of $\frac{\alpha}{2}$, $(W - W_c)$ was sufficiently large; but the value W_b was large. So the error introduced was small and it was not far from correct to substitute W_c for W in the expression for $\bar{S}$. The result obtained, namely $\bar{S}$ was maximum for $\theta = \frac{\alpha}{2}$, was true for all practical purposes.

In the shear resistance envelope for a given point say $\bar{S}^1, N^1$, the value of $\bar{S}^1$ was obtained for the critical arc having its chord inclination θ such than $\tan\theta = \frac{\bar{S}^1}{\bar{N}^1}$. This was so because

$$\frac{\bar{S}}{\bar{N}} = \frac{W \sin\theta}{W \cos\theta} = \tan\theta.$$

The above relation did not involve any inaccuracy because of the value of W being taken to be equal to W_c.

In para 3.3, the Author had mentioned that the tangent to the resistance envelope at the origin represented the value of the minimum angle of internal friction ϕ required for the stability of a bank, the soil composition of which had no cohesion, i.e., for $C = 0$. This was actually the significance of the observation that near the origin $\tan\theta = \tan\alpha$ under

$$\bar{S} = \frac{S}{L\gamma mH} = \frac{W \sin\theta}{L\gamma mH} = \frac{\sin\theta . \sin(\alpha - \theta)}{2 \sin\alpha}$$

$$\bar{N} = \frac{N}{L\gamma mH} = \frac{W \cos\theta}{L\gamma mH} = \frac{\cos\theta . \sin(\alpha - \theta)}{2 \sin\alpha}$$

Near the origin, both S and N were small. Both $\bar{S}$ and $\bar{N}$ can be small if W is small, i.e., θ was very nearly equal to α. Hence near the origin $\tan\theta$ was very nearly equal to $\tan\alpha$. This explained why the tangent to the shear resistance envelope at the origin was equal to the slope of the bank.

Again, for θ nearly equal to α, W is small which condition was obtained when the centre of the arc of failure was on the perpendicular bisector of the slope AC and when the radius of curvature was quite large. The truth of this inference could be verified from Plate II.

The accuracy with which the values of C and ϕ could be obtained was very limited. Moreover, the characteristics of soils changed under different conditions. To add to this, the maximum slope before failure for a material was different from the minimum slope after failure. Considering these aspects, the approximate results obtained in the above analysis might prove to be of practical utility.

Shri Joshi enquired why the locus of the centres of arc of failure given by the Author in Plate II was different for the locus suggested by Prof. Fellinius. This shape of the locus of the centres of critical circles for $\alpha = 60°$ was different from that of others and needed a check. The ends of these locii represented the centres of critical circles for $C = 0$, giving the maximum values of $\bar{S}$ corresponding to the graphs in Plate I. This tallied fairly with the remarks above for $\alpha = 90°$ and $60°$; but for lower values of α, it appeared that these observations were at variance and a check for the graphs was desirable.

It might be noted that toe-arc failures take place only with large values of α. The question of tallying of results with flat slopes was a matter more of academic interest, since toe circle failures did not occur in flat sloped banks.

Shri Joshi suggested that engineers might consider the possibility of increasing the stability of banks by introducing pin headers, or say by driving 1½ in. diameter concrete bars 4 to 5 ft in length in consolidated banks along lines radial to the possible critical arcs of failure.

Shri S. N. Gupta enquired about the exact slope in which failure took place. Referring to the practice of specifying a slope of 1 : 4 for banks less than 3 ft high and 1 : 2 slope for banks greater in height than 3 ft, Shri Gupta was of opinion that savings in earthwork in high approaches to bridges might result if the slopes were designed properly. For low banks, there was practically no savings.

Shri J. S. Narasimham said that the Author had assumed that the sliding mass was in equilibrium under the forces S, resultant shear, W, weight of the soil and the normal force. This was so only if the value of the "resultant shear S" took into consideration the 'neutral' and 'effective' pressures developed in the

embankment. The idealised assumptions viz., that the earth was not subject to changes of moisture and that the cohesion was uniform were not obtainable in practice.

In the expression $\bar{S} = \frac{S}{L\gamma_m H}$ the product $\gamma_m H$ had no mathematical significance. In the absence of any mathematical justification for dividing the total shear force and normal force by the product $\gamma_m H$ the values of $\bar{S}$ and $\bar{N}$ used in the shear envelope were purely empirical and had no rational significance.

The strength of a soil, in so far as its angle of internal friction was concerned, was not reduced to the same extent as that obtained by the weighted angle of internal friction, see example 3 of the Paper. The correct procedure was to determine in the laboratory the values of cohesive strength and the angle of internal friction at the moisture contents likely to be developed in the embankment and use these in the analysis. The construction of 'flow net' in simple cases was time consuming and a simple amended method was generally used. In the amended method, the saturated weight of the soil below the saturation line was taken into consideration for the driving force while the submerged density of the soil was taken into consideration for the resisting forces. By adopting this procedure the factor of safety was obtained on the safe side and the concept of the 'effective pressures' and 'neutral pressure' developed due to saturation were taken into consideration.

In Shri Narasimham's opinion the method suggested by the Author was questionable and had no practical value except in case of low embankments not subject to environmental conditions.

Shri D. N. Khurana* observed that the engineers in the field either wanted to design the angle of the slope or to find out the factor of safety of a particular angle of slope for known values of c and ϕ. It was difficult to draw tangents in the flatter portions of the resistance envelopes given in Plate I specially when the value of $\bar{N}$ exceeded 0.3. Tylor's curves, on the other hand gave direct readings and were adaptable for practical use easily.

He wanted to know if the graphs connecting $\bar{S}$ and N given in Plate I were drawn after conducting experiments.

Shri C. G. Swaminathan wished the Author to explain in detail as to how the new method of analysis was independent of the shear strength characteristics and whether the Author had in mind any strength curve other than the normally used linear one.

* This and the following Comments were received in writing.

In his opinion, most engineers would prefer to work out the factor of safety from one equation rather than from a graph. For practical purposes it was sufficient if the factor of safety was worked out for the worst case specially because the actual surface of failure differed considerably from the assumed circular surface.

Shri E. C. Chandrasekharan replying to the discussions, on behalf of the Author, said that the method of arriving at values of S and $\bar{N}$ was given in the introductory remarks. He was glad that almost all the speakers had said that the new method was sound and that it reduced calculation works when the factor of safety had to be calculated for various values of ϕ and c.

Referring to the observation of **Shri Mohan Rao**, that the analysis for $\phi = 0$ gave conservative results, Shri Candrasekharan said that it was obvious because $\phi = 0$ gave the worst condition of stability.

Shri Joshi had by calculations based on the assumption that the surface of failure was only a plane instead of a cylinder supported the conclusions drawn by the Author.

Answering **Shri S. N. Gupta's** remark about the practical utility of the method, Shri Chandrasekharan said that for low embankments up to 5 ft it might not be advantageous. But for high banks, stability analysis certainly contributed to the economy in design.

The division of S by $\gamma_m H$, which **Shri Narasimham** thought was irrational, was only a convenient artifice for arriving at the dimensionless factor and achieving a co-relation between c and ϕ and $\bar{N}$ and $\bar{S}$.

In conclusion he wished the Author had explained in more detail how his method was more advantageous over other methods.

Shri U. J. Bhatt (Chairman), concluding the discussion said that soil mechanics was of great importance to road builders. Though recent in origin, much work had been done in the field of soil mechanics and large sums of money had been saved by adopting methods based on soil science and many failures averted. Design of embankment slopes was specially important to road engineers. The method evolved by the Author did not apply to progressive failures. But the Paper was valuable in evolving a method by which saving in the calculations resulted, when many alternatives had to be investigated. He expressed thanks of the Society to the Author for his Paper.

Discussion on Paper No. 172*

"Bituminous Treatment of Brick Metal Water-Bound Macadam Surfaces In U. P."

By

D. C. CHATURVEDI

Sunday, June 19, 1955

Shri P. L. Varma (Chairman) called upon Shri D. C. Chaturvedi to introduce his Paper.

Shri D. C. Chaturvedi, introducing his Paper, said that the surfacing described had been tried in Uttar Pradesh for the last 20 years and found successful. Great care was necessary in the selection of overburnt bricks of good quality. Under-burnt bricks should not be used. Breaking of the brick ballast should be done only after the bricks were inspected and passed by the Engineer-in-charge.

The Los Angeles Abrasion Tests on brick ballasts from various places in the State revealed that good overburnt brick ballast had a value of 40 or less. So a value of 40 had been tentatively fixed as the limit for good ballast. This value could be altered if warranted by the behaviour of the ballast under field conditions. Shri Chaturvedi hoped that the discussion would bring out the practices current in other States.

In Holland, high strength bricks for use in road works were obtained by carefully controlling their manufacture. The grading of the soil used for the bricks was given special attention. The temperature and period of burning were controlled closely. Research with a view to evolve a process for the manufacture of good quality bricks, under conditions obtaining in India, by the roadside was necessary.

The treatment described in the Paper was, in Shri Chaturvedi's opinion, suitable for mitigating dust nuisance on roads passing through built up areas.

Shri N. Mohan Rao said that vitrification resulted in the formation of slag or glass like material which cemented the

* Published at pages 45-89 of the Journal of the Indian Roads Congress, Vol. XIX-1 April 1955.

particles together and rendered the product weather resistant. The temperature at which vitrification began and the temperature range over which it occurred without the material becoming too plastic to retain its shape depended on the nature of impurities. The defects in bricks due to warping, etc., generally attributed to excessive overburning were due to lack of control over the rate of cooling. Sponginess occurred only if the temperature was greater than the vitrification temperature.

The work done in the Building Research Station, Roorkee, revealed that with an increased value of the ratio of active to inactive silica, higher strength could be obtained even at lower temperatures. An admixture of 20 to 40 per cent of pulverised fuel ash, in some cases, was beneficial in reducing the vitrification temperature by nearly 100° C. Such admixtures in bricks, which were placed in the top layers of a kiln, produced vitrification even at the reduced temperature which prevailed in the top layers.

Shri Mohan Rao enquired why first class bricks were classed as inferior to overburnt bricks.

Shri Y. C. Gokhale said that the experience at the Central Road Research Institute showed that the samples received were small and in many cases it was not possible to carry out the Deval attrition test which required 44 lb of 2 to 1½ in. size aggregate. The total quantity of material required at the laboratory was more than 150 lb, from which 44 lb of aggregate of required size could be obtained. Hence, investigations on modifications of the Aggregate Crushing and Aggregate Impact tests which required roughly 8 lb of ½–⅜ in. size aggregate and yielded results comparable to those obtained from the original tests, were on hand. That involved sample of approximately 30 lb only.

The American Society of Testing Materials specified 60 per cent as the limit of the Los Angeles abrasion test value for use in base courses and 40 per cent for the surface courses. There was considerable difference between the load intensities coming on to the aggregates of the water-bound macadam base which was covered, for example, with 4 in. cement concrete surfacing and bituminous surface dressing. The aggregate in the former could be weaker than that in the latter. Assuming that the limits had been specified for the worst conditions, in his opinion, an aggregate giving even 70 per cent abrasion value could be used for water-bound macadam base to be covered with, say, 4 in. cement concrete surfacing. Hence, it was necessary to relate the abrasion values for base course material with the rigidity of the surface course.

In addition to the Deval attrition and the Los Angeles abrasion tests, aggregate crushing and the aggregate impact tests, specified by the British Standards Institution, would have yielded results useful for the research worker.

In his opinion, unconventional shapes and sizes of bricks could be more economically manufactured. Research was necessary to evolve manufacturing of bricks economically.

Shri Gokhale said that research was necessary to evolve new tests for aggregates so as to take into consideration the following aspects in addition to traffic load intensities :

(i) the position of the aggregate in the road structure, viz., base course or surface course ; and

(ii) the nature of the surrounding matrix, viz., hoggin in the case of water-bound macadam, binders in bituminous construction, or cement mortar in concrete constructions.

Appendix 3 of the Paper showed that the second coat of urface dressing was laid over the first after a lapse of about 6 to 4 months. It was not mentioned how the intervening period vas determined. In order to obtain maximum economic life for he surface dressing, it was necessary to find out the optimum ntervening period.

On page 69 of the Paper it was mentioned that on the Aligarh-Kasimpur road 80/100 bitumen was used at the rate of bout 39 lb per 100 sq. ft. for the first coat. The traffic intensity n this road was 700 tons per day. 45 lb of 80/100 bitumen per 00 sq. ft. for the traffic intensity of 5,500 tons per day, which vas about 8 times that on Aligarh-Kasimpur road, was used for he surface dressing work on test track on the Delhi-Mathura road ear the Central Road Research Institute. After two years, his surface dressing was in good condition and had not been provided with a second coat. It was necessary to find the absoute minimum quantity of binder for normal surface dressing work for various traffic intensities and weather conditions.

Shri R. Krishnamachari said that 40 per cent specified by the A.S.T.M. as the limit of Los Angeles abrasion value did not apply to Indian conditions having intensities of traffic of 1,000 tons or less. Tracks using brick metal having different abrasion and attrition values should be laid and observations made with the object of evolving standards suitable for Indian conditions.

Referring to para 10.1 of the Paper, where it was mentioned that 4½ in. was the minimum thickness of brick metal coat to receive surface dressing, Shri Krishnamachari desired to know the basis for the recommendation.

Shri K. Subba Rao mentioned the following as probable additional reasons for the failures described in para 5.1 of the Paper :

(i) absorption of moisture from the subgrade and sides, and

(ii) pockets of inferior or undersized brick ballast.

On the Great Northern Trunk Road in Guntur District, experiment with graded and ungraded metal was tried on a granite metal water-bound macadam in 1938. Within one year signs of deterioration were observed in the reach with graded metal. Ballast should, therefore, be ungraded to avoid pockets of undersized stones.

In his opinion, consolidation specified in the Paper was severe for the soft brick ballast. Traffic should not be allowed after consolidation when the surface was too wet. Final light rolling was desirable when the surface was slightly moist.

Shri K. C. De referred to para 2.3 of the Paper and said that he had found that the adhesion of tar to well burnt and overburnt brick metal mixed together was good. Reidel & Weber Test gave an adhesion number of 5 and carpets laid both with road tar and bitumen side by side, using same quality brick metals, were comparable in performance.

In pratice, 'Bull' type kilns could not produce overburnt bricks from well graded soil. Overburnt hard bricks were produced at temperatures 1080 to 1100° C and that temperature could not be obtained unless reverbaratory type of kilns were used. The details of this type of kilns were given in a Dutch book named "Kliner Wegen."

If a well consolidated water-bound macadam made out of good brick metal was treated with surface dressing in the proper way, after drying up of the macadam and had proper cross slope, it would give good service even under moderately heavy traffic. The surface had to be treated in such a way as to be perfectly waterproof otherwise penetration of water into the base course reduced the life of the road.

It was better to do surface dressings in two coats. In first coat sand and in the second coat chips should be used as

blinding materials. When bigger chips were used in the first coat, waterproofing of the surface was not secured. But use of sand in the first coat ensured a waterproof surface and at the same time sand mat formed served the purpose of cushion in between the bigger metals of the water-bound and the smaller chips of surface dressing in the second coat to resist wear and abrasion of the traffic. Thus the life of the road was greater.

Shri V. B. Manerikar enquired whether premixed asphalt carpet with graded aggregate would not give a stronger, more compact and better watertight surface on the brick ballast water-bound macadam, thus leading to greater durability and load bearing capacity. If a premixed carpet was laid on brick soling 4½ in. thick, ordinary bricks having low abrasive values could be used as they would form the base and not the wearing surface.

Shri J. S. Narasimham said that the Paper was a valuable contribution in regard to the construction of roads with burnt brick aggregates. It was desirable that the construction of such projects should be taken up after investigations in the laboratory the characteristics of the brick aggregates, optimum quantity of the binder required for such aggregates and the quantity of blindage material required for treatment. In this case, however, these pavements were constructed over a period of 10 to 15 years and the research investigation followed the construction. The Author, therefore, attempted to justify the service performance of these road surfaces with the results of some of the tests he had conducted in the laboratory.

In para 2.2 of the Paper, the Author had mentioned that the Los Angeles abrasion tests revealed 38.9 per cent loss of weight for the brick ballast as against a permissible value of 60 per cent. The use of the Los Angeles abrasion test for brick aggregates used as a base coat was questionable. The Los Angeles test was justifiable only for mineral aggregates such as granite, trap, and laterite etc., which were not subject to deterioration in strength due to the absorption of water. Absorption of water reduced the strength of brick aggregates considerably. Hence the Los Angeles abrasion test should be so adopted as to stimulate the field conditions of the pavement. So the brick aggregates should be saturated with that per cent of moisture as obtained in the pavement under the adverse conditions before they were tested.

The Author had used the immersion compression test for determining the affinity of brick aggregates, Table 2, item 3 of

the Paper. That test was suitable only for premixed carpets and was not suitable for paint coat surfaces over brick aggregate pavements. The test suitable to determine the affinity of brick aggregates to the binder was the Nicholson's stripping test.

In para 5.2, the Author had mentioned that in areas where wet brick aggregates were used, patches were formed quickly. Addition of 2 to 3 per cent of limestone dust to the brick aggregates would prevent stripping off of the binder in the presence of moisture.

Road surfaces failed mainly due to the use of excess quantity of binder. There was always an optimum limit for any one set of conditions whether it was premixed carpet or paint coat surfaces. The determination of this optimum quantity combined with a suitable type of stability test was absolutely essential before the quantity of binder and the quantity of blindage material were fixed.

Shri C. J. Fielder said that the Paper, in his opinion, was particularly welcome since it incorporated the results of laboratory research and full-scale road construction. The only satisfactory way to advance knowledge of the best methods of road construction and develop new techniques on sound practical lines was by the co-ordination of research in well equipped laboratories with full-scale road construction carried out under controlled conditions. It was necessary that subsequent performance be regularly observed and results recorded in a standardized manner. It was only by such means that results of practical value could be obtained. For this reason he considered the Paper had an important significance and hoped it would be the precursor of other similar Papers to be read before the Congress in the future.

He drew attention to the section dealing with the economics of the various types of treatment under discussion and the figures given in para 11.1, Table 5. These assumed that in the case of black-topped surfacing the water-bound surface should be renewed to a depth of 3½ in. after a period of 15 years. In his experience, if regular and efficient maintenance by resurfacing was provided, the water-bound macadam could normally be protected indefinitely and no such renewal need be budgeted for. In certain instances, traffic conditions might develop which rendered surface dressing no longer adequate to carry the enhanced load. This would necessitate imposing premix macadam on the existing surface, but this would not affect the deductions to be drawn under normal circumstances of roads continuing under surface dressing over water-bound macadam.

Shri M. S. Bisht drew attention to the fact that about 400 miles of modernised roads with brick ballast were in use in Uttar Pradesh. The traffic intensity on some of these roads was nearly 2,000 tons per day.

There was a general feeling that brick ballast could not stand the abrasion and attrition of road traffic. The Paper had shown that brick yielded satisfactory results. Experiments to produce better bricks suitable for road works were in progress in Uttar Pradesh.

Shri K. K. Nambiar said that the calculations of comparative costs of different surfacings were made on the assumption that kankar macadam surface could not be surface dressed with bitumen. The assumption on page 59 of the Paper that kankar macadam required renewal once every three years showed that the kankar was of a hard variety. In that case, it would be economical to surface dress it with bitumen, using hard granite chips for the dressing.

Col. S. K. Bose said that the nature of clay from which the brick ballast was made was very important. For example, greater amount of binder might be required to treat ballast made of montmorillonite clay than if the bricks were made of illite clay. Laboratory investigation with a view to reduce the extra 10 per cent binder required for brick metal followed by trials in the field was necessary.

Shri S. L. Kumar observed that the recommendation, put forward by the Author, that overburnt brick ballast could be used successfully as road metal in water-bound macadam where stone metal was scarce or very expensive, applied equally for reinforced concrete work. The reinforced concrete construction engineer had also to be content with brick aggregate for similar reasons. In addition, he had to make sure that salts in the brick aggregates had no deleterious effect on the reinforcement, such as corrosion, or caused damage to the structure by swelling etc.

Shri Kumar was not in favour of having bricks or clay ballast burnt for obtaining the overburnt brick metal as such a procedure proved more expensive and the metal was less satisfactory in quality. The best arrangement was to collect all overburnt bricks at various kilns in the neighbourhood of the work and have them broken to ballast of the required size.

In his opinion, overburnt bricks were preferable because when clay was burnt at a high temperature in the neighbourhood

of 1000° C., the deleterious effects which could be caused by clay minerals such as montmorrilonite were eliminated.

The Author's presentation of data on various test lengths, Appendix 3 of the Paper, suffered from several drawbacks and deficiencies, e.g., in column 8 he gave the maximum traffic intensity correct to the first digit. That gave an impression that the figures were as accurate as to vary for example between 623 and 625.

In the remarks column, the condition of the road was given. Unfortunately, the time of inspection on which these remarks were based was not given.

Again, in several test lengths on the Grand Trunk Road in Etawah District, vide item 3, the second coat of the wearing surface was not laid. The reasons for the omission were not convincing. The omission might adversely affect the useful life of the road. The quantities of materials required for the second coat were about half of that required for the first. So, it was far more economical to provide a second coat and increase the useful life. A well constructed black-topped road could be maintained indefinitely if the wearing part was renewed at certain specified intervals and the berms on the sides were maintained properly to give adequate support to the road bed.

It was mentioned on page 84 of the Paper that re-painting should be done when a mosaic surface appeared. Repainting on 'condition' basis was not conducive to getting a long life for the surface. Repainting on a 'programme' basis, a little earlier than the end of useful life, irrespective of the condition, increased the life. Therefore, in his opinion, repainting should be done a little before the mosaic condition of the road surface developed.

The comparative study of economy in Section 11 of the Paper was based on assumed figures of cost of maintenance, estimates of the useful life of the road bed and the period of renewal. Since experience with brick metal roads had not been spread over a long period, such as thirty or forty years, the assumed figures, in his opinion, had no basis. If one were to change the figures, the whole picture which the calculations and graphs presented got changed and conclusions drawn became valueless.

The Author's method of economic comparison was cumbersome. Shri Kumar suggested that such comparisons should be

based on the figures of annual cost of service (A) of a mile of road. These are based on the fundamental formula :

$$A = I + D + M$$

where A = Annual cost of service for a mile of the road

I = Interest charges at 3 per cent

D = Depreciation charges

$$= \frac{r(c-s)}{(1+r)^{n-1}}$$ where c = first cost, s = scrap value, r = rate of interest, and n = useful age in years.

M = Maintenance cost.

Shri Fateh Chand welcomed the Paper specially because the use of brick metal could reduce the cost of road by about half in places where stone had to be conveyed over long hauls.

Disagreeing with the Author on the point that there was no difference in efficiency and life of water-bound brick and stone ballast surface painted road, Shri Fateh Chand said that in a municipal area a water-bound macadam with brick metal gave way in three months and in six months the road was in a hopeless condition. It was very important that traffic conditions should be ascertained before adopting brick ballast. In his experience, slow-moving traffic, particularly iron-tyred traffic, 500 tons or even 200 tons of traffic caused greater damage to road than 1,000 tons of pneumatic-tyred traffic. The nature of the traffic and not the total tonnage was the most important aspect to be considered. The crushing strength of brick was much less than that of stone. So, when a heavy vehicle with narrow iron-tyred wheels came over it and moved slowly, not only the surface but also the upper crust got crushed.

In his opinion, extra quantities of grit and binder, as suggested by the Author, were not required. Only a little extra quantity was required in the first coat because of absorption. Tar could be used as successfully as bitumen.

Shri G. D. Joglekar* referred to the recommendation that 60 per cent of hand broken and 40 per cent crusher broken material should be mixed and wished to know the basis of the recommendation.

* This and the following comments were received in writing.

Shri P. N. Srivastava stated failures of brick ballast surface dressed roads had, in some cases, been caused by bad drainage. Water collecting in depressions due to defective consolidation or subsequent settlement caused more damage to brick ballast surfaces than to stone ballast surfaces. The reason was that brick ballast absorbed more moisture, resulting in loss of adhesion.

Because brick ballast was softer than stone, it got crushed under the thin surface dressing, and when bitumen got brittle in winter the surface broke. Also, failures occurred by seepage water getting in between the paint coat and the brick ballast, resulting in thin surface getting peeled out. Proper and timely maintenance was very vital for the brick ballast painted surfaces.

On page 55 of the Paper the Author had mentioned the various ways of burning brick ballast. In 1946, he had tried burning of irregular small clay balls for work on Saharanpur-Muzaffarnagar road with the idea of reducing the cost of moulding of bricks and the cost of breaking baked bricks into ballast. It was found that :

(i) burning was not very good; the ballast developed cracks ;

(ii) more coal was consumed in burning ;

(iii) during consolidation, the ballast crushed very badly even under a very light roller ; and

(iv) interlocking action of angular pieces was lost.

He was of opinion that the conventional method of obtaining overburnt bricks from Bull type kilns and breaking them into ballast was the only cheap method of getting suitable ballast and there was no short cut.

Comparison given for 30-year costs in Table 5 and Plate II of the Paper was not realistic. Maintenance cost of painted water-bound brick ballast was more under fairly heavy traffic. In addition, there was " creep " in the wearing coat of a water-bound brick ballast painted surface. Due to the ' creep ', undulations developed on the top and the riding surface became uneven. Prevention of these undulations required quicker renewal of wearing surface. Hence, for a black top surface painted over brick ballast, renewals should be made in 10 to 12 years and not 15 years as assumed by the Author.

Shri Basant Singh observed that the use of stone metal was expensive and, in fact, prohibitive where long hauls were involved. So, development of alternative materials was welcome.

The non-satisfactory adhesion of binder to moist brick ballast, mentioned in para 5.2 on page 53 of the Paper, had been got over by developing the "built-up-spray grout specification" given below.

This specification advocated the use of skin dry moist brick ballast before first coat of tar was sprayed. Bajri was spread over it and consolidated in accordance with the specification for water-bound with some limitations.

The built-up-spray grout method was applicable for the consolidation of both brick and stone metal wearing surfaces. In the Lahore Corporation, on account of heavier traffic intensities thicker coats of wearing surface were designed and laid with very good results. The quantities of materials ranged from 54 lb of binder in three sprays and 6½ cu. ft. of bajri per 100 sq. ft. laid in 4 or 5 coats.

Another method employed in the Punjab was to replace the stone wearing surface by grooved bricks with 1½ in. thick premixed sheet over the usual brick soling in short lengths as an experimental measure. Up to about a year after laying these grooved bricks, experiments showed no defects when the partition of the State took place.

Built-up-spray grout specification employed on Muzaffargarh-Alipur-Pajnad Road in Multan Provincial Division for the consolidation of brick metal.

Over brick soling and between mud walls (dowlies) spread a layer of 1 in. good clay. Over this clay spread 90 per cent of the brick metal by spinning basket method in such a manner that the brick metal from the lower portion of the stack (which is usually) dirty) was spread first and the neat brick metal from the top portion of the stack came on the surface. The use of the spinning basket method ensured uniform spreading against the usual defective dumping of metal in basket heaps which led to lot of patches and potholes later. Roll dry starting from the sides, remove unevenness of the surface by adding the 10 per cent reserve of the neat brick metal kept for the purpose.

As soon as the surface was correct to the template and the brick metal was fairly interlocked (precaution being taken to avoid excessive rolling) spray water, so that the top surface got fairly moist. A stirrup pump was found very useful for the purpose. Allow the surface to air and as soon as it was skin dry, spray tar No. 3 at the rate of 22 lb per 100 sq. ft. and cover with 3½ cu. ft. of bajri ½–¾ in. gauge per 100 sq. ft., spread in two

grades ½–¾ in., 70 per cent, rolled and followed by ¼–½ in. gauge, 30 per cent. Dry roll lightly till the bajri was well pressed.

Add water and consolidate as water-bound. Rolling should be stopped when the clay from bottom had risen up to just about ¾ in. from the surface.

Next day, make up the inequalities if any in the surface with premixed bajri and seal the surface with two coats of binder (Tar No. 3 or bitumen of suitable grade) and bajri using the following quantities :

	Binder lb per 100 sq. ft.	Bajri per 100 sq. ft. in. cu. ft.
II coat	18	2¼ (¼ to ⅜ in. gauge)
III coat to follow the second coat the same day.		
	20	1¼ to 1½ (⅛–¼ in. gauge).

No traffic was allowed on the finished road for about a week by which time the berms etc. were completed and the road and its adjoining land was neatly cleaned and given the final finishing touches.

When the traffic was first let on the road, precaution was taken that first of all only the pneumatic-tyred traffic was allowed to come on it and the traffic was so regulated with the help of the empty tar drums that the traffic traversed uniformly over the road surface and was not allowed to stick to particular tracks. Experience showed that with reasonable amount of traffic this precaution of allowing only pneumatic-tyred traffic was necessary for about two to three days, after which all the traffic was allowed.

Note 1. In the built-up-spray grout method above described, it was found that for the first grout coat before adding water and consolidating as water-bound macadam, use of tar had been advocated. Bitumen emulsions also gave good results but it required a heavier coat of at least 40 lb per 100 cu. ft. before it could really serve the purpose.

The two sealing coats on top could be done with tar or bitumen.

Note 2. In this specification, trolly sprayers with wide wheels had been found to be much more useful than the usual tank sprayers.

Shri C. G. Swaminathan stated that a study of the effect of tar impregnation on brick at the Central Road Research Institute showed very clearly that the compressive strength of a brick was considerably increased after treatment with tar. Sometimes there was an increase of 200 per cent in strength, and as the values were so erratic it was not possible to give an exact interpretation as to the reason or a basis for the increase. All these went to prove that the exact nature regarding the structure of brick and its relationship with strength was not very clear and that the problem of studying the behaviour of brick metal treated with a binder should be viewed from different angles other than the usual view points such as compressive strength, crushing strength, etc.

The Author had said that the quantity of binder required for surface dressing over brick ballast was about 10 per cent more than that required for use over stone ballast. Perhaps this quantity could be decreased if lower porosity bricks were used for the base.

The use of additives which had been developed abroad might increase the adhesion of the binder to brick ballast. From the laboratory analysis the Author had found that brick ballast had better affinity to bitumen than to tar, but field reports did not support this.

Shri D. C. Chaturvedi (Author) felt happy because the Paper had aroused considerable interest.

Shri N. Mohan Rao had enquired why first class bricks should be categorised as inferior material. The answer was that brick ballast from such bricks had not given good results both in the laboratory as well as in the field.

The Author agreed with Shri Mohan Rao that admixtures reduced the vitrification temperature, and was a useful method of getting large number of good quality bricks. The addition of pulverised fuel might lead to low strength product. However, investigations in the laboratory were called for.

Referring to the modification of the Aggregate Crushing Test, mentioned by **Shri Y. C. Gokhale**, the Author said that the size of aggregate sometimes influenced the results obtained in Los Angeles Test, and this aspect deserved consideration while devising modified test.

Regarding limits of abrasion values for aggregates forming water-bound macadam bases under different types of surfacing, Shri Chaturvedi felt that field studies should be carried out with different types of surfacings. He thought that 70 per cent for

abrasion value for the base course of a 4-in. cement concrete pavement was high. Results of Deval attrition test were reported in the Paper because in 1938 when the tests were made, the aggregate crushing and impact tests were not standardised.

Attempts were made in the past to produce brick metal from small bricks as mentioned in the Paper, but these were not successful. However, further experiments were necessary to produce good type of metal at roadside at low cost.

He agreed that new tests should be evolved which took into consideration all the factors which came into play under field conditions. Petrographic studies should also be carried out side by side with the physical tests as physical tests sometimes did not give a true picture of the behaviour in field.

Regarding period intervening between the first and second coats of surface dressing, the Author referred the page 84 of the Paper where it was mentioned that period between the two coats should not be less than three months and might extend to six or more if traffic was light. In practice, however, this period was sometimes more due to many factors like availability of funds, materials, etc. The optimum intervening period depended upon traffic intensity, type of material used, etc.

Shri Krishnamachari had said that the maximum of 40 per cent for the abrasion action did not apply to Indian conditions. This value had been tentatively fixed. In India, both the iron-tyred and pneumatic-tyred traffic used roads and, in his opinion, the value of 40 per cent was not high.

Agreeing with Shri Krishnamachari that test length using various types of brick metal should be laid and their behaviour observed, the Author said that the value of 40 could be revised if observations showed that it was necessary.

The minimum thickness of 4½ in. of brick metal had been specified so that the consolidated thickness was about 3 inches. It was not safe to provide thickness smaller than 3 inches.

Shri K. Subba Rao had given certain reasons for failures. There was little probability of water absorption from subgrade as brick ballast was generally consolidated on existing road which was not liable to become wet from below. Absorption from sides could be prevented by providing good drainage and edging.

Shri K. C. De had mentioned that he had found good adhesion of tar to brick metal by Reidel Weber Test. That might be due to the different mineralogical composition of soils

from which bricks were made. The field reports, however, had indicated that adhesion with tar was satisfactory in many cases.

Difficulty of getting overburnt brick metal in large quantities was there. Special types of kilns had to be divised to overburn bricks in large quantities.

Shri De had suggested the use of sand in the first coat and chips for the second coat in surface dressing in order to make the surface waterproof and to prolong its life. These specifications could be further tried in the field and behaviour of surface observed.

Shri Manerikar had enquired whether use of premix carpet over brick ballast had been tried. So far this type had not been tried.

Use of premix carpet over 4½ in. thick brick soling was also suggested by Shri Manerikar. This might be successful if bricks used in the soling were of very high quality as intensity of load from vehicles would be high in such cases. Use of ordinary brick might not prove successful. Some experiments on brick trackways were carried out on Delhi-Meerut Road, details of which were published in Indian Roads Congress Journal Vol. XIV-3, December, 1949. These results pointed out the possibilities of using bricks for highway construction. As mentioned in the introductory remarks, high quality bricks were used for pavements in Holland. In the U. S. A., bituminous filled vitrified bricks were used. Experiments should be done on this type of surfaces in India in order to reduce the cost of construction and to promote the use of local material.

Shri J. S. Narasimham had stated that the Paper justified the service performance of brick metal road surfaces by means of laboratory test. This was not the case. As already indicated in the Paper, attrition and adhesion tests were carried as far back as 1938 in Alipur Test House.

Results of tests using Los Angeles abrasion machine, carried out subsequently, were given in the Paper in order to show that the results were good with this type of test.

Shri Narasimham also had suggested that wet brick ballast should be tested in the Los Angeles machine in order to obtain real picture of its behaviour. In Los Angeles Abrsaion tests, use of water was not specified while in Deval type attrition tester, wet test was done. However, the suggestion was worth considering and it would be interesting to see the percentage loss in brick ballast when water was added to it.

Immersion-Compression tests were done on different aggregates in use in Uttar Pradesh as part of investigations on adhesion of binders with aggregates by different methods, and a Paper on this had been published in Indian Standards Institution Bulletin. Overburnt brick ballast was also included in these tests in order to get a comparative idea of the behaviour of brick ballast as compared to stones generally used. It was agreed that this type of test was suitable for premix carpets. Nicholson Stripping Test had not been carried out.

Shri Narasimham had suggested the addition of 2 to 3 per cent of limestone dust to brick aggregate to prevent stripping off of the binder in the presence of moisture. Agents such as lime, cement, were useful in increasing the adhesion of binders to wet aggregate.

The quantity of binder and grit specified to be used in water-bound macadam surfaces was based on experience in the field. Minimum thickness of brick ballast had also been fixed as a result of experience. The usual specifications in Uttar Pradesh were first coat painting with tar, followed by bitumen second coat, although different combination had been used.

The Author agreed with **Shri C. J. Fielder** who had stated that in calculation of total cost of surfaces renewal of surface had been assumed at an interval of 15 years, while if efficient and regular maintenance was done, renewals were not necessary. It was, however, intended to show that the cost would be under worst conditions.

The Author was very thankful to **Shri M. S. Bisht** for answering some of the points raised by some speakers.

Shri K. K. Nambiar had stated that kankar surface could be provided with a bituminous coat, provided kankar metal was of hard variety. But kankar of good quality was not easily available in Uttar Pradesh. There should be no hesitation in surface dressing a kankar water-bound macadam.

Col. Bose had enquired about type of clay used in manufacturing bricks. The information was not available. Investigations suggested by Col. Bose were worthwhile undertaking.

Shri S. L. Kumar had said that repainting should be done at regular intervals instead of on 'condition' basis as given in specifications. The Author drew attention to para 10.8 of the Paper where it was stated that due to several coats of paint at comparatively short intervals or repaint before there had been any reduction in thickness of existing coat or coats should be avoided to prevent formation of waviness. Shri Chaturvedi

agreed with Shri Kumar that surface should be observed regularly and the need for repaint decided and funds arranged well before the top coat was worn out.

Comparison of costs had been made on the basis of total cost calculated for a specified period (30 years) which included cost of initial construction, annual maintenance, periodical repainting and renewal, and followed the method given in the Paper " Economics of Highway Types " by K. S. Raghavachary. Kankar surface was included in the comparison as it was a common type of surface which required renewal frequently and because brick ballast was generally consolidated on such surfaces.

The assumption made in the calculations were mostly based on experience. The costs of construction, maintenance, repainting and renewal were based on present day rates. The period of repainting and renewal had been assumed as the same for both brick ballast and stone metal surfaces. The formula suggested by Shri Kumar could also be used but for depreciation we had to assume some scrap value.

Shri Chaturvedi agreed with **Shri Fateh Chand** that surface dressing over stone ballast could be cheaper than on kankar surface under some conditions. Also, surface dressing over brick ballast might not prove very successful where iron-tyred traffic was very heavy. But for fairly heavy traffic, the treatment was successful.

The conclusion that more grit and binder were required for first and second coat over brick ballast surface was based on experience in the field.

Shri Joglekar had asked why 60 per cent hand broken grit was recommended to be used. As mentioned in para 10.9 of the Paper, the suggestion was based on experience gained on this type of work. The ballast from the crusher got rounded and hence the use of these shortened the life of the surface. This, however, needed more experimentation.

As mentioned by **Shri Srivastava**, promptness in maintenance was essential. Once the brick ballast surface got exposed due to wearing out of the surface coat, the underlying brick ballast got crushed under the traffic giving rise to potholes. It was, therefore, important that patch repairs were done as soon as slight stripping or cracking of surface dressing occurred. For the same reason, repainting of the surface should be carried out well in time to avoid damage to the surface. During rainy season, patch repairs should be done by wet aggregate process by using lime or any other suitable agent.

Traffic should be distributed over the whole of the surface. If the traffic concentrated on strips, ruts which accumulated water and caused further damage were formed.

The edges of the painted macadam should be well protected by edging as described in the specifications. The withering away of exposed brick ballast edges was very quick.

Better drainage of berms and roadside pattries was also important. The brick ballast should neither be exposed to moisture nor to traffic.

Shri Srivastava had raised some points about the total cost of various surfaces. Even if the renewal period of brick ballast painted surface was 10 years instead of 15 years, as assumed in the calculations, the total cost of brick ballast water-bound painted surface on 30 years basis would be about Rs 2,87,600 instead of Rs 2,62,300 based on 15 years renewal period. Even then it was less than the cost of stone painted surface which was Rs 2,95,100.

Precautions necessary to avoid formation of waviness had been stated in para 10.8 of the Paper. Several coats of paint at comparatively short intervals or repaint before there had been any appreciable reduction in thickness of existing coat by action of traffic led to waviness. Excess of bitumen or tar and insufficient amount of grit also resulted in a soft pliable coating. If, therefore, formation of waviness was avoided, the renewal might not be required after 10-12 years and might be necessary say after 15 years.

The Author was thankful to **Shri Basant Singh** for his comments specially for giving specifications for built-up-spray grout employed on Muzaffarnagar-Alipur-Pajnad road for the consolidation of brick metal. This was very useful information. As moist brick ballast could be successfully treated in these specifications, it would be better if these specifications were tried in other States also.

Experiment should also be tried on grooved bricks as mentioned by Shri Basant Singh.

Shri Swaminathan had enquired about the basis on which different types of bricks were classified. In the field it was generally done by appearance. This might not be satisfactory and the best way was to get the brick ballast samples tested before being used. Abrasion test was not the only criterion. Other tests like aggregate crushing test or impact test should also be carried out and those brick ballasts which possessed good toughness and abrasion should only be used.

Shri P. L. Verma (Chairman) winding up the discussions observed that Uttar Pradesh had been following in the past the policy of providing high quality road pavements in contrast to the policy of providing large milage of roads at the same cost followed in the Punjab. It was satisfactory to note that with increase in the demand for larger milage a reversal of policy had taken place. The present Paper was indicative of the distinct departure from Uttar Pradesh Government's original road construction policy.

He stated that the first step should be to improve the compressive strength of burnt bricks. It was not possible to find overburnt brick ballast in areas where road construction programmes were sponsored as a by-product since in such areas buildings construction would practically be absent. We cannot possibly use overburnt brick ballast on road construction unless we produce it for this very purpose. Bull's kilns which was the standard brick manufacturing practice in the country produced brick for building construction and could be adopted easily to produce overburnt bricks. Temperature in the vertical section of the kiln could be measured and adjusted. The stack heights could be varied. By varying the quantity of coal used for burning and various controls mentioned above, it was possible to produce a high grade fused material than at present. In Chandigarh, experiments on a small scale were made but with the object of producing different coloured and varied texture bricks for building construction. If research were carried out on these lines the ordinary process for brick burning used all over India, could be easily adapted for producing brick ballast of high compression strength.

Brick surkhi dust formed by the crushing of brick ballast absorbed moisture very quickly and deterioration of water-bound macadam road occurred soon after. So with a view to reduce attrition, the method and specifications suggested by Shri Basant Singh, were evolved in the Punjab. These specifications had the added advantage of stabilising the earth used with oils from the tar or bitumen. A stabilised earth binder was interlocked. It was not only the interlocking of the aggregate but also the binding produced by stabilised clay in the body of the pavement that gave stability. Roads built to these specifications had lasted for 8 to 10 years in the Punjab without any difficulties having been encountered in maintenance and have carried heavier traffic than the ones mentioned by the Author.

Addition of lime or even kankar lime (which can be produced at site) will go a long way in stabilising the puzzolanic content of

the pavement produced by the grinding down of the bricks. Experiments on this aspect was worth a trial. He also suggested that where crushable materials like brick ballast was used it would be of advantage to use vibrating rollers of lesser tonnage than the Author had used. The result would be as dense a pavement but without a large quantity of crushed ballast. Adhesion between aggregate and tar or bitumen was a controversial subject, the results as given in the Paper might not be reproduceable. In the Punjab asphalts had been used with the primer and tar without primer. The results in both cases had been extremely satisfactory.

He congratulated the Author for kindling the otherwise decadent interest in the material (brick) all over India.

Discussion on Paper No. 173*

"Construction of a Submersible Bridge Across River Mahanadi Near Bhanjanagar (Ganjam) in Orissa"

By

E. V. S. IYER AND D. C. PANDA

Monday, June 20, 1955

Shri C. M. Bennett (Chairman) calling upon the Authors to introduce the Paper said that Shri E. V. S. Iyer was responsible for the design and Shri D. C. Panda was in charge of the construction work.

Shri E. V. S. Iyer, in introducing the Paper, observed that it was necessary to study the conditions at site before deciding upon departmental execution of work. Within three miles of the site of the bridge numerous bullock carts for the transport of materials and skilled and unskilled labour were available, making departmental execution easy and cheap. Where such favourable conditions did not exist, contractors generally quoted very high rates. Also, departmental execution might be costlier than in this bridge.

The current practice was to entrust major bridge works to specialist firms for execution according to their designs. Serious consideration should be given, he thought, to setting up an organization in each State for design and execution departmentally of major bridge works. Large dam projects and some railway bridges were executed departmentally.

The Indian Roads Congress Bridge Code dealt only with the conditions in respect of duration of interruption to traffic under which a submersible bridge could be constructed. It was necessary that a Code of Practice for submersible bridges, giving among other things the following, should be drawn up:

1. Rules fixing the deck level.
2. The conditions under which low level or high level causeways should be provided.
3. Rules for calculating the scour depth.

* Published at pages 91 to 109 of the Journal of the Indian Roads Congress, Volume XIX-1, April 1955.

4. The classification of the road on which submersible bridges were to be constructed.

Recently he had designed submersible bridges with timber or reinforced concrete piles. Even green timber piles when driven below the sub-soil water level were durable. In his opinion, such a type of construction had a great scope.

Shri R. P. Chanda observed that departmental works were economical only when the following conditions were fulfiled:

(1) Adequate stores, tools, implements and accessories were readily available in departmental stock.

(2) Skilled key workers were retained on a permanent basis by the department.

(3) Continuity of departmental work (otherwise organizations set up for one work brokeup after it was completed).

Shri R. P. Chanda said that information on the following points would have enhanced the value of the Paper:

(1) How the labour contract was selected, how their rates were settled, and whether the departmental rules for selection of contractors were followed.

(2) If for any item of work both muster roll labour and contract labour (separately) were employed, how did the rates compare.

Shri M. P. Apte felt that the choice of a submersible bridge was not a suitable one for the following reasons.

1. The load coming on each pier was hardly 50 tons. The total area of the concrete in the raft foundations and the apron was 1,816 sq. ft. and the raft had an average thickness of 2 ft 9 in. Thus the foundations provided were more expensive than those required for a high level bridge.

2. It was observed from Plate I of the Paper that open excavation was done for eleven feet below the ground and piles and boulder talus encased in wire netting were provided to protect the foundations from scour. With the provision of these it was not clear how the foundations for a high level bridge were costlier.

3. The piers for the high level bridge would not have been much expensive because the difference in the O. F. L. and H. F. L. was hardly 3.25 feet.

4. For a high level bridge, beams and slab of the balanced cantilever type would have effected a saving of about 25 per cent in the quantity of concrete.

Shri Apte wanted to know if there were any special reasons for providing an expansion joint of 1 in. for the short span of 15 feet.

While he was glad that the departmental execution of the work had given the staff an idea of the difficulties faced by contractors during execution of works, he did not agree with the Authors that departmental execution was the best method of training.

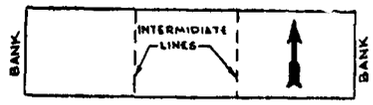
Referring to the details of the staff employed in the work, given in para 5.3 of the Paper, the average expenditure on establishment reckoned for the period of 13 months, February 1953 to March 1954, worked to an average of Rs 60 only. Shri Apte thought that an undue attempt to show that the establishment charges were low was made by the Author.

The rates of labour for 1 : 4 : 7 cement concrete and random rubble masonry including conveyance of rubble were Rs 7 and Rs 13 respectively. Such low rates were possible only when labour was paid very poor wages, not exceeding annas eight per day.

Shri K. F. Antia remarked that it was advantageous to combine a road bridge with an irrigation structure such as a weir, specially so because the bridge was in a Community Project area. In his opinion, a structure with pile foundations and prestressed concrete girders was cheaper. Pile foundations had many advantages and serious consideration should be given to this type of foundations. The Railways did departmental work where reconstruction or repairs had to be carried out within a stipulated time. In such cases, time and not the cost was the governing factor. Work done departmentally was not always cheaper than contract work.

Shri Antia pleaded for the establishment of a central plant pool as such a pool was a fundamental requirement for the construction of large bridges and as no individual authority could purchase them.

Shri S. Pal said that in West Bengal, where the rivers generally had sandy beds, some of the lesser major bridges were founded on rafts using sheet piles. Interlocked sheet piling was driven on the upstream and downstream sides and paralled to the bank. Where the width of the river was large, intermediate continuous sheet piling was adopted to confine the sand in separate compartment.



The tops of the sheet piling were encased in a continuous R. C. band. An R. C. raft anchored to the R. C. band was laid over the confined sand. Thin R. C. piers and deck slab designed as a rigid box were constructed over the raft. The cost of such bridges worked out to be less than bridges with well foundations by about one-third. In his opinion, the cost of such high level bridges would compare very favourably with that of the bridges of the type described in the Paper.

Shri Nivan Kurian remarked that in submersible bridges silting of the bed and erosion of the banks were common features, and wanted to know if account of this had been taken in the design.

Shri M. D. Menon remarked that for flooded structures, the following precautions were desirable :

1. The floor should be kept at some depth below the low bed level to prevent the floor acting as a weir when retrogression of levels took place.

The downstream apron should be calculated for $1\frac{1}{2}\ D$ where D was the maximum depth of scour for the maximum discharge.

For submersible bridges, sandy strata for a considerable depth was not a favourable condition. Rock or stiff clay was better.

The maximum high flood level was not given in the Paper. The scour depths for design should be calculated for the maximum high flood discharge.

In the appendix giving the calculations, the scour depth for piers and abutments were worked out separately. It was not clear why this was necessary.

Submersible bridges and weirs were not similar. The cut-off in submersible bridges was less and uplift pressures etc. had to be based on the cut-off.

The length of the floor was calculated using Bligh's formula whereas pressures were calculated by Khosla's formula. It was

rational to apply the latter for both the calculations, adopting a suitable exit gradient.

Shri Fateh Chand said that he had constructed causeways at a cost of Rs 125 per foot run. These causeways had a 4½ in. thick reinforced brick floor with light reinforcement. For railings, rolled steel joists at 10 to 15 ft centres connected by angle irons were used. In some cases, 2 ft thick cement concrete block in downstream apron was required to prevent scour.

Shri G. D. Joglekar* stated that he had provided cement concrete guard stones for a submersible bridge. Many of them were washed away due to floating trees and had to be renewed after every flood. Was there any such necessity in this bridge ?

A camber of 1 in 120 for the wearing coat was on the low side.

Shri P. N. Srivastava mentioned that a box type structure might have been economical. The thickness of the R. C. slab and the R. C. piers would be less and contribute to reduced cost. In Uttar Pradesh there were proposals to construct hollow piers with 6 in. thick R. C. shells and fill the hollow space with boulders.

Shri T. Krishnamurthi observed that the presence of stiff clay 10 to 15 ft below the bed suggested that larger spans with independent footings were cheaper.

Bligh's theory of creep had been replaced by later methods. So the Authors' preference to that method was not clear even though the exit gradient was checked by the Central Board of Irrigation method.

The effect of contraction due to the construction of the bridge was not considered in the scour calculations.

The calculated critical velocity was 2.8 ft per second while, under normal flood conditions, the velocity upstream, calculated by the Mannings formula, was 5 ft per second. In view of the large difference between the two it was not clear why the top of the raft was not kept below the bed level, particularly when the bed was sandy.

Rounding the end faces of the slab and a one-way camber or the roadway increased the coefficient of discharge of the deck.

The necessity for filling in the entire depth of 20 in. between the slabs was not clear. The provision of expansion joints at 7 ft centres was rather on the high side.

* This and subsequent comments were received in writing.

Mention of the low water level was necessary as that gave an idea of the difficulties of construction of the cut-offs.

The inconvenience caused by the barrel shaped floor was not sufficient, in his opinion, to dispense with timber centring. The erection and striking of the timber centring was cheaper than that adopted by the Author.

Submersible bridges were, generally, subject to peculiar forces which differed with the characteristics of the river. It was, therefore, essential that studies of the scale models of the river and the structure and laboratory analysis of the bed material were undertaken.

Shri J. T. Mehta mentioned that a slope for the deck keeping the upstream side 2 in. higher than the downstream side was hydraulically better. He enquired if the barrel of the vents had been given a slope towards the downstream side.

It would have been better to drive the piles at the downstream end of the cut-off wall keeping their tops at the bottom of the cut-off wall.

The weight of the slab, allowing for loss of weight due to floatation, worked out to 145 lb per sq. ft. as against 112 lb per sq. ft. of uplift. Since the spans were freely supported, anchoring of the slabs was necessary.

Resistance to flow was very much reduced if the upstream face of the slab were made triangular in section and the bottom edge rounded.

Shri B. G. Naik observed that the cost of Rs 500 per foot run was on the high side for this type of low level bridge. That was due, in his opinion, to the costly raft foundation with inverted arches. Piled foundations with 20 ft spans would have been cheaper specially as the depth of scour was not more than 20 ft and 10 to 15 ft of coarse sand overlay stiff clay.

In submersible bridges the increased velocity caused by the restricted waterway generally developed scour on the upstream side. With a provision of 34 ft length of apron on the downstream side, the timber piling on the upstream side served better than on the downstream side.

Provision of guard stones alone did not afford adequate protection to the mixed traffic of bullock carts. Many accidents had occurred to bullock carts even when guard stores were provided. For two-lane bridges, therefore, provision of some sort of collapsible railings should be compulsory. If such a

provision was not possible, he suggested that such bridges should be designed as single lane bridges and should be closed to motor traffic when bullock carts used the bridge.

Expansion joints 1 in. thick filled with tar and sand were provided between the deck slabs. Such joints generally did not serve the required purpose because if a corresponding gap was not kept in the wearing coat, cracks develop in the latter. It was advisable to have only an expansion gap between the deck slabs and stagger the joint of wearing coat just above it by providing angle and cleat arrangement.

Shri D. N. Khurana remarked that the coefficient 563 in the Ryve's formula used in the discharge calculations gave a low discharge. Dickens formula with a value of 1,400 for C was applicable to the Mahanadi basin and Orissa State where rainfall intensities were similar to that in Madhya Pradesh.

In his opinion the 1 : 4 : 7 mix used for the raft was poor. The raft acted as a continuous beam loaded uniformly from below. For wider spans, it was necessary to reinforce the raft.

Shri E. V. S. Iyer, (Author) in reply to the discussion, said that many speakers had said that a high level bridge was cheaper specially because the difference between the ordinary and high flood levels was small. As stated in the Paper, a high level bridge necessitated the construction of double banking 6 miles long to pass the discharge. The high flood bank submerged costly fertile lands. These factors influence the selection of a submersible bridge.

Shri Menon said that Bligh's theory was obsolete. The difference in the values calculated by Bligh's theory and that of lane, an American authority, was very little. The Author agreed with **Shri Chanda** that departmental work could be efficiently carried out only if good equipment were available and continuity of work assured. In the construction of the Mahanadi Bridge, however, no difficulties were experienced for want of equipment.

The departmental rules did contribute to delays in the execution of works. The procedure adopted in this work was that departmental labour on muster rolls was engaged for excavation of trenches for cut-offs. Payment to piece workers for metal collected at the quarries was made and the transport to the site of work was by departmental trucks or bullock carts paid departmentally. Local labour was engaged for items such as mixing concrete and laying in foundations etc. on "task work" basis.

Referring to **Shri Apte's** remarks that the foundations adopted were costly, the Author said that, in his opinion, the raft foundation was cheaper. It minimised pumping.

Misunderstanding arose in respect of establishment charges because the Paper was published in an abstract form. There were other methods for training young engineers and departmental work was one of them.

Shri Antia's suggestion that road bridges should be combined with irrigation works was a sound one and deserved careful consideration by the authorities concerned.

Answering **Shri Krishnamurthi's** remark that the scour depth should have been calculated for the maximum discharge. Shri Iyer said that in submersible bridges the critical condition was when the flood water was just about to overtop the structure. Under high flood conditions due to submergence of the structure the velocity through the vents was not higher than in the upstream side and consequently the scour depth might not be more than under ordinary flood conditions.

Vents had been provided from bank to bank and so the risk of scour near the abutments did not exist. Nevertheless, stone revetment had been provided for a length of 50 ft on the upstream and downstream sides.

The effect of end contraction was not considered because it was negligible.

The top of raft at the centre of the vents was kept below the bed level.

The Author agreed with Shri Krishnamurthi and Shri Mehta who had recommended the rounding of the edges of the slab. But the extra cost was substantial in small works and was not therefore attempted.

One way camber was desirable for the hydraulic efficiency of the structure but, in the Author's opinion was inconvenient for the vehicular traffic.

The Author did not agree with Shri Krishnamurthi's remark about the centring. Timber centring was actually used for few spans and had to be given up in favour of the method adopted. Moreover, the sand filled centring was cheaper.

Referring to **Shri Mehta's** enquiry about slope for the sill of the barrel, the Author said that no slope was given. In his

opinion, it was desirable to have the downstream side of the vents bellmouthed and to reduce high velocity of flow by having fish-tail piers. In this case, however, the velocity of flow was not excessive and the piers were not constructed to such a shape.

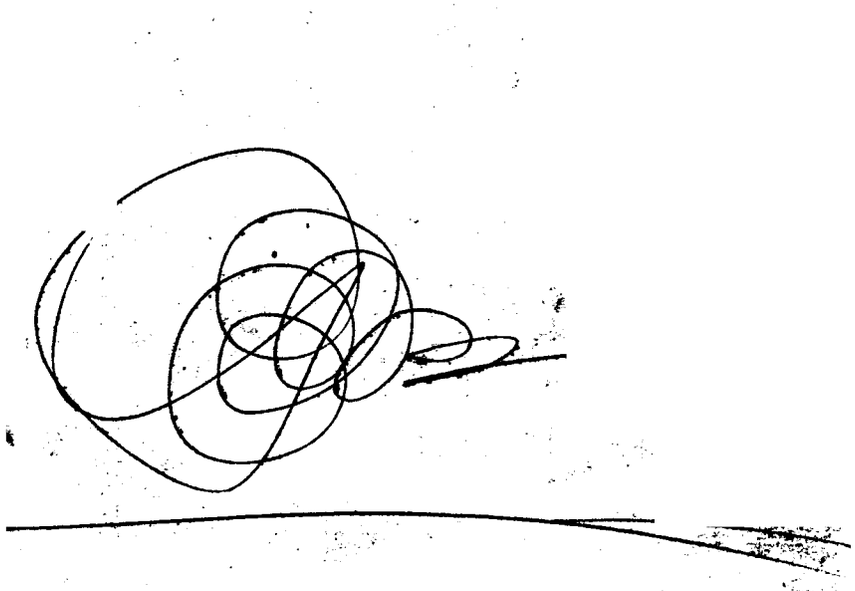
The main object of piles below the downstream cut-off wall was to protect the structure against retrogression of levels, if any. There was no point in providing piles in the foundation trench below the cut-off wall.

The critical condition for uplift was when the structure was about to be overtopped. When submergence took place, the uplift pressure was less and the loss of weight due to buoyancy was not of much consequence.

Anchoring of the slabs was considered risky due to possible unequal settlement.

Shri C. M. Bennett (Chairman), winding up the discussion, said that the main criticism was about the suitability of the site for a submersible bridge. The Author had answered the various speakers. Referring to Shri Antia's suggestion about combining irrigation structures with road bridges, the Chairman mentioned that there was a weir lower down the site of the bridge.

He thanked the Authors for the interesting Paper.



To

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"TRANSPORT-COMMUNICATIONS MONTHLY REVIEW"

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Discussion on Paper No. 174*

"Shear Failure in Anisotropic Materials"

By

C. G. SWAMINATHAN

Monday, June 20, 1955

Shri W. A. Griffiths (Chairman) called upon Dr. R. K. N. Iyengar to introduce the Paper on behalf of the Author.

Dr. R. K. N. Iyengar read out the written remarks of the Author. Shri Swaminathan stated that although the title of the Paper was general in its concept, the Paper was mainly concerned with the design of dense graded hot asphalt mixtures with shear failure as one of the criteria in design. So it was obvious that the shear constants could not be the same across all the planes within the mass. For an accurate assessment, variation in the values of these constants had to be taken into account.

The usual procedure for the study of bituminous mixtures was based on the Mohr envelope, an established procedure for shear analysis in soil mechanics. How far this was applicable to asphalt mixtures was questionable, especially when the viscosity of the binder was brought into play. Dr. Nijboer and others who, however, still used the Mohr circle in their analyses had allowed for this.

Also, the procedures for the design of asphalt mixtures, adopted by the Asphalt Institute of America and as given by Dr. Mcleod of U. S. A., were all based on this Mohr's critical circle and the straight line envelope. However, in most cases the envelope did not obey a linear law, but for simplicity it was assumed to be a straight line. The curvature of this envelope might be due to many reasons and it was shown in the Paper that anisotropy might be one of them.

It was well known that Coulomb's law was purely empirical and gave rise to many anomalies. The Paper drew attention to this aspect when dealing with shear failure for anisotropic materials.

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* Published at pages 167-188 of the Journal of the Indian Roads Congress, Vol. XIX-2, May 1955.

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The definition of cohesion as a fundamental property was one about which at present there was conflicting opinion. Attempts had been made to present a better concept regarding cohesion as it was evident that either a different interpretation of the parameters in a linear law should be given or a new law based on a clearer definitions of the fundamental properties should be developed. The Paper stressed the need for modifications of Coulomb's law.

The conclusions on page 187 of the Paper more or less summed up the results of the investigations on the shear failure in anisotropic materials with particular reference to asphalt mixtures. Although the Paper presented a purely theoretical approach, the Author felt that it might help the designers in giving proper weightage to test results in design of asphaltic mixtures.

The Author stated that comments had been received from Dr. Whiffen of the Road Research Laboratory, Harmondsworth. **Dr. Whiffen** observed that the graphical solutions were particularly ingenious. It was always only too easy to find fault with any Paper which purported to compute the failure stresses in road materials, because the arguments had to be based on idealised assumptions which did not hold in reality. In this case, however, the Author had forestalled some of these criticisms by himself casting doubts on his assumptions and if the arguments and conclusions given in the Paper made people think about the matter, then good would have been done. All the arguments were based on the material obeying Coulomb's law. He doubted whether road materials did this, particularly when their mechanical properties were dependent on the rate of loading and magnitude of applied stress. The fact that many road materials had plastic properties was not considered in the arguments. It was difficult to understand as to why the Author had given so much thought to the failure of road materials by direct stress causing shear failure. The Plate Bearing Test could admittedly be continued until failure occurred, but most of the roads did not fail in that way. Failures caused by chemical effects such as stripping, deterioration of the binder, etc., or by repeated application of load were usual. The Author showed that for purely cohesive material, the difference between the principal stresses was constant while for a purely friction material there was a linear relation between the principal stresses. For all the other possible combinations of the two assumed values of cohesion and internal friction, it was frequently found that the relation between them was neither linear nor simple. Dr. Whiffen thought that this conclusion did not helped much.

Professor Manton found the Paper very interesting.

Professor McKay thought that the approach to the problem

made in the Paper was fundamentally sound. But some of the assumptions made were questionable and the Paper was not of much value to soil mechanics engineers.

Shri R. N. Joshi said that the treatment in the Paper was based on the assumption that the principal shear strengths were developed on the planes of principal stresses, i.e., the principal planes of anisotropy coincided with the principal planes of applied stresses. It was also mentioned that if this were not so, procedure similar to one detailed in the Paper could be adopted with some modifications such as rotating the axes. It would have been helpful if the Authors had explained the procedure. This assumption meant that the Coulomb's lines for different planes were different and that the positions of the Coulomb's lines corresponding to principal stresses, σ_3 & σ_1, namely, the U – line and the V – line, were the extreme positions of the Coulomb's line and that at all intermediate planes Coulomb's line steadily changed from the U–line to the V – line.

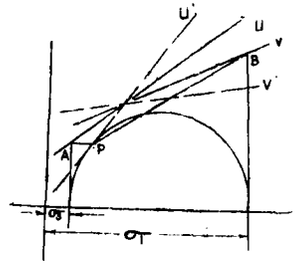

Fig. 1

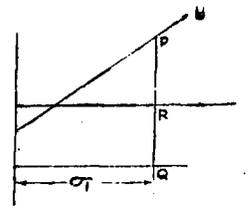

Fig. 2

Thus even if a straight line variation of shear strength for intermediate planes between the principal planes was assumed (para 2.1 (c) of the Paper), the shear strength line corresponding to normal stresses between the principal stresses σ_3 & σ_1 will consist of an intersecting pair of straight lines $A\ P\ B$, Fig. 1. Thus, if U' and V' were the Coulomb's lines for extreme positions, steadily changing from one position to the other, and U and V the Coulomb's lines for the two principal stresses σ_3 and σ_1, the strength line $A\ P\ B$ for planes intermediate to the planes of principal stresses, or the critical circle or the plane of failure could not be found by the procedure suggested by the Author.

Assuming U and V represented Coulomb's lines for two anisotropic planes and $\phi = 0$ for the V – line, a given compressive stress σ' on the plane corresponding to the U – line, a shear stress equal to PQ was developed, Fig. 2. By the principle of complementary shear, the shear stress in the plane at right angles should

be equal to PQ. But the material was not capable of developing a shear stress of more than RQ in that plane for any value of compressive stress. The fallacy existed even if $\phi \neq 0$ having different shear developing characteristics for perpendicular planes. How was the fallacy to be explained? Perhaps the solution was to be found in the theory of oblique shear*.

Shri C. G. Swaminathan (Author), in reply, repeated that the Paper had been written for the main purpose of adopting the procedures established in soil mechanics for the design of bituminous mixtures.

It was true, as **Dr. Whiffen** had pointed out, that the basis of this Paper was on idealised assumptions. Road materials did not always obey Coulomb's law and they did develop induced cohesion arising from applied stress. It was equally true that most of the roads did not fail by a single heavy load causing shear. But when a material such as an asphaltic mixture had to be designed for a pavement to carry a given traffic intensity, certain assumptions such as the validity of Coulomb's or some modified law were necessary and also the worst type of load for causing failure should be taken as the main factor in the design. Hence the subject matter of the Paper was restricted to that aspect of shear failure only. Dr. Whiffen had remarked that the plastic property of the road material was not considered and that the usual failures were caused by chemical effects such as stripping, etc. But in the design of asphaltic mixtures for the road surface, the viscosity of the binder was taken into consideration and the curvature of the Mohr envelope could be partially attributed to the plasticity of the material. Further, the question of failure from the point of view of chemical effects, stripping, etc., might influence the durability or the life of the road, but in the design proper only the strength characteristics had to be the criteria.

Dr. Whiffen had pointed out that the conclusions regarding the non-existence of the linear relationship between the principal stresses for the general case did not help much. That was included in the Paper for the main reason that for the general case of an anisotropic material, even on the basis of validity of Coulomb's law, a linear relationship between the principal stresses was not obtained. Further, it proved the anomalies that arose with the normal methods of analysis. So, in his opinion, the conclusion was helpful.

Prof. McKay had pointed out the questionable validity of some of the assumptions. The discussions incorporated at the end of the Paper did exactly the same. However, the assumptions were reviewed and the need for modification or reorientation of the existing concepts was stressed. One of the underlying ideas of the Paper was to make the designer of the flexible pavements to give thought to these and to use the test results judiciously.

* "Oblique Shear" by S. B. Joshi and R. N. Joshi, Proceedings of the Institution of Engineers (India), 1949.

Referring to **Shri R. N. Joshi's** comments, the Author said that when the planes of principal stresses did not coincide with the planes of principal strengths, assuming the orientation between the two sets of planes to be β, the angle of the plane of failure can be computed by substituting $\theta-\beta$ for θ. But the treatment of the general case was outside the scope of the Paper.

The line of failure must always be tangential to the circle of failure. There could never be two intersecting lines similar to AP and PB as shown in Fig. 2.

The U and V—lines were the lines of principal stresses. For each of the planes between the principal planes, a set of such lines existed. The plane of failure was that the corresponding strength line of which touched the critical circle.

Considerations of oblique or complementary shear were outside the scope of the Paper.

Shri W. A. Griffiths (Chairman) said that so far the type of road construction with which the Paper dealt had not been extensively adopted in India possibly because of its very high cost. Higher grade asphaltic carpets could only be laid where suitable hot mix plants were available and there were only three such places in India, viz., Calcutta, Bombay and Madras, where these were in use today. While the Paper was useful to the engineers of the Corporations of these towns, who own hot mix plant and construct a limited milage of roads with asphaltic concrete, it was of academic interest to others.

With the impetus which had been given to road construction by the first Five-Year Plan, he had little doubt, however, that the time was not far distant when engineers should consider the construction of roads adopting more durable and thicker bituminous carpets than at present. So the problem of "shear" would gradually assume much greater importance than it had done so far.

On behalf of the Society, he thanked Shri Swaminathan for having made the investigation into the problem and for expressing so clearly his findings in the Paper.

Discussion on Paper No. 175*

"Cement Concrete Surfacing and Experimental Concrete Road Construction on Agra—Bombay Road"

By

R. J. DHUMAL AND M.A. MEHTA

Monday, June 20, 1955

Shri Kishorilal (Chairman) called upon Shri Dhumal to introduce the Paper.

Shri R. J. Dhumal (Author) drew attention to para 2.5 of the Paper and said that he had found membrane curing cheaper when water for curing had to be carried more than two miles. Membrane curing could be used in arid or semi-arid regions where there was scarcity of water.

Shri Dhumal gave brief account of how the experimental lengths came to be constructed and drew special attention to the cement-bound macadam experiments described in sections 7 and 8 of the Paper. By the adoption of these specifications, savings were possible due to the following four factors :

(1) Saving in cement,

(2) Use of inferior and, therefore, cheaper aggregate in the bottom course,

(3) Saving in labour charges resulting from the fact that almost 75 per cent of the coarse aggregates did not pass through the mixer, and

(4) Quicker outturn.

The Author hoped that the data given in the Paper would stimulate the employment of the specification on large construction projects and effect substantial savings.

Col. S. K. Bose said that on the Agra-Bombay Road where the macadam crust was 12 in. or more and thoroughly consolidated, certain stretches were paved with concrete while others were treated with bituminous surfacing. The basis of selection was not given in the Paper. Although it was stated that the present condition of concrete pavement was very

* Published at pages 189-231 of the Journal of the Indian Roads Congress, Volume XIX—2, May 1955.

satisfactory, no mention was made of the present condition of the bituminous surfacing. In fact, with a type of road base as in the present case, the concrete pavement acted merely as a wearing surface. It was essential that the choice of cement concrete vis-a-vis bituminous pavement was made in a rational way. In his opinion, a concrete pavement should be adopted only where full use of its flexural strength could be made. Where a base course with good bearing capacity was available, as in this case, a bituminous pavement would be adequate and economical.

In experiments 3/A, 3/B, 4/A and 4/B, the Authors had introduced a 3½ in. thick layer of sandstone-cement-macadam, either sandwiched or grouted, over the existing water-bound macadam and the pavement consisted of 1½ in. thick premixed concrete. This 3½ in. thick layer would contribute very little in increasing the supporting power of a thoroughly consolidated water-bound macadam of considerable bearing capacity. It had been shown in example 2 of Paper No. 179* that when the modulus of elasticity of the base course was not more than, say, ten times the value of modulus of elasticity of the layer beneath it, the vertical stress in the subgrade was reduced by a small percentage (2.5 percentage in the example). It would have been advantageous to utilize the money spent on the cement base course in providing a thicker concrete pavement.

There was a danger in building up a rigid pavement in a series of thin layers. The constructional practice followed in western countries in providing thick concrete pavements in two or three layers was mainly due to limitations of the concrete-spreading machine which could finish concrete pavement up to a specified thickness only. Where the thickness of pavement was within the limit of one layer construction, there was no advantage in laying the pavement in several layers. Col. Bose remarked that 1½ in. thickness was not desirable, more so, if the time lag between the first and the second layer was large.

Shri K. K. Nambiar referred to para 2.3 of the Paper where it was stated that coarse aggregate was of two sizes, 1½ to 1 in. and ¾ in. down, blended in the ratio of 3 : 2 respectively and said that the exact grading was not clear from this description. In the four inch slabs, where two-course construction was adopted, the grading of aggregates for the two courses had not been given.

Provision of cut stone edging to cement concrete roads was not only totally unnecessary and wasteful but was also harmful

* Indian Roads Congress Journal, Vol. XIX-3, June 1955.

for pneumatic-tyred fast traffic. The money spent on these could be more usefully utilized for providing metalled berms which gave additional width of carriageway for passing and overtaking, and helped to keep the berms in level with the edges of concrete pavement. The practice in Madras State was to metal the berms for some width and provide a light pre-coated chipping carpet, thereby ensuring continuity of riding surface at the same level as the concrete pavement for overtaking and passing.

While agreeing with the Author that expansion joints at long distances with dummy groove contraction joints at short intervals was a very good practice, Shri Nambiar said that compressive stress set up in the long slabs by preventing them expanding was not an axial one. Any eccentricity in the thrust created enormous stresses and might blow up the slabs. The argument that preventing expansion induced prestress was erroneous.

In concrete pavements it was really the shrinkage and warping stresses that matter. These were taken care of by the dummy contraction joints and that was really the explanation.

Shri C. V. Nazareth said that it was recognised that an old water-bound macadam crust of adequate thickness had flexural rigidity but very limited abrasive strength and was liable to rapid deterioration under traffic. This had led to the bonding of relatively thin cement concrete slabs, 3 in. in thickness, to the macadam crust. If no slip occurred it was assumed that the crust and slab behaved under load like a single beam. Thin bonded concrete pavements, some of them now more than 15 years old in Uttar Pradesh, had given satisfactory service under heavy commercial and military traffic, both rubber and iron-tyred.

Some experienced engineers, however, thought that these bonded concrete roads were local successes only and could not be recommended for large-scale adoption. They contended that the preservation of the bond after a few cycles of expansion and contraction was problamatical. Should the bond be impaired, under such movements, there would be a tendency for the slab to vibrate under the impact of heavy wheels. The effects of fatigue would then arise, tending to weaken the slab and cause failure. They were, therefore, of opinion that the slab should be possessed of suitable inertia and should not be less than 5 in. thick for important routes or for conditions of heavy traffic. These considerations led to experiments 1 and 2 on bonded concrete: 3/A & B, and 4/A & B, in which the cement macadam sandwich and the cement grouted methods were adopted for the lower course. In experiments 3/B and 4/B, the lower courses had a concrete mix of the order of 1 : 3 : 7 by volume. The particulars

given in the Paper showed that the reduction in cost of the two course construction was about 15 per cent of 1 : 2 : 4 slab of the same depth.

In view of the success and economy of the two-course experiments 3/B and 4/B on the Bombay–Agra road, Shri Nazareth suggested that further lengths of half a mile each be laid in the different climatic and soil regions of the country. Initial and maintenance costs should be carefully recorded together with traffic figures. Valuable data would thus be available.

The Authors stated in para 2.2 of the Paper that where the concrete slab was greater in width than the water-bound macadam below, the base was extended with 1 : 4 : 8 concrete to a depth of 4 inches. He did not think that the use of lean concrete to extend the base width was necessary and, in any case, it was an expensive expedient. Where the earth berms were stable, they generally were, it was simple to extend the base by adding a 6-in. depth of metal on each side of the existing macadam to the required width and roll with a power roller. This method was successfully adopted for concrete pavements constructed on Madras–Bombay road, leading out of Madras city as early as 1938.

Shri K. Subba Rao observed that there was no difference in the behaviour of slabs cured by ponding and by chemical compounds on the Hyderabad–Masulipatam road where work was done in 1942.

His experience was that protection of slabs by shoulders was advantageous and that 2 ft water-bound macadam was adequate for the purpose. Also, a camber of 1 in 60 was on the high side. He had found 1 in 72 to be satisfactory.

Shri E. A. Nadirshah observed that the length allotted to each type was small and observations made from these experiments could by no means be generally accepted.

Referring to experiments 12 (a), (b) and (c), where slabs of 100 ft and over were constructed without any joints, Shri Nadirshah said that the first cracks which were observed during the first few weeks might be mainly due to the shrinkage of the concrete on account of setting and not to temperature changes.

At a dummy joint, once the cracking took place, the support of the adjoining slab was possible only through the aggregate interlock. Load transfer through aggregate interlock was not as effective as dowel bars. So the slab had to be designed for a corner loading.

Dummy groove made by means of a steel plate was normally much wider than what was necessary. Wide joints get revelled easily with heavy iron-tyred traffic. The use of joint cutting machines had been found to be satisfactory in forming very thin and neat dummy groove joints. The quantity of filler extruded during the expansion of the slab was also smaller with the result that the riding quality of the surface was good.

Referring to experiments 1 and 2, where premixed concrete of 3 in. and 4 in. thicknesses were tried, Shri Nadirshah said that experience elsewhere had indicated a 3 in. thickness was inadequate for a fairly heavy traffic. In the experiments which the Authors had described, it was possible that due to the lack of camber correction in the base the increased edge thicknesses could have helped in preventing cracks at the edges and the corners by heavy wheel loads. Besides the traffic intensity of 600 to 800 tons a day with nearly half of it in bullock carts was more severe on the wearing of the slab than on its structural capacity.

The statement on page 211, para 4 of the Paper, that " whilst the crushing strength and abrasive resistance of the top layer of a concrete pavement have to be high, there is scope for a comparatively weaker lower layer," was not correct. Wheel loads combined with the warping stresses due to temperature and moisture variations caused tensile and compressive stresses in the top and bottom fibres of concrete. Therefore, concrete pavement of varying crushing strengths through its depth was not desirable. He, however, agreed with the Authors that concrete of superior abrasive resistance was important for the top layer, which was subjected to abrasion by traffic.

The use of two different methods of construction viz., " Sandwich Method " for the lower $3\frac{1}{2}$ in. and the top $1\frac{1}{2}$ in. of rich premix concrete, required two different types of plant with substantial idle time for each of them when the other method of construction was in progress. It should have been better if both the layers were of premixed concrete using two different types of aggregates, viz., softer grade, for the lower layer and the harder quality for the top. The cost of construction in this case could have been lowered.

In the cement-bound macadam construction, para 7.3 of the Paper, the first layer of soft sandstone was seen to crumble under rolling. It was not mentioned whether the second layer of aggregates after spreading the mortar over the first layer got crushed.

In cement-bound macadam construction the mortar had a tendency to flow more towards edges and hence a test piece

removed from the middle of the slab would have been a better proof of thorough distribution of the mortar than the one removed from the edge of the pavement.

The penetration of cement grout depended on the size and the grading of the coarse aggregate, the thickness of the layer, the type of sand used in the grout, the cement-sand proportion, and the amount of water, etc. Unless very accurate analysis of all the above factors was made by preliminary experiments, it was difficult to guarantee an effective penetration of the grout through the entire depth of the material. The use of workability admixtures helped considerably in overcoming penetration difficulties due to any of the above factors. Substantial lengths had been constructed in all parts of the country using " Cheecol " as workability admixtures *. He disagreed with the remarks of the Authors that " the voids in the stone should be of such size as will allow the grout to flow through them freely ", as the economy in material and mainly in cement was dependent on the percentage of the voids in the coarse aggregate. Unless voids were minimum, large quantities of cement grout would be required to fill all the voids completely. With the workability admixtures, it could be possible to reduce these voids in the coarse aggregates and hence the quantity of grout by a preliminary rolling.

Shri Nadirshah desired to know details of the powder admixture used for patch repairs in mile 68/2, mentioned in para 2.6 of the Paper, and if the vertical ends of the slabs were also cured by the membrane method.

Shri K. G. Salvi said that from the analysis of Parbati sand given in para 3.8, it was seen that 60 per cent of the material between sieve No. 14 and 28 should cause particle interference and increase the water demand. He wished to know if the Authors had noted any such effect and water-cement ratios for obtaining good workable concrete of $1 : 2 : 3\frac{1}{2}$ type.

Referring to the experiment with slabs of 100 ft and over without joints, Shri Salvi wanted to know the thickness of the slabs and said that the uncracked lengths should not be taken to indicate the required joint spacings. Cracking had a lot to do with the type and uniformity of bonding of the slabs to the base. In a slab which was uniformly bonded to the base, the base exerted equal restraint at all places and instead of major cracks forming as reported in the Paper, these would be harmless hair cracks or what was known as crazing all over. In an ununiformly restrained slab, cracking of the type reported in the Paper was bound to occur and the spacing of these cracks would entirely depend on the condition of the bonding. In unfavourable conditions,

* " Cement Grouted Roads " by E. A. Nadirshah in the Journal of the Indian Roads Congress, Volume XIX—2, May 1955.

cracks might occur much closer than reported in the Paper. He felt that in bonded slabs the thickness of slabs influenced the uncracked lengths of the slabs because of the eccentricity between restraining and contracting forces.

That the uniformity of bonding had to do a lot with the cracking pattern of slabs was brought out from the results of experiments in sections 14A and 14B. Cracks did not occur in places where dummy groove joints had been placed, para 5.5 of the Paper. A possible solution for this was that restraint of the base round the dummy groove joints was substantial.

Shri Salvi desired to have information on:

1. the period of membrane curing before the road was opened to traffic, para 2.5,
2. the behaviour of the patch where no powder admixture was used, para 2.6, and
3. the basis for choosing the grading of sand given on page 226 of the Paper.

Shri K. Satyanarayana said that the cement-bound macadam sandwich method worked out to be only about 2 per cent cheaper than 4 in. premixed concrete at the rates for the materials given in para 3.7 of the Paper. So, in his opinion, it was not desirable to adopt the specification for long stretches.

Shri K. F. Antia observed that rolled concrete was a method of reducing the initial cost of construction of a rigid pavement. The savings ranged from 25 to 30 per cent. In Britain, very lean rolled concrete of 1 : 2 : 4 mix was used.

An important point which the experiments described in the Paper brought out was the possibility of using 1½ in. thick concrete surfacing with tougher aggregate over concrete using softer aggregate. The use of overburnt brick for the lower course in areas where good stone was scarce was advantageous.

Shri J. T. Mehta* stated that results of tests carried out by other agencies showed that concrete cured by membrane coating developed about 80 per cent of the strength of concrete cured by water. The Authors had, however, remarked in para 2.5 of the Paper that "in arid and semi-arid regions where there is seasonal scarcity of water, membrane curing presents an economic advantage over curing by water and can be equally effective."

No mention had been made if any cubes were taken from concrete slabs cured by different methods and tested for strength. In the absence of core tests it was difficult to judge the accuracy

* This and subsequent comments were received in writing.

of the statement. There was difficulty for water in Zalawad district of Saurashtra. So membrane curing, if it were equally effective as water curing, could be adopted with advantage.

It had been stated in para 2.2 of the Paper that an old and very well consolidated water-bound macadam crust of a thickness generally exceeding 12 in. existed. A 3-in. pavement could be laid successfully on such a base but where the base was not so strong it was risky to lay a 3-in. pavement. Similarly because the base was extraordinarily good, use of a two-course pavement with sandstone aggregate for the bottom course was successful.

Shri K. S. Sankaran enquired the reasons for changing the gradings for experiments 1, 2, 12 and 14, mentioned in para 3.6 of the Paper.

He was of opinion that the experiments should be conducted on longer stretches than those mentioned in the Paper.

Shri G. D. Joglekar stated that the quantity of cement for 1½ in. thick cement mortar 1 : 2½ was 19.80 cwt and for 1 : 3 mortar 17.74 cwt. Thus the total quantity of cement for experiment 3/A was 53.62 cwt and 51.56 cwt for 3/B. On this basis, the savings in cement worked out to 47 per cent for experiment 3/A and 50 per cent for experiment 3/B.

If the cost of the experiments 3/A and 3/B had been given in Appendix 2, it would have been helpful in judging the economics of the surface.

Shri R. J. Dhumal (Author) in reply to **Col. Bose** who wanted to know why certain miles had been improved with concrete surfacing and others black-topped, said that concrete surfacing was resorted to where intensity of traffic was heavy and black-topping was taken up where intensity of traffic was comparatively lighter.

Shri E. A. Nadirshah had enquired whether the sides of the slabs were treated with membrane or not. The membrane was spread through a nozzle in a fine spray. The spray was effective in an area with 1½ ft radius from the nozzle. The spray was used at the edges for covering the sides.

Answering **Shri G.D. Joglekar**, the Author said that the quantities in Table 1 were worked out by absolute volume method as shown on page 217 of the Paper.

Shri Kishorilal (Chairman) said that there was shortage of cement in the country. The Paper was instructive and useful information had been given. He thanked the Authors for their interesting Paper.

Discussion on Paper No. 176*

"Rivers And Ferries of North Bengal"

By

R. P. CHANDA

Tuesday, June 21, 1955

Shri M. L. Bahl (Chairman) called upon **Shri R. P. Chanda** to introduce his Paper.

Shri R. P. Chanda, introducing his Paper, said that during the record floods of 1954 there occurred many changes in the course of rivers in North Bengal. For example, the Sil-Torsa, the ferry across which was described in para 6.2 of the Paper, was nearly silted up, whereas another branch of the Torsa was enlarged resulting in the collapse of a bridge.

It might be possible to replace ferries across National Highways or State Highways. But ferries had to operate on crossings of other roads for a long time. Even though traffic offering was small, communications are vital to the people. Once due to poor ferry service, when the road from Cooch-Behar to Mathabhanga was cut off, prices of essential commodities in the Mathabhanga area had shot up.

For the ferry described in para 6.5 of the Paper, three blade propellers were used. The assembly of the engine was done in the P. W. D. workshop at Jorhat.

The boats used for the ferries described in para 6.1 are the same as detailed under serial No. 1 in Appendix 1. The Assam P. W. D. had improved the stability and capacity of these by providing two lines of empty tar drums under the rafts. These drums were held together by cross bars and served as floats between the boats. The raft was clear of the float when empty but pressed down under load.

In sub-para 2, under para 5.2, page 239, of the Paper and the last sub-para on page 249, the word "ballahs" should read 'baklas'. Baklas were spliced sal logs.

Ferries might be improved by: (1) employing light pontoons with sharp noses, (2) making available suitable power units with sufficient spare parts, (3) extensively using light steel cribs for jetties and temporary bridges in the fair season, and (4) providing

*Published at pages 233-258 of the Journal of the Indian Roads Congress, Volume XIX-2, May 1955.

trackways of sal planks or other suitable material for long sandy beds.

Other methods of ensuring good ferry services were: (1) the revenue collected should be wholly utilized for the improvement of the ferries, (2) increasing the toll charges, (3) inducing the lessees to provide modern boats etc. by increasing the period of lease from one year to 3 years or longer, (4) providing improved crafts and equipment by the department on hire to the lessees, and (5) reviewing and amending the Ferries Act passed about 60 years back to suit the present day conditions.

Shri V. S. Goel said that a proper design of the mechanical details of the ferry boats to suit the special conditions under which they had to work was essential. He made the following suggestions for improving the operation of the services.

1. The boats employed should have high stability and be capable of plying in shallow waters.

2. The difficulty of the propeller blades getting damaged due to striking against the bed material could be overcome if propulsion by water jets could be employed.

3. Instead of 7 or 16 h.p. engines, truck engines whose replacements were readily available could be used. When the craft was so designed as to facilitate replacement of the engine unit as a whole, completely overhauled engine units could be kept spare and used. Keeping a spare engine costed only a fraction of the total cost of the ferry craft but ensured 95 per cent availability of the craft.

4. When the crafts are equipped with caterpillar tracks, Fig. 1, at the sides or pneumatic tyres, they could move when stuck in sand. When these wheels or tracks were connected to the engine with a high reduction gearing it was possible to pull the craft out with high tractive effort at low speed if it got stuck up in sand.

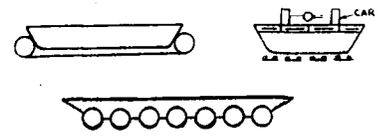

Fig. 1

5. It was possible to design craft which consolidated the approach roads by employing powerful diesel engines. Such vehicles would be amphibian carriers which moved in sand or water with their own power.

6. When a ferry boat got stuck against a sand dune there was wastage of time and effort. When the current was fast there was danger of an accident. If a buffer was mounted on the boat, Fig. 2, there was reduction of damage to the boat and the impact was evened out.

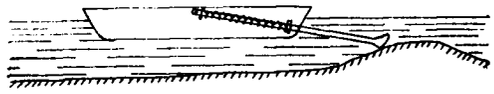

Fig. 2

If the problem was sufficient in magnitude, Shri Goel thought, it could be considered for inclusion in the programme of research at the Central Road Research Institute.

Shri R. P. Chanda, Author, replying to the discussion said that, while a high degree of mechanisation was worthwhile on important routes, sufficient funds were not available for employing improved boats on secondary roads.

In North Bengal boats plying in shallow waters had flat bottoms and the propellers were slightly raised above the keels of the boats. So, in his opinion, water jet propulsion was not necessary.

To guard against the boats striking against hidden shoals or buried trees, usually the boatmen stand in front of the boat and check the depth of water with a pole from time to time. In swift flowing rivers, however, it was worthwhile employing the suggested buffer arrangement.

Shri M. L. Bahl, (Chairman), observed that the conditions described in the Paper existed in North Bihar also. In Bihar also there was a Ferries Act which was an old one. It was necessary to amend the Act to suit present day condition.

In Bihar, country boats, mar boats, aluminium boats with or without outboard engines, pontoon bridges, and combination of pontoon and temporary bridges were in use. Also, at Sonapurhat a trial ferry had been successfully worked for some years across a river 800 ft wide. A 1 in. diameter wire rope was stretched across the river on sal ballahs. Aluminium boats were connected to the wire rope by means of pulleys. It took about 20 minutes to cross the river.

He thanked the Author for the Paper which has focussed attention on ferry operation.

Discussion on Paper No. 177*

"Design and Construction of Prestressed Concrete Bridge Across River Palar."

By

K. K. NAMBIAR

Tuesday, June 21, 1955

Shri M. S. Bisht (Chairman), requesting the Author to introduce the Paper, observed that prestressed concrete has been in use in Europe for a number of years and that other countries have also, of late, taken to this new technique of construction. As may be expected when new ideas are introduced, there has been some hesitation in India to adopt this new technique and the pioneer effort of Madras in accepting a prestressed concrete design for the construction of the Palar Bridge will go a long way in popularising this type of construction and in supplying experience in this field.

Shri K. K. Nambiar (Author), introducing the Paper, observed that the Palar Bridge was the first prestressed concrete road bridge to be constructed in India. Small beginnings in introducing prestressing to concrete were made about sixteen years ago when two garages at Meerut and some hangers at Karachi were constructed in prestressed concrete. Later on, the Railway authorities constructed three small bridges in prestressed concrete on the Assam Rail Link. But so far as road bridges were concerned the Palar Bridge was the first prestressed concrete bridge to be constructed in India and with its length of 2,218 ft was one of the longest prestressed concrete bridge in Asia. A large prestressed concrete bridge with 14 spans of 150 ft each was under construction across the Coleroon river in Madras State.

After the construction of the bridge, apart from the usual tests, certain special tests were carried out in order to study the distribution of loads in the case of T-beams and slab design. Some designers were of opinion that the end beams should be designed for the loads coming on them, assuming that the deck slab was continuous and carried over rigid supports. The other view was that in view of the rigidity of the structure, the end beams took at least as much load as the intermediate beams and,

* Published at pages 301 to 359 of the Journal of the Indian Roads Congress, Volume XIX-3, June, 55.

therefore, there was no justification in making the end beams less stronger than the intermediate beams. The tests conducted at Palar Bridge had shown that the latter assumption was nearer the actual state of affairs than the former.

One of the greatest advantages of prestressed concrete construction was that even if fine cracks developed due to exceptional temporary loading, the cracks closed by themselves immediately after removal of the load. Another advantage was that the saving in steel could be as great as 70 per cent and the saving in concrete as much as 30 per cent. The possibility of reduction in section depth of the section came in handy when there was insufficient headroom.

Great care was taken at all stages of construction to ensure that the quality of materials and workmanship was not below that specified. A mobile laboratory was stationed always at the work site to make tests of concrete and other materials used in the construction. Daily record of stresses and strains in prestressing work was also maintained.

Concluding, the Author stated that the design was prepared by The Stressed Concrete Constructions Ltd. and modified according to the suggestions made by the Ministry of Transport (Roads Wing).

Shri R. N. Joshi pointed out that the discharge measured at the anicut 60 miles upstream of the site plus the discharge of the two streams meeting the river between the anicut and the site of the bridge differed from the discharge measured at the railway bridge four miles downstream of the site, in the floods of 1946, by more than 25 per cent. The discharge at the railway bridge, in his opinion, was the proper guide to the possible discharge at the bridge site. He enquired if discharges were calculated using the formula based on catchment area.

The assumption that all the four main girders shared the load equally was justified only if the cross giders were rigid.

Short specification of the machinery, for example the horse power of engines, discharging capacity of pumps, kilowatt capacity of generators, capacities and pressures of compressors, would have increased the usefulness of the list given in Appendix 3 of the Paper.

An advantage of prestressed concrete main beams was their lightness. While having the advantage of economy inherent in lightness, it did not have the disadvantage of a light R.C.C. structure, which did not possess the stabilising effects of dead load. If the effect of live load was small compared with that of

the dead load, any increase in the live load beyond the specified one affected the structure but little. For the main beam of an R. C. C. bridge of 100 ft span, dead load bending moment was about 70 per cent of the total moment whereas for a prestressed concrete beam of similar span, it was about 50 per cent.

In his opinion, the procedures adopted for well sinking work on this construction were as crude as the methods of superstructure were modren.

Shri G. Venkatesulu observed that the superstructure adopted for the bridge was of composite construction—composite in the sense that part of it was precast and part cast-in-situ. The mix of concrete in the ribs and in the flanges was different. Their ages at any time were also different so that the effects of differential shrinkage should also have been taken into account in the final calculation. The article did not say why these effetcs were not considered in the design. It was not clear whether in evaluating the section constants of the composite section, due allowance was made for the different values of the elastic modulii of the precast concrete and the cast-in-situ concrete.

The factor of safety against cracking had been worked out as 1 per cent. But this appeared to be a printers' mistake, for actual working had shown that the figure should have been 1.1. The factor of safety against cracking generally specified was 1.5. No doubt, insistence on such a high factor of safety would increase the section but since the technique of construction was new it would perhaps be better to be a bit conservative. Would the Author give any reference which recommended such a low factor of safety as 1.1?

The failure of a prestressed concrete structure might occur due to two causes—one, the crushing of the concrete and, second, the snapping of the high tensile wire. The resisting moment of the structure had been worked out assuming that the prestressing cables would fail first. It would be desirable to work out the resisting movement based on the crushing of concrete also.

The diaphragms and the deck slab were constructed in ordinary reinforced concrete, giving an ultimate crushing strength of 3,000 lb per sq. in. on 6-in. cubes. The equivalent cylinder strength was about $8 \times 3000 = 24{,}000$ lb per sq. in. The permissible compressive stress adopted was 950 lb per sq. in. Thus the factor of safety was 2.5 only. The draft I. R. C. Bridge Code specified a factor of safety of 3.6. The Paper did not make clear how a factor of safety less than that recommended by the Code was permitted in the design.

In a quality-controlled concrete, a rational design of the mix was quite essential. The Author had stated that no special grading was adopted. The design of the mix of the concrete should have been left to the contractor.

There was no cross prestressing of the beams and the diaphragm walls did not appear adequate. Was the deflection equal in all the beams when load testing was done?

There was a long time lag between the casting of the beams and the casting of the slab. The reinforcement provided did not appear adequate for the bond.

It was good that cement concrete 1 : 3 : 6 was adopted for the piers. What was the assumed strength of this concrete and were any experiments conducted to assess its strength?

Was it necessary to sink the wells through 32 ft clay as was done in some cases? Was it necessary to provide 2 ft thick concrete plug at the top?

Shri S. Pal wanted to know why the width of roadway was kept 22 ft and why no footpaths were provided?

When two separate wells were sunk for carrying one pier, it happened many times that the wells tended to come towards each other. Was such tendency observed during well sinking and what were the maximum tilts and shifts observed?

The width of the cutting edge was 6 inches. Did such a 'blunt' cutting edge not handicap sinking operations?

Some of the wells were more than 40 ft deep, yet the thickness of steining was only 2 feet. Was this not too thick for the depths sunk? Was any kentledge used for sinking? Was there any special reason for putting the reinforcement in the well steining on both sides of the steining instead of keeping it at the centre?

The bottom of the well caps was at R. L. 88.00, while the average bed level was at R. L. 92.00. Was there any trouble from percolation during concreting of the well caps? In West Bengal owing to the difficulty of casting a single well cap over two separate wells, a twin well was invariably used and concreting below river bed was facilitated by erecting a temporary coffer dam on the periphery of the well steining itself.

Shri E. V. S. Iyer said borings had shown 10 to 12 ft of sand on stiff clay overlying disintegrated rock. The depth of the foundation rock was not excessive. In such circumstances shorter spans of the T-beams and slab type would have been economical.

The bottom plugging was of 1 : 2 : 4 concrete. A leaner mix could have been adopted.

The gradients and radii did not appear to be according to National Highway standards.

Shri K. Srinivasa Rao, who was in charge of the construction, said that prestressing the girders was commenced after the concrete had attained a strength of 4,000 lb per sq. in. This was about a week after the girders were cast. Generally, there was a time lag of about 1½ months between prestressing and the casting of the in-situ deck slab.

Shri Srinivasa Rao thought that water-cement ratio and compaction were the important factors contributing to the strength of concrete. In the beams electrically operated shutter vibrators were used and the compaction was satisfactory even though the slump was not even ⅛ of an inch. Test results of the cubes showed that the strength was very good.

Shri Ratnagar had commented that the values of E were different for precast and cast-in-situ portions and that suitable modification was necessary in the design on this account. The E value for instantaneous loading for concrete of different mixes was practically same.

The effect of applying a live load to a composite beam with a top flange not prestressed had a tendency to reduce stresses in the prestressed portion and the modulus of elasticity of concrete for release of stress was greater than for increase of stress. Also, modulus of elasticity in compression for concrete was greater at lower stresses than at higher stresses. Also, the stress in the slabs was low. In view of the above it was considered that the adoption of the same value of E for both the prestressed and in-situ work did not make much difference.

Shri R. D. Ratnagar* felt that an acknowledgment and a reference to Messrs Stressed Concrete Constructions Ltd. of Madras, who were responsible for the design of the superstructure should have been made in the Paper. Shri Venugopal, the present Director of Messrs Stressed Concrete Constructions Ltd., who undertook to carry out the test to destruction of the prestressed concrete girder at his own cost, had done yeoman

* Received in writing.

service to advance the cause of prestressed concrete construction in India.

It would have been very useful if the Author had mentioned how the total cost of Rs 25 lakh compared with the cost of the original proposal of continuous T-beams and bow-string girders.

Since the values of modulii of elasticity were different for the precast and the cast-in-situ portions, some corrections will have to be made before the section could be considered as homogeneous. If the whole section were to be treated as homogeneous, the cross-sectional area of the in-situ concrete flange should be reduced and for this purpose it would be much better to reduce the width of the flange in the ratio $\frac{E \text{ in-situ}}{E \text{ precast}}$ than the depth.

Shri Ratnagar desired that the Author might give his views on the suitability of prestresed concrete construction for bridge work in India.

Shri K. K. Nambiar (Author) referred to **Shri G. Venkatesulu's** comment about the low factor of safety and said that the test on prototype beam indicated that minute hair cracks which could be observed with a magnifying glass developed.

Referring to the enquiry about watertightness of the bottom plugging, the Author said that after the wells were plugged they were de-watered and were found to be watertight. After half a dozen wells were tested in that manner, tests on other wells were not done. He felt that there was no necessity of de-watering the wells and testing them for watertightness. What harm was there if some water found its way into the wells? In certain bridges now under construction on the west coast of Madras State, no sandfilling was done. After bottom plugging was done, they were filled only with water and sealed by the capping slab.

Shri R.N. Joshi wanted information on the distribution of load on the four beams and whether there was sufficient rigidity in the diaphragms to warrant such distribution. As already stated, the test conducted indicated that there was considerable rigidity due to the diaphragms and the load distribution among the four beams was more or less equal when the superimposed load was placed central to the cross section of the bridge. For eccentric disposition of the superimposed loads, the end beams took greater proportion of load than the intermediate beams. This was nothing new as, as early as in 1933, the Oregon State Highway Department made similar investigations which indicated that the exterior girders took as much, if not more, load than the interior girders. This led to the adoption by Oregon of a specification

where the total load on the span was divided equally between all girders when adequate diaphragms beams were provided. Tests in India had also confirmed the observations and he hoped that this method of distribution will be used in future.

Shri Joshi doubted whether prestressed concrete would be cheaper than ordinary reinforced concrete construction. Comparison of tenders for this and other bridge works showed that prestressed concrete construction was cheaper than ordinary reinforced concrete construction, and when high tensile wires were made in India there would be greater reduction in cost by adoption of this technique.

The well sinking work was let on contract; even though modern methods were not used, local labour and talent were employed and the work done according to specifications. The Department could not interfere with the methods adopted. In the South there were very experienced and expert well sinkers who could turn out a very good job.

Shri R. K. N. Iyengar suggested the use of a cutting edge with $\frac{1}{2}$-in. plates welded or rivetted to the kerb projecting outside the face of the well. The Author did not recommend the adoption of this type of well kerb as the extra diameter of the kerb would result in leaving a small clearance between face of the well and the clayey soil face through which the well was sunk. Such a clearance resulted in reduction of the skin friction. There was no serious trouble due to any tilting or displacement of the wells.

Dr. Iyengar wanted the information on the charges of gelignite used in the case of these wells. Only light charges were used, not exceeding half a cartridge of 'blasting gelatine' which was about 4 ounces. Heavier charges were not recommended.

Sand plugging was done under water and sand was agitated and tamped to ensure the expulsion of all air bubbles for obtaining the maximum density under saturated conditions.

Shri N. Mohan Rao wanted to know whether the characteristics of the soils in foundations were studied and whether the bearing capacity of clayey soils in foundations was ascertained. Though details of these were not mentioned in the Paper, this matter was carefully gone into at every stage. The clay met with in the foundations of this bridge was of a very stiff type with satisfactory bearing power. In cases of doubt, in addition to the laboratory investigation, in-situ tests were made after sinking the wells to some depth to ascertain the bearing power of soils. Two feet diameter and $1\frac{1}{2}$-ft diameter bearing plates were used. A stanchion was loaded by the reaction of hydraulic jacks

used for the purpose of transmitting the load to the bottom of the well and the settlement was observed carefully. Time settlement curves were prepared to study the bearing power and settlement.

Shri P.J. Jagus wanted to know whether tests were carried out for ascertaining the strength of concrete used for prestressed concrete work. Tests made showed a strength exceeding 6,000 lb per sq. in. in almost all the cases, whereas a strength of 5,000 lb per sq. in. had been specified for the cubes at 28 days. A testing machine of 100-ton capacity was used and several 6-in. cubes could not be crushed by the machine, indicating that the strength was more than 6,222 lb per sq. in. The cubes could not be crushed even when the loading was increased to 120 tons, for which there was a provision in the testing machine though the machine was not calibrated between 100 and 120 tons. There was no need to use the penalty clause for recovery at twice the issue rate as the results of tests were uniformly satisfactory.

Shri M.P. Apte referred to certain difficulties in well sinking by manual labour. Well sinkers in Madras were experienced and no difficulties were experienced.

He also referred to the danger of blasting inside the wells. The Author agreed with him that blasting was risky when done without proper care. There were instances in other bridges of the well steining having cracked owing to careless blasting and also in one case of cutting edge having been blown away to some distance. Shri Nambiar said that he had given thought to the question of blasting inside the well under water and had come to the conclusion that blasting inside water somewhere in the middle section of the well which was often resorted to give a shake to the well to help sinking was a bad practice. Blasting should be done below the level of the cutting edge for which a hole should be drilled with a pneumatic drill or other device and a cartridge of a moderate size used for blasting. In such cases, there was no danger of the steining cracking or the kerb sustaining any damage.

The Author agreed with **Shri S. Pal** that 24 feet carriageway was desirable.

Shri E. V. S. Iyer asked whether 90 ft was the economical span. The original design for this bridge was for a number of spans of 100 ft bowstring girders and the remaining spans being of 60 ft R. C. C. T-beam and slab type. When tenders were invited for the work, an alternative design was submitted by Associated Engineering Syndicate, providing for prestressed concrete superstructure with 90 ft spans. As this was found to be more economical, the tenders were accepted.

Referring to **Shri R. D. Ratnagar's** remark about his views on prestressed concrete construction in India, Shri Nambiar said that the object of writing a Paper was to make available to other engineers his experience in this type of construction. No doubt there was a certain amount of scepticism in adopting this new technique. It was only natural. It was so even in the case of reinforced concrete construction some years ago. Even in England reinforced concrete had to fight a great deal of prejudice, in its early days. The following extract from a booklet published by Concrete Publications Ltd., London, concerning the construction of three reinforced concrete bridges over the river Thames opened by George VI, the Prince of Wales, in July 1937 illustrates this.

> "Reinforced concrete had to fight a great deal of prejudice in this country, particularly among the older members of the engineering profession. This was partly due to the fact that its use in conjunction with steel reinforcement was first extensively developed on the Continent, and it was looked upon here as a 'foreign invention' and, therefore, taboo, or at any rate to be viewed with suspicion as a 'new fangled innovation.' Thanks to the energy and pertinacity of its advocates it gradually made its way and having been tried in many forms is now accepted by engineers and architects as a very valuable and adaptable method of construction....."

Because this type of construction was new for India, a clause was introduced in the contract that one full scale beam of the type to be used on the bridge should be tested to destruction to the satisfaction of the Department. Accordingly, a test on a 96-ft beam was conducted in June 1952 at the site of work in the presence of a distinguished gathering of engineers drawn from all parts of India. The results of the test were completely satisfactory and any doubts regarding the suitability of this type of construction were dispelled.

Shri M. S. Bisht (Chairman) said that the importance of prestressed concrete lay in the saving that resulted not only in concrete but also in steel. In Uttar Pradesh also a prestressed concrete bridge of 11 spans of 65 ft each had been built.

He thanked the Author for his interesting Paper.

Discussion on Paper No. 178 *

"Traffic Rotaries"

By

THE SPECIFICATIONS & STANDARDS COMMITTEE OF THE INDIAN ROADS CONGRESS

Tuesday, June 21, 1955

Shri K. K. Nambiar (Chairman) called upon Shri J. M. Trehan to introduce the Paper.

Shri J. M. Trehan (Member-Secretary of the Specifications and Standards Committee), introducing the Paper on behalf of the Committee, mentioned that Delhi and New Delhi had grown considerably during the last two decades on account of the circumstances created by World War II and the influx of the displaced population from Pakistan. Consequent on the increase in population vehicular traffic of all types had increased and thus necessity arose to improve the roads and junctions. Most of the rotaries which were provided by the city planners were more for scenic effect than for meeting traffic requirements. Automatic traffic control devices had not been provided as the volume of traffic did not justify their installation. Consequently many of the road junctions have had to be re-designed to meet modern requirements. The experience gained in the design has been incorporated in the Paper for consideration of the Members of the Congress.

The Paper dealt with the general principles of designing rotaries, the conditions which justified their construction, their advantages, disadvantages and limitations, the methods of channelizing traffic on to and out of them, and the design standards. In formulating the recommendations the practices followed in foreign countries, where the problem had been studied in detail, had been considered. An important part of the Paper was the examples of the rotaries designed and constructed in Delhi and New Delhi. They illustrated the application of the general principles in actual practice. In some of those examples, all the desired standards suggested in the Paper could not be applied. That showed how site conditions limited the realization of ideals.

* Published at pages 367 to 422 in the Journal of the Indian Roads Congress, Volume XIX-3, June 1955.

Dr. R. K. N. Iyengar pointed out that the recommendations given in para 3.1 of the Paper that "the construction of a traffic rotary was justified if the volume of traffic was 500 vehicles per hour" might not apply to Indian conditions as the minimum number of vehicles depended on the importance of the intersecting roads. He suggested that this minimum should be fixed only after actual counts had been taken.

Referring to para 7.2 and 7.3 of the Paper, Dr. Iyengar remarked that it was rather doubtful whether, on account of the mixed nature of traffic, the American data would hold good for conditions in India. For the same reasons the reduction in speed at the intersection in urban areas (para 7.4) would be definitely more than that observed under American conditions.

For calculating the weaving length (para 10.7), which was one of the most important factors affecting the design and functions of a rotary, periodical counts of the slow-moving traffic, e.g., tongas, bullock-carts, cycles, etc., should have been taken into account for obtaining the correct value. Coming to paras 10.9 and 10.10 of the Paper, Dr. Iyengar felt that the bullockcart traffic could not be neglected on account of a general want of road sense in the drivers of bullock carts and their zig-zag movements. Therefore, the weaving lengths recommended might be revised after research in this direction had been carried out. In view of the mixed traffic, he suggested that the Committee should be more liberal in fixing the minimum width of the rotary carriageway and width of the road at the entrances and exits.

Dr. Iyengar pointed out that most of the standards and recommendations on this Paper had been based on practices in vogue in the U. K and the U.S.A. and suggested that, in view of the peculiar characteristics of the traffic in the country, the final recommendations should be based on extensive research and field observations relating to the various factors involved in the design of rotary junctions. He mentioned that one of the research problems on hand in the Traffic Division of the Central Road Research Institute was the "Investigations on Road Intersections with Special Reference to Roundabouts" for evolving suitable designs essential for the smooth flow of traffic and for increasing the carrying capacity of roads.

Lastly, Dr. Iyengar said that due consideration should be paid to the "Grade separated rotaries" or "Two-level rotaries" which would segregate the fast and the slow traffic at the junctions. According to this arrangement, the fast traffic could be taken over the ramps at a higher level whereas slow traffic would go under the rotary.

Shri T. S. Khanna said that most of the recommendations in this Paper were based on the experiences in the western countries where the traffic conditions were quite different from those prevailing in India. He emphasized that field observations should be made before finally recommending the standards.

Shri Khanna suggested that studies should be conducted to find out if in a rotary having concentric outer kerbs, the resulting unused area could be used safely by the slow traffic, Fig. 1. Further, he suggested that the recommendations for the length, shape and location of merging lanes and channelizing islands might be made on the basis of field studies.

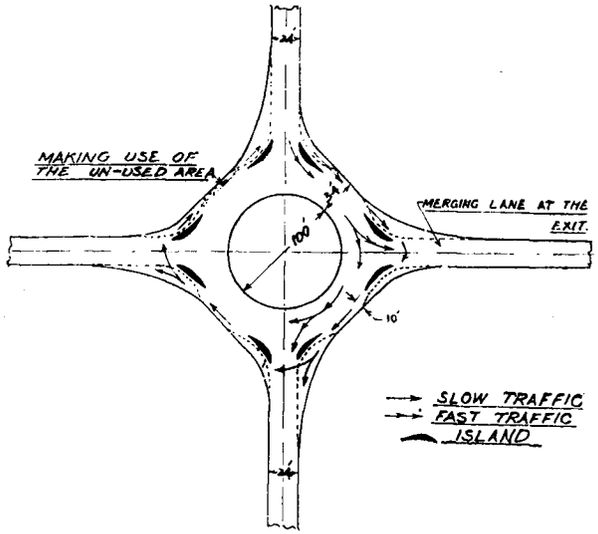

Fig. 1

Shri Khanna said that field investigations should be carried out to establish rational relationship between the size of the central island and the width of the rotary carriageway. He also advocated field studies regarding the economic justification for building two-level traffic rotaries.

Shri C. L. N. Iyengar said that sometimes traffic rotaries were taken to include small, circular masonry structures constructed haphazardly. These merely served to separate area of conflict but, by no means, satisfied the primary requirements for uninterrupted flow of traffic. In his opinion, there were three

conditions which were necessary for the successful operation of a rotary :

1. the correct use of the rotary :
2. little reduction in the speeds of vehicles ; and
3. minimum interference from pedestrians and other causes at entrances and exits.

In some cities, rotaries could be used with advantage in conjunction with stop-signs, or signal controls, on minor street crossings. It would have been much better, he remarked, if this Paper were preceded by another Paper on the design of level or grade intersections with or without signalization.

He pointed out that, the values of friction recommended in para 9.2 of the Paper for designing the minimum radii were on the high side. Even in New Jersey (U.S.A.), which had a very large number of rotaries, a much lower value than that recommended by A.A.S.H.O. had been adopted. For a design speed of 25 m.p.h., no driver needed a coefficient greater than 0.28 as against 0.43 recommended in the Paper.

The speaker felt that the width of the rotary carriageway was rather inadequate as 30 ft on the curve did not provide three lanes as stated in para 11.4. The lane width would be more, nearly 13 ft to 14 ft, instead of 10 feet. Continuing, Shri Iyengar said that the Paper should mention the minimum number of lanes for the merging of left turning and weaving traffic when their volumes were high. Commenting on the minimum acceptable gap (para 22.6) he said that the gap for weaving was much higher than 2.1 seconds and that with lower speeds of vehicles envisaged, anything less than 4 seconds was impractical. He, therefore, suggested that the calculations for capacity should be modified accordingly.

Lastly, he suggested that the Indian Roads Congress Standards for Highway Layouts, Street Junctions, and Rotaries should be made available to all the town planning authorities to help them in their designs.

Dr. Lal C. Verman supported previous speakers in so far as the remarks related to the collection of additional data by means of field observations under Indian conditions.

He suggested that this Paper should have included also the channelization of traffic as it was an effective method of ensuring safety on the road. He pointed out that the Police authorities

seemed to think that an island placed at a junction without relating it to the needs of the traffic could help to increase the safety of the road. But, actually in practice, these islands enhanced hazards to the traffic and were responsible for frequent accidents. He pleaded that the code of practice for rotaries should forcefully bring out this fact to the notice of the traffic authorities and impress on them that the design of a junction was a highly technical job to be dealt with by expert engineers only.

Referring to the 'Basic Requirements of Intersections', mentioned in para 6 of the Paper, he pointed out that the design should provide also for the gradual transition of speed as the traffic approached the rotary junction.

One reason why tangential flow at rotaries should be discouraged was that in one direction drivers travelling along a tangential approach road at a rotary junction altogether by-passed the rotary on their left. This should be stated in the Paper.

The minimum weaving distance (para 10) should be based on the higher of the two figures resulting from the two sets of calculations given. Further, due attention must be paid for the segregation of slow-moving traffic in urban areas. He quoted an example of a tonga, which had the general tendency of keeping close to the central island and rushing straight at a rotary junction from one road to the opposite road, Fig. 2. This, he said, was objectionable because the fast-moving traffic was thus compelled to cross the path of slow traffic twice.

It would be more reasonable Dr. Verman said, to base increase in width of cycle tracks (para 19.2) on the density of traffic instead of a fixed increment of 3 ft as recommended in the Paper.

Finally, Dr. Verman wanted to know if the cautionary sign for a rotary given in Fig. 17 of the Paper was in accordance with the U.N.O's recommendations.

Shri S. P. Govindarajulu, commenting on para 3.1 of the Paper, which related to the volume of traffic justifying the construction of a rotary, asked as to what type of junction should be constructed when the volume of traffic was less than 500 vehicles per hour. He remarked that the Specifications and Standards Committee should evolve designs for junctions of a main road 30 ft wide and a subsidiary road carrying very little traffic.

Shri K. Sinha mentioned a few construction difficulties such as limitations of space, carrying out costly drainage works, etc., before any improvements to roads and road junctions could

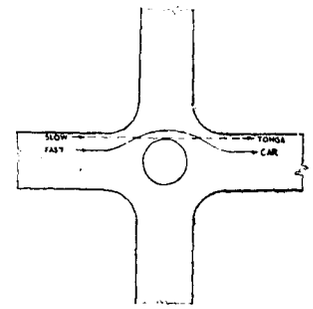

Fig. 2

be effected in a city like Banaras which had underground drainage system. Co-operation between the road authority and the department dealing with telephone and electric supply systems was essential for prompt execution of road improvement.

Shri J. S. Narasimham said that as rotaries were usually constructed on urban roads, there must be some provision for recesses at bus stops near them either at entry or at exit. These positions should be defined by painting the kerbs yellow. Similarly, kerbs at entries and exits should be painted to denote non-overtaking zones near a rotary junction.

Referring to para 20.1 of the Paper, which mentioned that avenue plantation in the central island adversely affected the view of the motorist, Shri Narasimham thought the central island could be planted with low shrubs which would not obstruct the motorists' line of sight. He stressed that landscaping not only in the central island but also along the footpaths was necessary in urban areas.

Shri J. M. Trehan, replying to the discussion on behalf of the Committee, said that most of the speakers had said the Standards recommended did not take into consideration the slow-moving traffic peculiar to India and were critical about the use of experience in foreign countries for recommending standards. The design of most of the elements of a rotary was influenced by the fast-moving traffic only. For example, the most important elements—the radius of the central island, the entry and exit radii, the maximum and minimum weaving lengths, superelevation and crossfall, were in no way influenced by the slow traffic. The bullock cart affected only the capacity of the rotary. Research in foreign countries in this regard had not yet reached a conclusive stage. The Paper had mentioned this in para 22.9 and recommended that due weight should be given to the slow traffic. Observations made in Delhi, which had still got quite a good

percentage of slow-moving vehicles and where a number of rotaries had been constructed according to the principles laid down in the Paper, showed that the application of those principles was suitable to Indian conditions.

Standards recommended in the Paper, like any other Standards, were subject to periodical review to keep pace with new developments and experiences. Modifications, if any, necessitated by observations under Indian conditions, could be incorporated in the future revisions.

With reference to **Dr. R. K. N. Iyengar's** comments, Shri Trehan agreed that because of the mixed nature of traffic in India the reduction in speed and the weaving lengths might at times differ from those mentioned in paras 7.4 and 10.7. But to recommend weaving lengths taking into account this reduction in speed was not desirable because it was not possible always to ensure the presence of slow traffic, and if only fast traffic used the rotary, it would be hazardous.

As regards Dr. Iyengar's observations relating to paras 10.9 and 10.10 of the Paper, the minimum width of rotary carriageway recommended had proved to be adequate in practice.

The Specifications & Standards Committee would only be too glad to utilize data that was being collected from investigations on hand at the Central Road Research Institute, to review the recommendations contained in the Paper.

Grade separated rotaries suggested by Dr. Iyengar were outside the scope of the Paper which was confined only to rotary junctions at grade.

Referring to **Shri T. S. Khanna's** comments Shri Trehan stated that it did not seem possible that the slow-moving traffic could be made to use only the additional area of the rotary carriageway obtained by making the outer kerbs concentric with the central island. No relationship was apparent between the size of the central island and the width of the rotary carriageway. The size of the central island had a bearing on the angle of weaving and the weaving length, whereas the width of the rotary carriageway was a function of the volume of traffic and had to be related to the widths of approach roads.

In reply to **Shri C. L. N. Iyengar,** Shri Trehan said that the points mentioned in the comments had been taken into account in making the recommendations. Reduction in speed was dependent, inter alia, on the size of the central island which could not be very big from considerations of economy. Fig. 16 of the Paper showed how cyclists and pedestrians should be taken round the junction to reduce interference with the motor traffic to the minimum. If, however, the pedestrian and cyclist traffic was heavy, sub-ways were a solution to avoid accidents.

The design of intersections at grade (other than rotaries) was the subject matter of a separate Paper.

The reason for adopting the value of the coefficient of friction recommended had already been given in para 9.2 of the Paper.

Normally a vehicle overtook not more than one vehicle at a point. So the minimum width of 30 ft, for the rotary carriageway, viz., recommended in paras 11.3 and 11.4 of the Paper was probably inadequate.

Referring to the minimum acceptable gap for weaving, Shri Trehan said that 2.1 seconds mentioned in para 22.6 was based on the observations made at the Yale University. For details of this study, Technical Report No. 4, Bureau of Highway Traffic, Yale University, could be referred to.

Shri Trehan agreed with **Dr. Lal C. Verman** that the design of junctions should be left to road engineers as the traffic police department could not be expected to deal with engineering aspects of road design.

Channelization of traffic was a vast subject and had been included in a Paper on Intersections at Grade drafted by the Specifications and Standards Committee. Gradual change in speed near a junction could be effected if a warning sign was put up at a reasonable distance as mentioned in para 6.2 (b).

Shri Trehan said that for reasons given in para 10.11 of the Paper, it was not desirable to adopt the higher of the two weaving lengths given in Table 3. He was doubtful if segregation of traffic at junctions in urban areas was worthwhile pressing for as it could not be easily and economically achieved. As the volume of slow-traffic in cities was on the decrease every day, the problem visualized by Dr. Verman might get solved itself. The example given by Dr. Verman, Fig. 2, was an extreme case. Such problems were best solved by "educating" the road user.

Referring to his querry regarding the sign post, Shri Trehan said that the sign adopted was as given in the Motor Vehicles Act, 1939.

Replying to **Shri Govindarajulu,** Shri Trehan said that where traffic was less than 500 vehicles per hour, channelization, if possible at the site, was the answer.

Shri Trehan observed that the points raised by **Shri K. Sinha**, although very important, were purely of an administrative nature.

With reference to **Shri J. S. Narasimham's** suggestion regarding siting of bus stops, Shri Trehan replied that the Specifications and Standards Committee had under consideration recommendations on Intersections at Grade, wherein it was proposed to deal with the subject. This Paper had not deprecated planting of hedges which would not obstruct view on the central island.

Shri K. K. Nambiar (Chairman) concluded the discussions by thanking the Specifications and Standards Committee for producing a Paper which dealt with an important subject. He suggested that the Indian Roads Congress should finalize its recommendations on traffic rotaries and communicate them to all the States for adoption. In the absence of proper guidance, Police authorities constructed small traffic posts at road junctions which caused considerable inconvenience and hazards to traffic.

Discussion on Paper No. 179*

"The Influence of a Superimposed Layer in Increasing the Load Bearing Capacity of A Rigid Pavement

By

COL. S. K. BOSE

Tuesday, June 21, 1955

Shri E. A. Nadirshah (Chairman) called upon Col. S. K. Bose to introduce his Paper.

Col. S. K. Bose said that he got interested in the problem first in 1949 when a team for testing airfields with a view to evaluate their strength visited India for collecting data. The team performed tests not only for finding the modulus of subgrade reaction but also the load-deformation characteristics of the airfield structure by conducting the plate bearing test on the pavement.

In his opinion, Burmister's theory was not applicable in evaluating the strength of existing pavements. Also, Westergaard's formulae were not enough. Burmister's method of two layer system was extremely useful in understanding the various factors that influenced the relationship between subgrade and pavement thickness. Table 1 in the Paper and Table 1 in Appendix 1 showed how the variations in the ratio of the loaded area and thickness of pavement, and the ratio of modulus of elasticity of the pavement and modulus of elasticity of the subgrade influenced the strength of the pavement. Burmister made the assumptions that the top layer should have a modulus of elasticity equal to or greater than that below it.

For finding a suitable formula in designing of a flexible overlay, Steinbrenner's principle that the deformation of the loaded area was equal to the maximum deformation at the surface of a firm base, e.g., the concrete pavement, was made use of. The maximum deflections that were given by Burmister, both for rigid and flexible pavements, were used. However, the Author was not quite sure if that was the correct method because in adopting the procedure of determining stresses the assumption that a bituminous layer behaved in all respects

* Published at pages 499 to 549 of the Journal of the Indian Roads Congress, Volume XIX-3, June 1955.

different from elastic layer was made. As a check, the C.B.R. method was used as explained in para 5.3 of the Paper.

No systematic or authentic data about temperature variations which could be used in calculating the temperature stresses was available. Westergaard's formula for temperature stresses assumed that the temperature variation was linear. In U.K. experiments were carried out and according to Thomlinson's theory the temperature variation was non-linear. The experiments carried out in the U.S.A. showed that, under American conditions, the Thomlinson's curve required modification. Observations made in U.K. agreed more closely with the values obtained from Thomlinson's method than from the values given by Westergaard's formulae. In the absence of investigations in India, both the Thomlinson and the Westergaard's methods were tried. It was heartening to hear the President, Shri Mathrani, stressing the need for a rational design of pavements. Evolving a rational design was possible only if the data on which it was based was reliable. So the Author emphasised that authentic data on temperature stresses should be gathered throughout the country. Perhaps the Indian Roads Congress would use its offices in initiating such an investigation.

Shri C. L. N. Iyengar said that the Paper contained lot of valuable information on 'pavement design'. Rational theories for design of pavement thickness would be satisfactory if the basic assumptions made in the design could be attained in the field. If conditions in the field were same as were assumed, the pavement would behave exactly as it was designed to function. But problems were there and these were caused, wholly or in part, by unforeseen conditions such as (i) wheel loads in excess of the safe maximum load using the pavement; (ii) variable nature of subgrade, and (iii) the designer.

The duration of application of a load had an influence on the amount of yielding that took place in the pavement structure and on the amount of stress that it created. A sustained load caused more stress than a load applied for a short time. A moving load might cause less stress than a load at rest. On the other hand, impact stresses of large magnitude caused by rough surfaces, heavy wheel loads, hard tyres and high vehicle speeds could be very destructive even though they act for very short periods. Much work remained to be done before the relations that existed were thoroughly understood.

So, much reliance had to be placed upon the observed performance of pavements and it was not correct to make general observations based on the results obtained by using rational

formulae for design of the thickness, particularly in comparison with one another.

The design of overlays on existing concrete pavements, the real start was given by U.S. Corps of Engineers in 1943, when they had to strengthen airfields in United Kingdom to suit the operation of B-17's and B-24's which caused large scale failures on 6 in. or 8 in. pavements. Surprisingly enough, even to this day, the U. S. Corps of Engineers computed the thickness of overlays using empirical formulae based on experience rather than by theoretical analysis, e.g., the thickness of concrete overlay dc was determined by the formula

$$dc = \sqrt{(d^k - cd_e^2)}$$

in which d = thickness, equivalent single slab placed directly on foundation,

d_e = thickness of existing slab,

k = bond coefficient varying from 1.87 for fully bonded slabs to 2 for no bond conditions, and

c = a coefficient representing conditions of existing pavement.

If the Author had given some examples of actual work done in both flexible and concrete overlays together with their behaviour, his findings could have been better supported.

Page 516, item 5.4, para (a), the statement that "a bitumen overlay can take heavier load than 8-in. concrete overlay because of the larger deflection that is permissible in flexible pavements than in rigid pavement" appears to be incorrectly worded. It should be 'deformation' instead of 'deflection' as stated; otherwise as the load transfer through both the types of overlays to the existing pavement had to be at least equal, for equal strength, the larger deflection in the overlay would cause failure of the existing pavement.

In para 6.9 of the Paper, the Author had stated that investigations under Indian conditions were needed to find out the applicability of either Westergaard's or Thomlinson's formulae for temperature stresses. Shri Iyengar said that Thomlinson's formula was an improvement on Westergaard's formula.

The conclusion given in paras 10.1 and 10.2 of the Paper appeared to be questionable as the selection of overlay was not made solely from considerations of the load bearing capacity. The relative costs of construction, cost of maintenance, life and

resistance to the various forces to which the pavement was subjected had to be considered.

Regarding the development of a heat resisting bituminous composition, to date no satisfactory indigenous product was obtainable even for filling joints in concrete pavements exposed to jet blasts. It was doubtful whether it was practicable to use heat resisting materials for take-off and touch-down areas, taxiways and other hard standings.

Shri J. S. Narasimham said that the Paper contained valuable information and could be termed "Library Research".

In example 7 on page 514, equation (1) based on Steinbrenner's principle given on page 507 of the Paper was used for arriving at the maximum deflection under the load. Assuming the permissible deflection in concrete and the bituminous pavements according to the assumptions made by Burmister, the Author had calculated the maximum deflection under the load as 0.15 by using equation (1). The application of equation (1) to calculate maximum deflection in a bituminous overlay over a rigid pavement was questionable as the medium below bituminous pavement was concrete 8-in. thick. It did not seem correct to assume the top of the cement concrete pavement as top of the subgrade for purposes of calculation of the maximum deflection by Steinbrenner's method. The Author had adopted the Burmister's graph shown on page 542 giving the relationship between settlement coefficient and thickness of pavement in getting the modified value for reduction of elasticity for the subgrade. This was not correct. Further, the problem dealt with was a 3-layered system, whereas Burmister's graph was applicable to a 2-layered system. The result obtained namely, $P = 78{,}000$ lb was very high.

Shri N. Mohan Rao said that the need for strengthening the road might be due to many causes but it was mainly due to (1) the lack of the bearing capacity in the soil below the pavement, or (2) the pavement not satisfactorily standing the wheel loads because of fatigue and other effects.

If the aim was only to reduce the stresses in soil, it was not necessary to have an overlay with a modulus of elasticity greater than that of the existing pavement. An overlay having modulus of elasticity equal to that of the existing pavement would serve the purpose.

Shri Mohan Rao said that when a pavement failed due to subgrade deficiency, the overlay should be laid only after

"mudjacking" to ensure that the original pavement was again uniformly supported.

The following factors, other than those mentioned by the Author, had to be taken into account in designing a pavement:

(1) total traffic intensity,

(2) total wheel load, tyre pressure and area of contact,

(3) effect of dynamic loading, and

(4) repetition of loadings.

In a wheel load of 10,000 lb and tyre pressure of 100 lb per sq. in., the contact area was 100 sq. in. and the intensity was 100 lb per sq. in. In wheel load of 6,000 lb and a tyre pressure of 60 lb per sq. in. also the tyre contact area was 100 sq. in. but the intensity was only 60 lb per sq. in. Even though a/h was constant in both the cases, the former needed a thicker pavement. So it was necessary to bring in the intensity of pressure into the calculations.

He enquired if the Author had studied the effect of dynamic loading in a two-layer and a three-layer system.

Due to repetition of a loading, fatigue occurred in the pavement and each repetition contributed to the progressive yielding of the soil. Mr. Middle Brooks of the U.S. Army had conducted some tests in America on this effect. A flexible pavement which was loaded to 0.2 inch deflection under a 30 in. diameter plate had stood well for static loading. But when the wheel loads for which the pavement was designed (based on static load test) traversed the pavement, it was found that the pavement had failed when the deflection was hardly 0.1 inch. The repetition of loading was very important in a rigid pavement where fatigue occurred in concrete and the normal deflection allowed under load was only 0.05 inch. Repetition of loading might not be a serious problem in runways. But it is important in roads. Employing a factor of safety, taking into account the number of repetitions, was essential.

Shri Fateh Chand referred to the remark of the Author that a layered construction was necessary in thick concrete pavements and said that the two layers should be laid practically simultaneously.

Shri D. C. Chaturvedi mentioned that cement concrete slabs as thin as 3 in. were laid in Uttar Pradesh and the information given in the Paper was useful in designing flexible overlays

on these. He suggested that flexible overlays might be laid over thin slabs and their behaviour observed. He agreed that investigation regarding temperature stresses in rigid pavements under Indian conditions should be undertaken by various Central and State research laboratories and the Indian Roads Congress should co-ordinate this work and draw out a programme.

Some investigations were undertaken by U.P., P.W.D. in 1941 regarding temperature distribution and its effect on thin concrete slabs. The following were some of the results :

1. Variation of temperature at the bottom of a 3-in. slab (during the month of November) was 12° against a variation of (96 – 61) = 35° in the surface temperature.

2. The expansion of the slab was not proportional to the surface temperature but to the temperature of the interior of the slab.

3. Co-efficient of expansion was about 4.4×10^{-6} for bonded slab and 5.5×10^{-6} for insulated slabs. The bond with the sub-grade retarded the free movement of slab but the bond was liable to be broken due to repeated expansion and contraction. Expansion joints were, therefore, absolutely necessary in bonded as well as insulated slabs.

4. The variation of temperature in thin slabs was not linear.

5. Reversal of streses in the pavement occurred every 24 hours. From morning to afternoon temperature in top layer was higher than in bottom while from evening to early morning the reverse was the case.

As above conclusions were based on data collected for about 3 days only, it was necessary that these should be collected for different months and under different climatic conditions.

Shri R. Nagarajan* mentioned that the application of the various methods of theoretical analysis to pavements was subject to many limitations and, in certain cases, theoretical calculations, gave results different from the values obtained by actual measurement. For example, Burmister's method referred to by the Author did not take into account the following factors :

1. That the soils and materials forming the pavement were very far from ideal elastic materials.

2. The value of limiting displacement chosen was arbitrary.

* Comments received in writing.

3. The effect of dynamic loading, which was of considerable importance, was neglected.

He agreed with the Author that efforts should be made to modify the theories to conform to actual observation under different conditions.

The Author had combined many of the theoretical concepts, each with its own limitations. So, in his opinion, the conclusion drawn should not be given complete credence except after experimental verification of the various factors on a full scale.

While discussing the temperature stresses in the concrete pavement slab, the Author had brought out many of the theoretical concepts. It might be of interest to point out that the Road Research Laboratory, Harmondsworth, had studied variation of temperature gradient across concrete pavement slabs for a long period extending over years. From the annual records of temperature gradient across a 9-in. slab presented by Loe,' it was seen that the total period for which the temperature gradient was positive (the top hotter than the bottom) was greater than the total period for which the temperature gradient was negative (the bottom hotter than the top) and for more than 12 per cent of the time there was no temperature gradient across the thickness of the slab. The value of the maximum of positive temperature gradient was far greater than the value of the maximum of negative temperature gradient, and the maximum value of positive temperature gradient occurred when a hot sunny day followed a cool night. For the slab studied by Loe, the maximum value of temperature gradient was 17° F. Sparkes[9] from a study of temperature records over many years across a 6-in thick concrete slab found that the maximum temperature gradient was 31° F. The maximum temperature gradient of 32.4° F. for a slab 8.67 in. thick was recorded by Dr. Emberle in Germany. Shri Nagarajan was of opinion that the value of temperature gradient would be approximately 30° F. for 6 to 9 in. thick concrete slabs under Indian conditions. The Author showed by his computations that for a slab 8-in. thick, the temperature gradient was 21.5° F. for the climatic conditions of Poona. Shri Nagarajan favoured a higher and a safer value, namely, 30° F. He supported the Author's suggestion that detailed investigation under Indian conditions, which will help the development of rational design procedures for pavements, should be undertaken.

When discussing the suitability of airfield pavements for jet aircraft, the Author had pointed out the difficulties experienced with the flexible bituminous pavements and layers superimposed over concrete pavement due to the inability

of the bituminous materials to stand the hot blasts. Similar difficulties were experienced with the ordinary concrete pavements also at the joints which were spaced at close intervals, in addition to the pitting of the concrete surface. Prestressed concrete pavement which had joints at intervals of 400 ft and greater and with its greatly improved structural behaviour was superior to other types mentioned in the Paper.

The serious objection to prestressed concrete pavements had so far been the technical difficulties involved in the construction itself and in the production of a high quality concrete. With the experience gained in many prestressed concrete constructions, these difficulties should be overcome.

The first airfield pavement of prestressed concrete was completed in 1947 by M. Freyssinet of France for the Orly airport, Paris. It was standing in an excellent condition after 8 years of service. The cost studies of prestressed concrete pavement construction, mostly applied to roads, went to show that it was far more economical than the conventional concrete pavement of equal strength and compared favourably with other types of pavements as well.

Col. S. K. Bose (Author) referred to the remark of **Shri C. L. N. Iyengar**, that all the conditions assumed in the theoretical analysis were not actually in the field and said that for simplicity sake some assumptions had to be made. If the many variables were introduced the analysis became involved.

In the very beginning it was mentioned that the Paper dealt with two aspects viz. wheel load and temperature stresses. Before final design was made it was no doubt, necessary to take into consideration repetition of loads, changes in the moisture etc.

Maintenance of the flexible pavement was easy. On the other hand the rigid pavement was extremely cracky.

Referring to **Shri J. S. Narasimham's** remarks the Author said Burmister had made some assumptions about the maximum permissible deformations for rigid and flexible pavements. These were gtven in example 7 of the Paper. The maximum deflection for the overlay system at the centre of the load is 0.2 in. which is maximum for a flexible pavement minus .05 in. which is the maximum for rigid pavements.

Referring to **Shri N. Mohan Rao's** comments Col. Bose said that it was necessary to go in for a rigid overlay having a modulus of elasticity higher than that of the pavement to be improved, if full value for the money was to be had.

Shri Mohan Rao desired that factors other than those mentioned in the Paper should have been taken into account. The Paper concerned itself with the problem of the strengthening existing concrete pavements by superimposed layers and only two principal aspects namely wheel load and temperature variations had been considered.

Shri E. A. Nadirshah (Chairman) said that the Paper had been received late and even a casual reading revealed that in the present state of development, all the mathematical theories on pavement design required verification even for roads for which they were originally intended. Therefore, their extension to airfields should be done cautiously. Though there were some accepted theoretical methods for arriving at the thicknesses of flexible and rigid pavements for a given set of loading, weather and subgrade conditions, the procedure in converse applied to examples as was done in the Paper was not likely to give good results. Perhaps, very rough calculations or trends could be arrived at if a large number of examples were worked out. Hence, the only rational method appeared to be to base the design on the observed behaviour of completed projects. Since there were a wide range of subgrade conditions and as field observations of existing pavements were not available, and as construction and maintenance costs had to be considered, the remarks in para 10.1, page 534 of the Paper, might not be justifiable particularly when the effects of deleterious exhaust gases from jet planes had still to be investigated. This meant "placing the cart before the horse."

Only empirical formulae were still in use. Besides, considerable amount of testing and valuation of rigid and flexible pavement overlays had been scheduled during this year by U. S. Corps of Engineers at their rigid pavement laboratory at Lockbourne airforce base and Sharonville in Ohio. If similar observation on overlay work already done at various airports in India were collected, it would possibly help in a better appraisal of the results obtained from these theoretical calculations. He hoped that Col. Bose and his colleagues would bring the practical aspects for a further discussion of the subject. He once again thanked Col. Bose on his behalf and on behalf of the members of the I. R. C. in preparing a very interesting Paper and for giving very patiently satisfactory answers to the points raised by various speakers. The subject was of great importance and views expressed in discussion were so divergent that it was a fit case to recommend to the Council to appoint a special committee or to entrust the work to one of the existing committees to go into the various questions involved and to arrive at a correct solution.

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3. Chaston, F. N.—'Prestressed Concrete Pavements'—Proceedings Symposium on Prestressed Concrete, Sydney, June-July 1953.
4. Nagarajan, R.—'Prestressed Concrete Pavements'—Indian Concrete Journal, June 1955.

CORRIGENDUM TO THE PAPER

Pages 507 and 508	instead of 'W_c' read 'W_o'.
Page 508	in equation 2, instead of '$2(1-W_s^2)$' read '$2(1-\mu_s^2)$'
Page 509	in equation 5, instead of $\frac{'C_3'}{C}$ read $\frac{'C_3'}{C_2}$
Page 514, Example 7	instead of '$(0.2-0.15)=0.15$' read '$(0.2-0.05)=0.15$'.
Page 523	give equation number 14(a) to the equation given.
Page 526, last but one line	instead of 'equation 15', read 'equation 14(a)'.
Page 528, first line	instead of equation '14' read '14(a)'.
second line	omit the figures '262 × 0.532.'
Page 540	in equation (1.2), instead of 'P' read 'p'.
Page 541, sixth line	instead of 'equations 2 and 3' read equations '1.2 and 1.3'.
Page 542, Figure 1	the values of settlement co-efficients F_w below 0.1 should read 0.08, 0.06, 0.05, 0.04, 0.03 and 0.02.

INDIAN ROADS CONGRESS

Classified List of Papers, etc., in the Proceedings I to XIX

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8	Cycle Tracks.	R. S. 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

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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
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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
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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
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19	A note of 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	—
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22	Waterproofing of Alkaline Soil by Linseed Oil Cake.	B. R. Sen & Manohar Lal	XV-3	—	492 to 500	—
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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
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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
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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

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3	Notes on the use of Tar, Bitumen and Emulsions in the Punjab.	R. Trevor Jones	I	5 (a)	135-145 & 168-182	7
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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
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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	—	153-172	—

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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
13	A Review on "Modern Road Construction in Concrete."	Lt.-Col. W.P. Andrews	XIII-1	—	169 to 173	—
14	Cement Concrete Trackway.	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 122-1	—
10	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 Influnce of a Superimposed Layer in increasing the Load Bearing Capacity of a Rigid Pavement.	S. K. Bose	XIX-3 & 4	179	499 to 541-3 & 725 to 734-4	179

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6	Reinforced Cement Concrete Bridges of 24 ft span constructed in Gwalior State.	S. N. Bhaduri	IV	C	1(c)-20 (c)	47
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24	R. C. Bridges in Travancore State.	S. Rajaraman	XI Parts 3 & 4	118	301 to 325 -3, & 569 to 576-4	118
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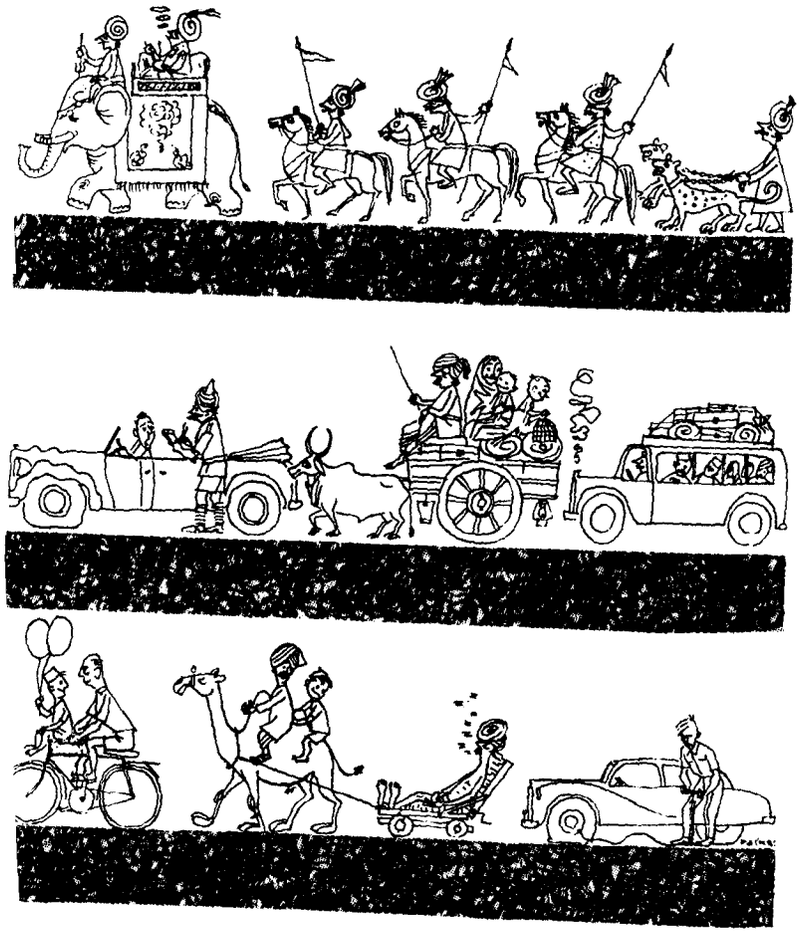

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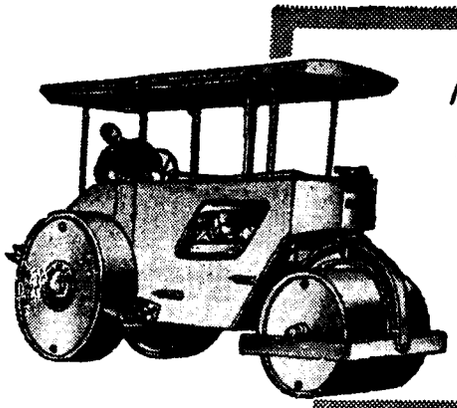

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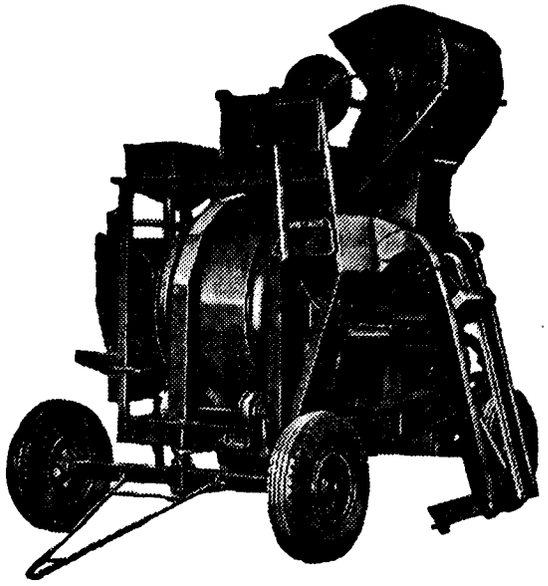

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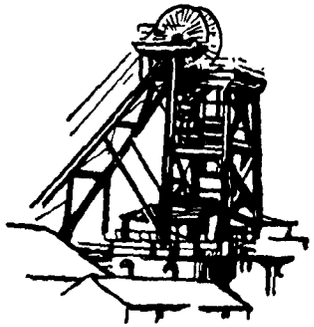

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