Journal of Indian Roads Congress

Dr Rajendra Prasad
President of the Republic of India
is pleased to be the
Patron
of the
Indian Roads Congress, New Delhi.

By Command of the President of the Republic of India

Military Secretary's Office,
The 5th March 1951

B. Mallaya, Colonel
Military Secretary to the President

INDIAN ROADS CONGRESS

ESTABLISHED : 1934 REGISTERED : 1937

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Chief Engineer, Buildings & Roads, Uttar Pradesh.
Chief Engineer (Highways), Madras.
Chief Engineer, Buildings & Roads, Punjab.
A representative of Railway Testing & Research Centre, Ministry of Railways, Lucknow.
A representative of Central Standards Office for Railways [Joint Director, Standardisation (Track)].
A representative of the Poona Irrigation Research Station.
A representative each from Lucknow, Madras, Karnal, Bihar & Hyderabad Research Stations.
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12. LOCAL COMMITTEE OF THE TEST TRACK COMMITTEE TO SUPERVISE DELHI-MATHURA ROAD TESTS.

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Consulting Engineer (Road Development)
A representative of C. P. W. D.
J. M. Trehan
Dr. Bh. Subbaraju

13. CEMENT CONCRETE ROAD SURFACING COMMITTEE.

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Chief Engineer (Highways), Madras, Goverdhan Lal
A representative of C. R. R. I.

14. ROAD TRANSPORT DEVELOPMENT COMMITTEE.

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Jagdish Prasad, C. P. Subbiah
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The Consulting Engineer to the Govt. of India (Road Development) is an ex-officio Member of all Committees.

INDIAN ROADS CONGRESS

NOTICES AND ANNOUNCEMENTS

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

The next General Session of the Indian Roads Congress will be held at Hyderabad from the 6th to the 13th January, 1959. (Programme printed on inside front cover). Members are requested to contribute Papers on any subject connected with Highway Engineering for discussion at the Session.

2. **Procedure**: Members who intend to contribute Papers on any subject connected with Highway Engineering are requested to intimate the fact to the Secretary, Indian Roads Congress, and to send a short synopsis of their proposed Papers as early as possible.

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

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

From past experience it is observed that most of the Members send in their contributions at the last moment, when the Congress Office is busy on work connected with the Session. As it takes a long time to get Papers printed in the Journal and as it is desirable that Members should have time to study Papers well in advance of the date of the Session, it is hoped that Members will make an effort to send their contributions **as early as possible**.

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

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

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

(i) **The Mitchell Medal** :

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

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

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

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

7. Rules and Regulations for the contribution of Technical Papers and the award of the Medals are published on pages 10 to 15.

II. RULES AND REGULATIONS FOR THE CONTRIBUTION OF TECHNICAL PAPERS AND THE AWARD OF MEDALS

1. The following Medals are available for award:

(*i*) **The Mitchell Medal**:

This is a bronze medal to be awarded annually for exceptionally good Papers contributed to the Indian Roads Congress in any year. This has been instituted to perpetuate Sir Kenneth Mitchell's connection with the Indian Roads Congress.

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

This is also a bronze medal to be awarded annually for Papers considered by the Council of the Indian Roads Congress to be of a decidedly more than average merit.

2. PROCEDURE FOR CONTRIBUTION OF TECHNICAL PAPERS

2.1. Our procedure in the past had been to invite Members to contribute Papers a few months before the holding of the General Sessions of the Indian Roads Congress. On receipt, the accepted Papers were circulated in advance to Members for prior study a month or so before the date fixed for discussion. This procedure resulted in the receipt of a large number of Papers all at one time and editing and printing had often to be done very hurriedly. Also Members often found that one month did not give them sufficient time to study all the Papers before the discussion at the Congress Session.

2.2. It has, therefore, been decided by the Council that Members should be invited, to contribute technical Papers throughout the year, as and when they are ready, and that the accepted Papers should be published in the Journals of the Society which, it is hoped, will be issued quarterly in future.

2.3. The Council considers that this will give Members more time to study the Papers and will also facilitate editing and printing. A record of the discussion and the comments received by correspondence will be published with the Author's replies in the Journal issued after the General Session.

2.4. It will be realized that it will only be possible to give effect to this new scheme if Members co-operate. The Council makes this special appeal to members to contribute Papers for discussion throughout the year at their convenience.

3. RULES FOR THE CONTRIBUTION OF TECHNICAL PAPERS

3.1. The Standing Rules for guidance when contributing Papers, are reprinted below. It is requested that Members read these rules and observe them when submitting Papers to the Congress.

3.2 Members intending to contribute Papers to the Indian Roads Congress on any subject connected with Highway Engineering are requested to send their contributions to the Secretary as and when these are ready without waiting for a special invitation.

3.3. Final acceptance of the Papers rests with the Council. In order, however, to avoid disappointment through the Council having to reject Papers owing to an excessive number being written on any one subject or for any other reason, it is requested that any Member intending to write a Paper should intimate to the Secretary the subject on which he wishes to write and enclose a short synopsis of the proposed Paper. He will then be informed whether his offer can be accepted.

3.4. The Council reserve the right to publish any Paper in the form of an abstract. When a Paper is published in abstract form the manuscript copy of the Paper as sent by the Author will be added to the Indian Roads Congress Library and made available for inspection by interested Members.

3.5. The Council have decided that Papers from non-Members who are experts or who have specialized knowledge will be welcome and acceptance of the Paper will carry honorary membership for the Author for the year provided there are good reasons that the contributor cannot join the Congress as an ordinary member.

3.6. The Council have expressed the opinion that Members, when choosing subjects for contributing Papers, should bear in mind the fact that there is often a good deal more to be learnt from failures than from success.

4. SCRIPT

4.1. The following instructions are for the guidance of Authors of Papers:

a. **All contributions should be drafted in the third person.**

b. Papers should be typed on one side of good stout paper of foolscap size, double spacing being used

and an ample margin (not less than 2 inches) should be left on the left hand side. **At least three copies of the typescript matter should be sent.**

c. The Author's full name, designation, academic qualifications and correct postal address should be given below the title of the Paper.

5. ILLUSTRATIONS

5.1. Illustrations fall into two classes, *viz.*,

a. Line drawings.

b. Half-tones.

5.2. *Line drawings* should be made in black Indian ink on superior white drawing paper or tracing cloth. Blue prints are of no use for reproduction and black line prints are also unsatisfactory.

Line drawings are generally classified into two categories:

a. Diagrams which go into the body of the Paper.

b. Plates which are generally on separate large size sheets.

5.3. *Diagrams*: The matter for the Journal is printed in 10 pt. size type (nearly $\frac{1}{16}$ in. in height); therefore, the written matter in diagrams should be so made that the size of the letter when reduced for reproduction should be about 1/16 in. The printed area of a page measures $6\frac{3}{4}$ in. deep by $4\frac{1}{4}$ in. wide. Therefore, the ultimate size of such drawings will not generally be more than 5 in. × 4 in. Thus, if a diagram is to be reduced to one quarter of the size submitted by the Author, the lettering on it should not be less than $\frac{1}{4}$ inch in height.

5.4. *Plates*: Plates should preferably be prepared in widths that are multiples of $7\frac{1}{2}$ in. The size of letters used in the plate should be so chosen that after reduction no letter would be less than 1/16 in. in size. Thus, if the width is 15 in. the minimum size of the letter should be $\frac{1}{8}$ in. The thickness of the letter should also stand corresponding reduction. The title should be in the right hand bottom corner in letters of such size that when reduced the size will be at least $\frac{1}{8}$ in. The name of the Author may be printed, if desired, at the bottom right hand side.

5.5. Scale should be drawn in the plate below the title to admit of reduction of drawings without altering the correct relation of the scale to the drawing. Mere mention of the scale

thus "Scale 10 ft = 1 inch" should be avoided as this would be incorrect when size of the plate was reduced photographically.

5.6. Coloured inks should not be used. When it is desired to distinguish lines, dotted or chain dotted lines should be used instead of colours.

5.7.1. In drawing diagrams or graphs, the following points deserve the consideration of Authors.

5.7.2. From the standpoint of pleasing appearance, a rectangular graph or drawing with proportions between 3 by 5 and 3 by 4 is to be preferred to a square one.

5.7.3. The appearance and effectiveness of a graph depend in a large measure on the relative thickness of lines used in its component parts. The thickest line should be used for the principal curve. If several curves are presented on the same graph, the line width used for curves should be less than that used when a single curve is presented. Co-ordinate rulings should be the narrowest in thickness. Principal reference lines such as the axes should be wider than other rulings but narrower than curves. For the size of reduction that is usually adopted, for the I. R. C. Journals it is considered that the thickest line *when finally reduced* should not be more than $2\frac{1}{2}$ points, *i. e.*, 0·035 inch in width.

5.8. Finished illustrations should not be folded for purposes of despatch. When mailed flat, they should be stiffened by using card boards or rolled with the drawing outside to prevent cracking of the Indian ink lines and securely packed.

5.9. "*Half-tones*" are ordinary photographs and it is necessary to see that prints are clear, slightly over printed and preferably glazed. Photographs which are dim or out of focus do not come out distinctly in reproduction and make a bad "half-tone". Negatives should accompany the photographs whenever possible, and will, if desired, be returned when done with. Captions should be written on the back of prints in soft pencil.

6. BRIDGE DETAILS

6.1. Members contributing Papers on any bridge work actually carried out are requested to give *inter alia* the following details.

a. A site plan showing the road and river for two miles on either side of the bridge site;

b. A dimensioned cross-section of the roadway;

c. The loading on which the design is based;

d. The cost per square foot of the elevation area comprised by the formation level and the bottom of the foundations; and

e. The ratio of the total cost of the substructure to the cost of those parts of the superstructure as are subject to variation with variation of span.

7. UNITS

7.1. Members are particularly requested to use the standard units of weight, measure, and cost given below:

STANDARD UNITS OF WEIGHT AND MEASURE

	Description of works	Units to be adopted
1.	Road material such as metal gravel or moorum, sand	100 cu. ft.
2.	Binder in surface dressing and grout	lb per 100 sq. ft.
3.	Binder in premix, carpets, etc.	lb per cu. ft. of aggregate.
4.	Cement	By weight and not by volume
5.	Water-cement ratio	gallons of water per cu. ft. of cement (assumed as 90 lb)
6.	Cost and rates	In Indian Standard currency (Rupees, etc.)

8. FORMULAE

8.1. Mathematical formulae should be drawn carefully by hand and not set out with the typewriter.

9. ABBREVIATIONS

9.1. The use of symbols should be avoided. For example 6′-2″ × 3′-3″ should be written 6 feet 2 inches by 3 feet 3 inches. Similarly 225° C. should be written as 225 degrees centigrade, and so on.

10. ITALICS AND EMPHASIS

10.1. Only those words and phrases which are to be printed in italics should be underlined.

11. PARAGRAPHING

11.1. When divisions and sub-divisions are designated by numbers and letters, the following symbols may be used in the arrangements indicated.

I.

II.

1.

2.

a.

b.

(i)

(ii)

12. ACKNOWLEDGMENTS

12.1. Sources of quotations appearing in the Papers should be stated and acknowledgment should be made for all information culled from books, periodicals, and proceedings of sister Societies, etc.

III. PROCEDURE REGARDING THE DISCUSSION OF PAPERS AT THE ANNUAL SESSIONS OF THE INDIAN ROADS CONGRESS

1. The order in which Papers will be taken up for discussion will be decided by the Council and intimated to members attending the Session.

2. The Chairman will introduce the Author and will call upon him to present his Paper for discussion. The Paper will be taken as read. Introductory remarks shall not ordinarily take more than 10 minutes and, unless the Author had something new to say which came to his notice since the submission of his Paper, the introduction should be limited to 250 words. After the introduction, the Paper will be open to discussion.

3. To facilitate the conduct of business and the fixation of time for various sittings and individual Papers, those desirous of raising questions or offering comments at the meeting should inform the Secretary well in advance (*at least 24 hours before the meeting*) about the Papers on which they would like to speak and the time they would take. Those who have not given the required intimation to the Secretary may, at the discretion of the Chairman be allowed to take part in the discussion if time permits and after those who have intimated their intention to speak in advance have spoken.

4. A copy of or the nature of the comments which a member intends to make should be sent in advance to the Author of the Paper and a copy endorsed to the Secretary.

5. If the comments are likely to take more than ten minutes or if they involve lengthy mathematical matter or diagrams, it would be desirable to send a copy of these to the Secretary at least 2 weeks before the date of the meeting so as to enable him to have them printed and circulated to all members attending the meeting before the discussion on the Paper takes place. These comments may, at the discretion of the Chairman, be taken as read and the member making them will thus only be required to explain generally the nature of his comments. The Author will, if possible, reply at the meeting as if the comments had been made orally.

6. Members who do not want to speak but want clarification of any issues arising out of the discussion or the introductory remarks of the Author should write out their queries on

"Comment Slips" which will be provided for the purpose while the discussions are in progress. Volunteers will be deputed to distribute and collect these slips at frequent intervals. The slips will be sorted out by the Secretary and at the end of the talk by the Speaker or Speakers, the Chairman will read out the queries and the Speaker or the Author will give a reply.

7. Members who are unable to attend the Session and who desire to comment on any Paper should send one copy of a note of their comments to the Author of the Paper and two typescript copies to the Secretary. A gist of the comments together with the Author's reply thereto will appear in the Proceedings.

8. After all members wishing to do so have spoken on a Paper, or when the Chairman considers that because of lack of time the discussion must be brought to a close, the Author will be called upon to reply.

9. If the Author of a Paper is unable to be present, he should depute another member to introduce his Paper and to reply to the discussion and should inform the Secretary accordingly.

IV. LIBRARY

1. Information and books on loan from the libraries of the Consulting Engineer (Road Development) and the Indian Roads Congress are available to **Members** of the Indian Roads Congress and can, on application, be had of the Secretary, Indian Roads Congress, New Delhi under the following arrangements :

(a) **For Members of the Indian Roads Congress who are in the service of the Central or State Governments.**

Specifically named books or literature in response to enquiries on technical subjects will be sent to officers of the rank of Executive Engineer and above. Others should apply through their Executive Engineers or officers of equivalent rank.

(b) **For Members of the Indian Roads Congress who are not in the service of the Central or State Governments.**

Applications for specifically named books as well as enquiries for literature on technical subjects should clearly state the Member's roll number, his correct postal address, and the title and Author of the book.

2. The library is intended primarily for reference. It is the source of information from which the Secretary, Indian Roads Congress, is enabled to answer enquiries addressed to him.

3. **Books are loaned for reference only and not for continuous use.** The library cannot be expected to relieve officers of the necessity of purchasing books required constantly or for long periods of time.

4. Ordinarily not more than two books will be issued at a time, but in special cases a larger number may be issued at the discretion of the Secretary.

5. The following rules will be strictly enforced :

(a) Books are issued for one month in the first instance. If a book is required for a longer period, an intimation should be sent to the Secretary, Indian Roads Congress for renewal before the due date of return. The book may then be re-issued for another month at a time at the discretion of the Secretary but in no case will any book be issued for a total period exceeding three months.

(b) If a member does not return library books when the period of loan has expired or in any case within three months of the date of issue and thus deprives other members of their use, he will be liable for a fine at the rate of one anna a day for every day of retention up to three months and two annas a day thereafter up to six months. The Secretary will also have no power to issue any more books to the member until all the books already issued are returned. If all books are not returned within six months, twice the cost of the books will be debited to the borrower in addition to the fine referred to above.

(c) Current issues of Journals cannot be issued to members outside the office of the Consulting Engineer Road Developments) but back issues of certain Journals may be sent on loan for a limited period.

(d) Books are issued strictly subject to the condition, in all cases, that they will be returned promptly if actually required and called for by the Secretary, Indian Roads Congress. Retention of a book after it had been recalled will render the member liable to the same penalties as if he had retained a book beyond the period of original loan.

(e) Borrowers are requested to take every care of books while in their possession, and particularly not to mark, underline, or note on the pages.

(f) If, during the period of issue to a borrower, any book is lost or so damaged as to be unserviceable for future use, the Secretary shall recover from the borrower a sum equal to the cost of obtaining another copy of the book.

6. **Instructions**:

(a) No acknowledgment is required other than the postal acknowledgment card.

(b) While returning books, care should be taken to get them adequately packed to prevent damage in transit. They should be sent **"registered** and **acknowledgment due"**.

7. **General**:

(a) Rare or specially valuable books and certain books of reference will not be sent out of the library.

(b) Any book may, however, be consulted in the library during office hours.

(c) Members who retain books for longer than a month after they have been called back or for longer than six months from the date of original issue and thus selfishly deprive other members of the use of the books, will be fined and/or charged subject to the penalties stated in these rules and deprived of all the privileges of membership until the dues are paid.

NOTE: All Members of the Indian Roads Congress, not in arrears of subscription for more than 90 days, are entitled to borrow books.

V. NEW ADMISSIONS

LIST OF MEMBERS OF THE INDIAN ROADS CONGRESS ENROLLED FROM 11-4-58 TO 30-9-58

Serial No.	*Roll No.*	*Name*	*Address*
1	2409	Shri D. Hariharan	Resident Engineer, Shobha, Ranganathapuram, **Coimbatore.**
2	2410	Lt.-Col. N. B. Grant	Staff Officer, Engineer-in-Chief Branch, Kashmir House, **New Delhi.**
3	2411	Shri M. Z. H. Siddiquee	Assistant Engineer, P.W.D. (R & B) I/c., Project Sub Division, Arrah, **District Shahabad** (Bihar).
4	2412	Shri M. L. Sethi	Junior Engineer, P. W. D., B/R., Nohar, **District Ganganagar** (Rajasthan).
5	2413	Shri S. Badaruddin	Lecturer in Civil Engineering, Engineering College, Osmania University, **Hyderabad-Dn.** (Andhra Pradesh).
6	2414	Shri K. V. Ekambaram	Chief Engineer (Highways), Chepauk, **Madras-5.**
7	2415	Shri M. D. Tank	Deputy Engineer, P.W.D. Navsari Sub Division, **Navsari** (Bombay State).
8	2416	Shri N. Shanmugam	Junior Engineer, Highways, Local Development Works, Pattukottai, **Tanjore District** (Madras State).
9	2417	Shri K. S. Ramanujachari	Assistant Garrison Engineer B/R South, C/o Garrison Engineer (M.E.S.), **Deolali** (Bombay State).
10	2418	Shri A. N. Thusu	Divisional Engineer, Magarmal Bagh, **Srinagar** (Kashmir).
11	2419	Shri R. M. Pillai	Assistant Engineer, Highways, Bridges Special Sub Division, Polur, **N. A. District.**
12	2420	Shri G. Seshaiah	Assistant Engineer, Highways, Bapatla, **Guntur District,** (Andhra Pradesh).

Serial No.	*Roll No.*	*Name*	*Address*
13	2421	Shri Ramjee Singh	Personal Assistant to the Superintending Engineer, North Bihar Circle, P.W.D., **Muzaffarpur** (Bihar).
14	2422	Shri Ramesh Chandra	District Engineer, P. W. D., **Hardoi** (U.P.).
15	2423	Shri K. Sundara Rajan	Junior Engineer, Highways, Office of the Superintending Engineer, Highways, **Cuddapah** (Andhra Pradesh).
16	2424	Shri L. Alreja	Junior Engineer, C/o. Shri Radha Krishna Alreja, Assistant Revenue Officer, City Corporation, **Udaipur** (Rajasthan).
17	2425	Shri Gurmej Singh	Sub Divisional Officer, (W & B), Belonia Sub Division, **Belonia** (Tripura).
18	2426	Shri Y. N. Chandra Shekara Iyer	Assistant Engineer, Gaya Improvement Trust, **Gaya** (Bihar).
19	2427	Shri D. K. Gupta	Assistant Engineer, P.W.D., 3, Hardwar Road, **Dehra-Dun.** (Uttar Pradesh).
20	2428	Shri J. A. Shahmiri	Assistant Engineer, 'Chaman' Aerodrome Road, Barzala, **Srinagar** (Kashmir).
21	2429	Shri K. D. S. Shond	Junior Engineer, P.W.D., Near Railway Station Gangashahar, **Bikaner** (Rajasthan).
22	2430	Shri B. V. Subba Rao	Assistant Engineer, Highways, Local Development Works, **Srikakulam** (Andhra Pradesh).
23	2431	Shri K. Perumal	Junior Engineer, Highways, P.O. Polur, **North Arcot District,** (Madras State).
24	2432	Shri M. A. Samath	Assistant Engineer, Highways, Local Development Works, Tiruvannamalai, **N. A. District.** (Madras State).
25	2433	Shri Ved Prakash	Junior Engineer, Basai Bridge, P.O. Suwasra Mandi, **Distt. Mandsaur** (M. P.)
26	2434	Shri R. R. Mittal	Assistant Engineer, P.W.D., **Bareilly** (U.P.).

Serial No.	*Roll No.*	*Name*	*Address*
27	2435	Shri D. N. Sarma	Assistant Engineer, Executive Engineer's Office, Mangaldoi, **District Darrang** (Assam).
28	2436	Shri S. V. Sharma	Assistant Engineer, Community Projects, **Udaipur** (Rajasthan).
29	2437	Shri Dharm Vir	Assistant Engineer, P.W.D., **Meerut.** (Uttar Pradesh).
30	2438	Shri B. L. Mathur	Assistant Engineer, District P. W. D. (B & R), **Kotah** (Rajasthan).
31	2439	Shri K. Kailayam	Assistant Engineer, Highways, Bridges Investigation, Gandhipuram, **Coimbatore** (Madras State).

ASSOCIATE (HONORARY MEMBER)

1	72	Economic Commission for Asia and the Far East	Bangkok, **Thailand.**

VI. DEATHS

The Council have received with regret intimation of the following death :

Serial No.	*Roll No.*	*Name*	*Address*
1	1321	T. K. Sahay	Executive Engineer, P. W. D., Hazaribagh Division, **Hazaribagh** (Bihar).

VII. 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 Road Congress.

Serial No.	*Roll No.*	*Name*	*Address*
1	1497	Deshpande, D. V.	63, Shukrawar Peth, **Poona-2.**
2	259	Mohd. Ibrahim	Executive Engineer, Hydro Electric Civil Division, Tungabhadra Project, Khairatabad P. O., **Hyderabad-Deccan.**

THE 52ND COUNCIL MEETING

Bombay, August 1958.

Bombay, rightly described as the "Gateway of India", a cosmopolitan city and the most modern city of India was the venue of the 52nd Council Meeting of the Indian Roads Congress. The Government of Bombay had placed various committee rooms of the Sachivalaya at the disposal of the Congress for holding their Council and Committee meetings. This was not the first time that the Government of Bombay extended their hospitality to the Congress. Earlier the Congress met in Bombay in December, 1939 and January, 1950. The Council also held a separate meeting in March, 1944.

Shri S. K. Patil, Minister of Transport and Communications arrives to inaugurate the Council meeting

The Council meeting was befittingly inaugurated on the 9th August by Shri S. K. Patil, Minister of Transport and Communications, Government of India.

In a predominantly agricultural country like India, Shri Patil said, roads were the main arteries of communication bring-

ing together the rural and urban population. No Government which aimed at uplifting the Indian villages could ignore the development of the roads in the country.

Referring to 20-year Plan on road development, the Minister said that it is not impossible of achievement. Apart from the fact that road transport was complementary to rail communications, roads by themselves formed an important factor in the economic life of the country.

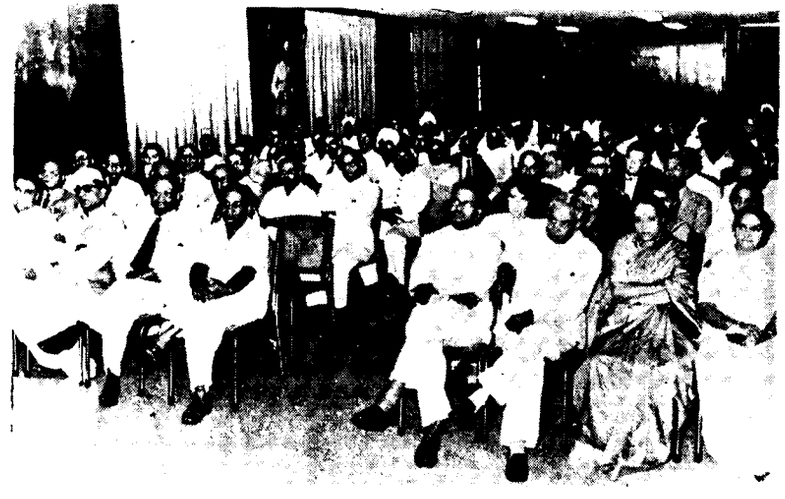
The Government of India were well aware of needs of more finance for road development and recently they had decided that Rs 5.58 crores—about half the sum realised from additional taxes on cement—would be utilized to build "expressways" on an experimental basis and to extend the highways.

Shri S. K. Patil, delivering the Inaugural Address

Praising India's engineers, he said that they "are doing a job of which any nation will be proud of". He announced that the Government of India had decided to form a national cadre for engineering, medicine and forestry on the lines of the Indian Administrative Service.

He wanted the engineers to display their talent and skill in seeing that roads built by them are durable.

Earlier, Shri W. X. Mascarenhas, President, Indian Roads Congress emphasised the need for road development because an effective system of communication "activised the national



The audience listens to the speeches with rapt attention

economy". He also suggested the promotion of construction of modernised surfaces by mechanised means to secure quality control and the maximum value for the money.

Shri Sujan Singh, Vice-President, Indian Roads Congress proposed a vote of thanks.

The Council met for three days and discussed various important subjects. They recommended the setting up of Highway Department in each State and the creation of an All-India Service of Engineers. The Council also expressed the view that mechanised methods in road construction should be used as far as possible to exercise economy and to obtain quality control, and taking particular care that any such process should not lead to un-employment; on the other hand, it should create new avenues of employment with the opening of new industries. It was agreed that a few specimens of road making machinery should be imported and then standard designs evolved, otherwise, there will be difficulty of spare parts. The training of personnel to man the equipment was equally important. Among other subjects discussed by the Council were the possibility of

The Council meeting

Another view of the Council meeting

arranging a P. W. D. Ministers' Conference, holding a Session in Ceylon, standardising traffic census form for non-urban roads, finalization of the bridge code, the recommendations of the stabilized soil roads committee and the compilation and publication of a list of all bridge and road building machinery manufacturers suppliers and dealers in different parts of India along with their addresses and types of machinery sold by them.

The Council discusses the second Road Development Plan

On this occasion, many technical committees also met and discussed various important subjects. The Traffic Engineering Committee considered evolving of general principles of parking and loading of vehicles. Another important subject discussed by the Committee was the regulation of mixed traffic in towns. In busy town, traffic is subject to many hazards and its regulation is becoming increasingly difficult.

The presence of slow-moving vehicles hampers flow of traffic. Therefore, segregation of various types of traffic is very essential and this may be done as far as possible. Providing of separate cycle-tracks and foot-paths for pedestrians are also necessary. Expressways, exclusively for fast-moving motor vehicles, are necessary at some places. Pedestrian crossings, traffic light signals, central reservation in the carriageway are also important and should be provided. It is also essential to provide over-bridges or under-bridges at difficult crossings to accelerate the

movement of traffic. Continuous effort should be made to educate the public about road use.

Other subjects discussed by the Committee were the participation of Indian Roads Congress in Traffic Study Week being organised in India under the auspices of ECAFE and nomenclature for traffic engineering terms.

The Specifications and Standards Committee considered the design of kilometer stones and discussed its future programme. The Bridges Committee discussed the revision of Section II of the Indian Roads Congress Bridge Code dealing with loads and stresses.

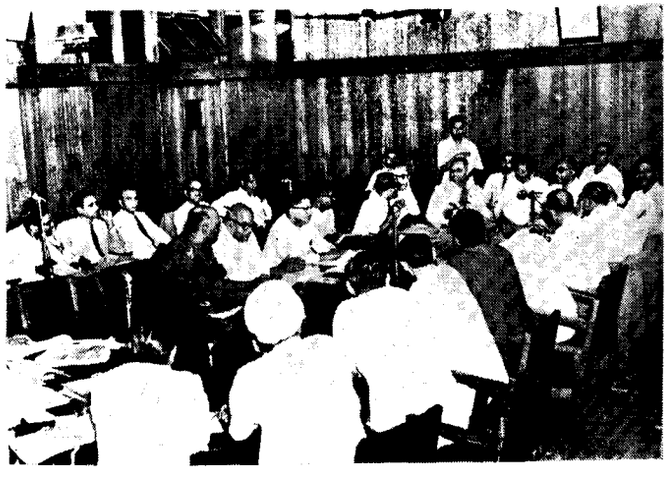
During the first Five-Year Plan, nearly 38,140 miles of unsurfaced roads and 6,120 miles of surfaced roads were built under Community Project and National Extension Service scheme in various parts of India. The Community Projects Road Deve-

Specifications and Standards Committee meeting

lopment Committee met to prepare a scheme recommending measures to be adopted for properly maintaining roads constructed under the Community Project Schemes.

The Soil Research Committee discussed the specifications for stabilized soil base and wearing courses, stabilization of black cotton soil and their classification.

The Research Organization Committee discussed the various points arising out of the general report on Road Research done in India during the last year. The other subject discussed by the Committee was the difficulty experienced in procuring equipment for research laboratories on account of shortage of foreign exchange.



Bridges Committee meeting

The Road Transport Operation Cost Committee which was appointed at the instance of the Government of India to study (i) the cost of operation of motor vehicles on different classes of roads and (ii) the economy resulting from road improvement, reviewed the progress made about the experiments being conducted by U.P. and the Bombay State Transport Undertakings. As recommended by the Committee at its last meeting, the State Transport Undertaking in Himachal Pradesh agreed to conduct the experiments in order to bring the hill roads under the scope of the investigation.

The prevention of Ribbon Development Committee also held its meeting and while noting the progress made by the various State Governments about the prevention of Ribbon Development on roads emphasised the need of passing Highway Bills on the lines of the draft Model Highway Bill prepared by the Government of India and circulated to State Governments.

Research Organisation Committee meeting

The Education Committee met and discussed the various problems relating to the education of highway engineers including arranging of refresher courses for the practising engineers.

The Cement Concrete Road Surfacing Committee discussed the various practices regarding cement concrete road pavements.

The road transport development problems were also reviewed by the Committee dealing with this subject.

The Manufacture of Road Making Machinery and Mechanization Committee noted the progress made in regard to the manufacture of stone crusher and concrete mixers in India. The Committee felt that the question of manufacturing motor graders should also be examined as the demand for this item of machinery will be increasing for the maintenance of earth and gravel roads. It was decided that in view of the new method of bulk distribution of bitumen the question of manufacture of bitumen distributors, hot-mix plant, etc., required for black-topping should be examined. Progress about the manufacture of various other items of road-making machinery was also discussed.

Other highlights of the Council meeting were a Contributory Dinner on the 9th August, lunches by A.C.C. & M/s. Burmah-Shell, tea by I.R.T.D.A. and Bombay State Road Transport

Corporation. These occasions provided the necessary relaxation and refreshment in the midst of the strenuous deliberations. They also provided an opportunity for associating local gentry with the activities of the Indian Roads Congress.

Shri U. J. Bhatt, Chief Engineer, Bombay proposing a toast at the I.R.C. Contributory Dinner at the National Sports Club

Shri S. K. Patil speaking at the Contributory Dinner

The lunch of the A.C.C. at the Willingdon Club

Reception by the I.R.T.D.A. at the Taj

The Session of the Council ended on the 11th and on the 12th inspections of Burmah-Shell Refinery, Atomic Energy Centre, Premier Automobiles Workshop and the Aarey Milk Colony, one of the most modern milk colonies in the world, situated in a park 20 miles from Bombay, were arranged. The visits to these places were really very interesting and instructive.

The Council meeting was preceded by a series of meetings of he Chief Engineers held on the 6th, 7th and 8th August, 1958 to liscuss the Second All-India Road Development Plan. Keeping n view that the financial position is not likely to ease soon,

The Chief Engineers' Meeting

Another view of the Chief Engineers' Meeting

the Plan has been formulated with due restraint. At the same time, a certain minimum facility in roads has to be provided. The Plan envisages an overall increase in the road length from 26 to 52 miles per hundred square miles of area which is quite low. The corresponding figures for the United States of America and the United Kingdom and France are 100, 200, and 300 miles per hundred square miles. Even for achieving this modest objective the cost of the Plan works out to Rs 4,700 crores spread over a period of 20 years from 1961. The Plan takes into consideration an increase in the number of motor vehicles corresponding to the increase in the road milage.

PRESIDENTIAL ADDRESS

by

SHRI W. X. MASCARENHAS

Shri Patil, Ladies and Gentlemen,

This is the first time that the Union Minister for Transport and Communications has inauguated a Council Meeting of the Indian Roads Congress and we are therefore deeply grateful to you, Sir, for the signal honour you have done us in spite of your many preoccuptions and the unremitting demands of your high office.

Shri W. X. Mascarenhas, delivering the Presidential Address

It is hardly necessary for me, Sir, to emphasise to this distinguished gathering or to a national leader of your perception and stature the importance of roads which has been recognised from the remotest antiquity. The Rig Veda mentions Mahapatha, which my friend Shri Sinha would undoubtedly classify as national highways today. The Arthashastra and Sukraniti refer at length to the earliest road-planning in India. Apparently

a fairly elaborate Roads Department was instituted by Chandragupta. Special Officers were entrusted with road maintenance and road amenities in the form of kosminars, road-side arboriculture and wells and serais at regular intervals were provided on a scale that would have delighted the heart of my friend Shri Saraiya, Chairman of the State Road Transport Corporation.

During the Pathan & Mogul Periods the road system was greatly extended and Tavernier could record in the mid 17th Century that he found travel in India quite as comfortable as in Europe. Only inconsiderable fragments were however surfaced and most rivers unbridged. The British first undertook the systematic metalling and bridging of important roads but until the Great War road planning was somewhat fortuitous and all roads were designed for animal-drawn traffic only.

That great cataclysm in human affairs marked also the turning-point in road development in India. I will not weary you, Ladies & Gentlemen, with tracing the subsequent history of this development though it holds many important lessons alike for the planners and the politicians Today it is obvious that communications should be one of the first cares of any progressive Government for even the most primary Government functions become virtually impossible without them: conversely the better the communications the better can administrative energy be applied and distributed and the sooner and more effectively will all the social services and projects of a Welfare State such as we would wish ours to be, reach and uplift the common people. Communications as you, Sir, know more than most, not only serve as arteries for the flow of goods and services but also promote the commerce of ideas, ideals and aspirations and it would need a more eloquent tongue than mine and more time than you would be willing to give, Ladies and Gentlemen, to recount all the advantages of a good system of communications. One point only I shall make. **By closely linking up town and country, we shall not only benefit both but help to redress the growing imbalance between the urban and rural populations. Country life and rural occupations would become more attractive and the life and outlook of the villager brought nearer to the urban level.**

I have spoken of communications, which of course include waterways, railways and airways but it is self-evident that in a predominantly agricultural country of the size of India, highways must always remain the backbone of the transportation system. On the Agenda for today's Meeting we have the most momentous item, since the famous Nagpur Road Plan of 1943 was formulated—namely the successor to that Plan on which the

C. Es. have been working for sometime now and which after informal discussion by the I. R. C. will be put into its final shape and submitted for the approval of Government. The New Plan aims at increasing the total road length in the country which is expected to be 331,000 miles in 1961 to a total of 654,000 miles in a period of 20 years. Out of this 654,000 miles, only half will be surfaced. The implementation of the Plan will involve an expenditure of about Rs 4,700 crores. Put somewhat differently, the Plan envisages an overall increase in the road length from 26 to 52 miles per 100 sq. miles. The corresponding figures for U. S. A., U. K. and France are 100, 200 and 300 miles per 100 sq. miles.

This target may strike some as being over-ambitious and perhaps it is, considered in relation to our present resources but considered in relation to our actual needs we cannot do with less, if we are at all to plan a better life for the mass of our people in a reasonable period of time. As you are aware, Ladies and Gentlemen, in the field of aviation the resistance increases enormously with every increase in speed. The air just seems to pile up in a seemingly less and less penetrable mass, until at a critical speed you break through the sound barrier and the resistance thereafter is far less formidable. So also we have to make a superhuman effort in our plans of development to battle with seemingly insurmountable difficulties and obstacles until we have acquired the criticial momentum that will enable us to crash through the poverty barrier whereafter the country will be able to progress with much less agony and travail that now beset us. Viewed in this perspective, Rs 4,700 crores on road development in 20 years does not seem so very over-ambitious after all! As a pilot survey made by the I. R. T. D. A. in 1943 in Bombay State showed, for every rupee spent on the construction and maintenance of roads the return to the villages served exceeded 3 rupees, besides creating several other additional sources of revenue to Government. Road development thus activises the whole national economy and we have been heartened to read in knowledgeable predictions of the 3rd Five-Year Plan that the emphasis will shift in a significant measure from major irrigation and heavy industry and steel all involving a large foreign exchange component to transport, power and minor Irrigation.

In this connection, may I be permitted to point out one rather important factor in irrigation development, which appears to have been overlooked or seriously under-estimated by our planners? Great disappointment has been expressed recently about the poor utilisation of irrigation facilities that have been provided all over the country by the completion of enormous irrigation projects. Special Government Committees have

even been appointed to investigate the causes. It is however an elementary fact that it takes anything from 15 to 20 years for a canal to develop to its full potential. I know myself from personal experience that it was more than 20 years, with several setbacks and many vicissitudes, before the Godavari Canals and the Pravra Canals were fully developed. The same was true of the Nira Right Bank Canal. It is therefore unrealistic to expect that you have only to provide water and it will immediately be used. The bigger the irrigation project the longer it normally takes for full development. Minor irrigation alone achieves comparatively quick results. But what has this to do with road development? The point I am trying to make is that in view of this very considerable lag between the provision of irrigation facilities and their proper utilisation, it is a matter for consideration whether the pace of major irrigation construction cannot be slowed down somewhat thus freeing funds for pushing forward road development programmes. Incidentally road development will accelerate the utilisation of irrigation facilities and in this context may be regarded as of equal importance as the provision of easy agricultural credit or the application of chemical fertilisers and bulky manures. Moreover road development both directly through the constructional activity it creates and indirectly through the additional transportation it promotes is an ideal means for mopping up local pockets of unemployment. But when all is said and done, there still remains room for a difference of opinion as to how much of our resources should be devoted to road development. Again within the limits of the financial allotments that are finally decided on, there is room for a difference of opinion as to whether the money should be spent on extending the road milage or improving the existing milage or doing a bit of both.

But there can be no two opinions about the necessity of making every rupee spent go all the way of 16 annas and getting the best value for money both in terms of construction and maintenance costs and of transportation costs per ton-mile to the community.

This brings me, Sir, to the crux of the road problem as I see it and the burden of my song this morning.

In the realm of technology and engineering, as indeed in the whole scientific world, progress and efficiency are inseparably linked up with specialisation. It is therefore tragic that in the middle of the 20th Century and in the age of nuclear fission and inter-continental ballistic missiles and Sputniks and other man-made earth satellites and progressing blue-prints for inter-planetary travel I should have to plead for the establishment of a

Communications Deptt. in all the States of the Union to deal with roads, inland waterways and minor ports, and also airways and railways to the extent that these two subjects fall within the purview of the States. Not only must there be such a Specialist Communications Deptt. in every State but there must be specialisation within the Deptt. itself and specialist sub-cadres should be assigned to roads, waterways and minor ports and harbours. The omnibus character of the PWD cadres was suited to the horse and buggy days of the last quarter of the 19th Century when they were just instituted and the infrequent and comparatively simple works then undertaken.

Today we have works of such complexity, variety and magnitude going on everywhere that there is therefore plenty of scope for specialisation and a separate Communications Deptt. is an absolute necessity for most States. Even small countries like Greece, Turkey, Israel and Egypt have such Deptts. and reap the rewards of the specialised skills that they foster. Fundamental and Applied Research in Highway Engineering should also be encouraged—the Chief Minister of Bombay recently made this point in a public address—but now I ask: can you have sustained any fruitful research without specialisation? Needless to say we must first attract some of the best brains and recruit some of the most outstanding talent in the country to the engineering profession, and this we can only hope to do if we offer engineers the same scope for the exercise of their abilities and the same rewards, whether in the form of emoluments or social approbation, as, in a sort of hangover from pre-independence days, we reserve only for pure administrators and the custodians of law and order! **I would therefore urge that the Indian Service of Engineers should be revived and put on the same footing as regards the scale of pay and conditions of services as the I.A.S.** In fact I cannot see why Mr. Paul Appleby's suggestion of a single Civil Service for the whole country should not be accepted with an Administrative Wing, and Engineering Wing, a Medical Wing and so on, all wings drawing the same emoluments and all ranking as equals or near equals. To my mind, it is a complete travesty of social justice, something out of Alice in Wonderland but not nearly as funny, that a C.E. on the revised scale of pay though he is one of the principal architects of his country's future fortunes and responsible for spending crores of rupees every year should draw the same salary as a senior District Collector who has been passed over as useless for anything but a District charge. I am aware that this is a time of great difficulty and stress and that everybody and more particularly the Services should be filled with a special sense of dedication and of sacrifice. I can assure you, Sir, that engineers from C.Es. down are prepared to make any sacrifices that the national interest demands;

all I ask for is equality of sacrifice at least as between the different services.

Two other important points may be made while we are on the subject of securing maximum efficiency in road planning and construction.

The first is the need to ensure a proper flow of work. I cannot emphasise too strongly that a financial allotment or even a budgetary appropriation is not a plan. A plan implies a more or less precise scheme of road construction or improvement in which not only milages and class of road and numbers and type of bridge are fixed but also all technical details are planned in advance. If this kind of planning is done at the commencement of every 5-Year Plan and the conflicting claims of different regions and different interests are reconciled at the highest level well in advance, the engineers will be left free to get on with their jobs and will give a better account of themselves than they can under present conditions.

It is also essential that there should be some yardstick or norm that will enable us to fix the number of Officers and subordinates of different categories required to implement any given road plan. It is astonishing how in the chancelleries of the State and Central Govts., Secretaries and Jt. Secretaries spring up with a rapidity reminiscent of the theory of spontaneous generation, whereas the very mountains must be in labour, before they produce one Chief Engineer! I do not say that all these Secretaries and Jt. Secretaries are not necessary; I do say that additional C.Es. are even more necessary.

The second point that I would like to make is that we are urged from socio-economic considerations to adopt labour-intensive as against capital-intensive methods in road construction. This is of course a sound principle of national policy, so long as we get as good work by labour-intensive methods as we would by the use of machinery even if it means more time for the completion of a project. But if quality control is impossible without the use of machinery and if in addition we fail even to get proper value for money, then I think capital-intensive methods are fully justified. In my considered opinion we get something like 8 annas in the rupee only for every asphaltic carpet laid by present methods and I would therefore urge the immediate adoption of mechanised processes for bitumastic carpet laying from the crushing of the metal to the final laying and finishing of the wearing surface. This would mean that we must negotiate with foreign firms for the purchase of the necessary plant on the basis of a system of deferred payments or manufacture the plant in the country in association with foreign makers.

To recapitulate, my pleas are:

1. Road development activises the whole of the national economy and therefore more funds should be allotted to it.
2. A separate Communications Deptt. should be set up in each State to cover roads, inland waterways, minor ports, and to the extent with which the State Govts. are concerned with them, also airways and railways.
3. The Indian Service of Engineers should be revived and be allowed a scale of pay and conditions of service comparable to those of the I.A.S.
4. Specialisation should be encouraged within the newly constituted Communications Deptt. by the establishment of sub-cadres of specialists and research should be encouraged.
5. The road component of every Five-Year Plan should be determined in advance at the highest level and the pattern and pace of construction approved and then adhered to throughout the period of the Plan.
6. The numbers of Engineer Officers required to implement any road plan should be determined by a generally agreed formula embodying reasonable norms of works-load.
7. The construction of modernized surfaces by mechanised means should be promoted to secure quality control and maximum value for money.

These, Sir, are my pleas, mere aspirations, but, as I believe, also the pleas and aspirations of all road engineers in the country and indeed all those who have given careful thought to the subject. They have been voiced in some shape or form at different times by different people but I believe the time has now come for purposive and constructive action.

You, Sir, have always been a doughty champion of worthy causes and if you are convinced of the soundness of my pleas with your great authority as Union Minister, with your great gifts and tremendous enthusiasm and drive you could change the whole pattern of road organization and development almost overnight. It is true that you will have to carry the States with you in some measure, but your own convictions must ultimately persuade them to the right course. We, the Members of the Indian Roads Congress pledge ourselves, to afford you the fullest

co-operation in any action which you may wish to take. If there is any shortage of experienced personnel I can assure you, Sir, that there is plenty of talent, patriotism and zeal to serve outside the charmed circles of the bureaucratic cadres, but only a man of your imagination and dynamic leadership can harness them in the service of the country, but they can be so harnessed and even in an honorary capacity. In his Paradise Lost, Milton describes how Satan sat exalted:

"High on a throne of State
That far outshone the wealth of Ormuz and of Ind."

The legend of India's fabled wealth that inspired poets and beckoned conquerors has long been replaced by the harrowing tale of a vast country, rich in national resources, but with its teeming millions steeped in ignorance, poverty and want. **Your engineers are your chief instruments in producing the additional wealth we so sorely need.** If they are not just pushed around or regarded as mere hewers of wood and drawers of water but treated as worthy partners in a noble enterprise, they will meet every challenge, overcome every difficulty, make every sacrifice to build up the great and prosperous India of our dreams.

This, Sir, is not an oratorical peroration, vain words signifying nothing. It is a *cri du coeur* wrung from a life-time of experience in the P.W.D. I am confident that it will not fall on deaf ears!

MESSAGE

from

Shri D. S. DESAI,

Minister for Public Works, Bombay.

"I welcome your presence in Bombay for the momentous deliberations regarding finalising the Outline of the Second Road Plan (1961–81) for the country. It is in the fitness of things that the Union Minister of Transport and Communications, my friend Shri S. K. Patil, has kindly consented to inaugurate the meeting in Bombay as the venue. The Nagpur Plan was the first milestone in the development of the Country's road system and it is gratifying to note that the target of the Nagpur Plan will be generally realised by 1961. Let Bombay be the second milestone in the further plan which the nation may tomorrow call as the Bombay plan for building the road-system of our country. I wish the deliberations of the Council fruitful results and all success".

SPEECH

of

Shri SUJAN SINGH,

Vice-President of the Indian Roads Congress.

It is fortunate that Shri S. K. Patil, our Minister for Transport and Communications is opening the Indian Roads Congress Council Session in Bombay. In fact, for a function like this to be inaugurated in this City by one of the outstanding figures which the City had produced, and who at the same time is Minister for Transport and Communications in the Union Govt., is singularly appropriate.

Shri Patil's interest are, as all of us know, very catholic and comprehensive, and I do know that even before he assumed his present high office, he was always interested in the transportation problems in the country.

It was only a Minister for Transport in the making who could be, as Shri Patil was, a Fellow of the Royal Geographical Society for a number of years and President of the All-India

Motor Union Congress and Local Self Government Institute of India.

There have been not only in this country but in other democracies as well, many ministers assuming control over departments without having had an opportunity for acquiring detailed knowledge of the problems. Shri Patil's A. I. C. C. membership for 28 years, his membership of the Bombay Municipal Corporation for 17 years, his close association with the local W. I. A. A. for well over a decade, and his constant and ceaseless travels within the country on behalf of the political organisation to which he belongs, were certainly training grounds to enable him to rise to the full stature of the very competent Minister of Transport which he is today. This valuable background and experience will, I am certain, enable him to tackle roads and transport problems with real insight and understanding.

We are grateful to you, Sir, for the honour you have done us by inaugurating this Session. I can assure you that the Indian Roads Congress Council members genuinely feel that their efforts in improving road communications in the country will be transported into a higher level of recognition by your presence here this morning.

On behalf of the President and the Council of the Indian Roads Congress, I also thank Shri H. P. Sinha, Consulting Engineer, Road Development, Govt. of India and his colleagues in the Ministry of Transport for helping us in every respect to make this session a success.

Our sincerest thanks are also due to the Bombay State P. W. D., Shri U. J. Bhatt, Chief Engineer, and Shri A. B. Haval, Local Organising Secretary for making excellent arrangements for the session.

In the end, I thank all the guests who have graced this occasion with their presence and the Indian Merchants Chamber for having so kindly allowed the use of their hall for this occasion.

SPEECH

by

Shri A. D. DHINGRA

(Chairman, Bombay Branch of the Indian Roads and Transport Development Association)

Shri S. K. Patil and Friends,

On behalf of the Bombay Branch of the Indian Roads and Transport Development Association I have great pleasure in welcoming you here this evening. Our particular thanks are due to the Minister for Transport and Communications for having graciously responded to our invitation. The Council of the Indian Roads Congress is meeting in Bombay this year after a lapse of some 8 years, the last meeting having been held in this City at the time of the Annual General Meeting of the I. R. C. in Bombay in the year 1950.

During this period a great deal has happened in the field of roads and road transport. Although the entire Nagpur Plan including bridges and lay-outs of roads is not expected to be completed by 1960-61 for a number of reasons, it is a great achievement that the target of road milage envisaged in that Plan is expected to be exceeded by that year by about 48,000 miles including, of course, the milage of roads constructed under Community Projects.

In regard to road transport a number of developments have taken place. The most important of them is the growing awareness of the fact that rail transport is not sufficient for the requirements of the Second Five-Year Plan and that, therefore, road transport has to be developed to the extent to which the railway transport is deficient. The amendment to the Motor Vehicles Act in November, 1956 abolishing the distance limit on motor transport proposed in the Amending Bill was the first step in this direction. Then came the report of the Estimates Committee of the Lok Sabha, followed by the appointment of an Inter-State Transport Commission envisaged in the Motor Vehicles Amendment Act. And now we have the appointment of a Road Transport Reorganisation Committee under the able Chairmanship of one of the past Presidents of this Association, namely Shri M. R. Masani, M. P.

Whilst all these measures are welome and will undoubtedly lead to an expansion of road transport in due course, the most pressing need of the country today is the number of vehicles

required to cope with the estimated traffic during the next three years. Our Council has estimated that the minimum requirements of long-distance traffic of the Second Five-Year Plan is of the order of about 200 million tons per annum by 1960-61, out of which the railways can cope with only about 160 million tons per annum. Therefore, the country has to make provision for the remaining about 40 million tons per annum.

Careful estimates prepared on the basis of the targets of production of commercial vehicles in the country show that after allowing for replacements of old vehicles there will be a gap of about 75,000 trucks to meet this traffic. This gap can be reduced to a certain extent by putting on the road as many trailers as it is possible to manufacture locally. However, the remaining vehicles will have to be provided and the greatest problem of the moment is to find the requisite foreign exchange for them. I do not wish to go into the details of this question at this stage, but I like to bring this fact specifically to the notice of our Transport Minister with a request to him to take early steps in the matter.

The present meeting of the I.R.C. Council is in a sense a historic one since it has to consider and finalise the 20-years' Road Development Plan proposed by the Chief Engineers' Conference at the last session of the I.R.C. at Shillong. The Plan is still under consideration. Also it has to be considered by the public and, therefore, the full extent of the general reaction to it will take some time to be known. However, there are certain main aspects to which it may be useful to invite your attention.

The first is that it is proposed to raise the intensity of road milage in the country from 0.26 to 0.52 miles per square mile of territory and the actual road mileage from 3,79,000 to 6,54,000. Another aspect is the increase in the milage of National Highways from about 13,800 to 25,000, of State Highways from about 35,000 to 1,02,000, of Major District Roads from about 95,200 to 2,00,000, and of other District Roads from about 78,300 to 2,00,000. This is a very welcome change, in that it suggests upgrading of a number of important roads. It has also been proposed to provide about 1,000 miles of Express Highways at certain points with at least four-lane modern type surfaces and grade separations at most of road crossings on them. The National and State Highways will have at least two-lane carriageways with modern type surfaces, while major district roads will be suitable for all-weather use with at least a metalled single-lane carriageway, and other district roads will also be useful throughout the year except at major crossings. The maximum distance of any place in the country from a metalled road will be 3 miles and from any road 1.5 miles in an agricultural area, thus

bringing the bulk of our villages nearer to markets, hospitals, schools and sub-stations of administration.

While there is no doubt that the upgrading of the major roads in the country will lead to the development of road transport there is one aspect to which I cannot help having to draw your attention.

This is in regard to the milage of National Highways which it is proposed to be raised to only 25,000 against a 20,000 mile target envisaged in the Nagpur Plan. In view of the fact that the bulk of the long-distance road traffic in the country will have to be carried by the National Highways, I have no doubt in my own mind that the addition of only 5,000 miles during the next 20 years of intense economic development in our country to the Nagpur target of 20,000 miles based on the pre-Independence static economy is very insufficient by all standards and my earnest plea to the Council of the Indian Roads Congress is to pay attention to this aspect in their deliberations during the next few days.

The total cost of the Plan as estimated is of the order of Rs 4,700 crores. This figure, however, need not frighten any one since the Plan has mentioned that this amount can be met with a uniformly increasing annual expenditure of only about Rs 17 crores per annum during the next 20 years. When expressed in this way the amount does not look formidable and with the various suggestions made by the Conference regarding the resources and the methods of tapping them, I have no doubt whatsoever that the Plan is feasible.

Gentlemen, I thank you for having spared the time to come here in response to our invitation.

Minutes of the 52nd Council Meeting of the

INDIAN ROADS CONGRESS

held at Bombay from the 9th to 11th August 1958.

Present :

W. X. Mascarenhas — President

F. P. Antia, Dr.	B. S. Jootla
M. P. Apte	Kishore Lal
K. Barua	S. R. Mehra
D. G. Bhagat	K. K. Nambiar
U. J. Bhatt	L. R. Patel
S. K. Bose, Brig.	B. Prasad
P. V. Divatia	R. C. Roy
N. Durrani	D. C. Sharma
K. V. Ekambaram	K. Sinha
G. S. Ganapathy	H. P. Sinha
V. V. Gopalakrishna Iyer	S. N. Sinha
S. N. Gupta	Sujan Singh
R. K. N. Iyengar, Dr.	Lal C. Verman, Dr.

A. J. D'Costa — Secretary

The following co-opted members attended :

K. F. Antia	N. D. Daftary
S. L. Bazaz	P. D. Shivdasani

B. V. Vagh

The following invited members attended :

Baleswar Nath	M. K. Ganguli, Dr.
J. K. Bannerjee	N. S. Gupchup
R. S. Bhalla	Hardayal
S. N. Dhar, Brig.	A. B. Haval
A. D. Dhingra	J. M. Trehan

1. Minutes of the Executive Committee

The Council considered and approved the minutes of the meetings of the Executive Committee held at New Delhi on the 8th March and the 14th July 1958.

2. Setting of separate Highway Departments in States

The Council felt that the time was ripe now for setting up separate Highway Departments in the States, but the formation of separate Highway Departments to deal exclusively with road construction and maintenance depended on the quantum of work likely to be handled by such a Department. After detailed discussion, the Council decided to recommend to the Government of India to advise the State Governments to set up separate Highways Departments which apart from planning of overall road development would be rquired to integrate and guide the activities of various local and other road authorities in the State. They, however, expressed the view that in case there was not sufficient work in a particular State for setting up of a separate Department to deal with Highways alone, buildings and other subjects, e.g., minor ports, inland waterways, etc., may continue to remain with the Highways Department till such time as the volume of road work justified a separate Highways Department.

3. Creation of an All-India service of Engineers

The Council greatly appreciated the decision of the Government of India regarding the creation of an All-India service of Engineers on the lines of the Indian Administrative Service announced by the Minister of Transport and Communications at the inauguration of the Council meeting.

The Council recorded that if it is desired that the best talent of the Country should be attracted to scientific and engineering professions, which is most essential for the rapid development of the Country, it is absolutely necessary that the present service conditions of engineers are improved commensurate with their work and responsibility. Further it is not only the pay and prospects of engineers, but also the administrative set up and the resultant atmosphere that call for a thorough review in the context of the present-day conditions in the Country.

4. Mechanised methods in road construction

The Council considered the question of using mechanised methods in road construction. It was the view of the Council that mechanized methods in road construction have to be adopted more and more because of the high quality of work required to be produced for main highways by rigid control on quality of output. With this object in view, it was felt that the possibilities of manufacturing in India as many items of road making machinery as possible both for new works and maintenance should be explored. Recommendations regarding specific types of road machinery, their standardisation (by importing a few specimens) if necessary, assembly, spare parts, training of personnel, maintenance, and best possible service facilities would have to be made. All these considerations should be examined by the Road-Making Machinery & Mechanization Committee of the Indian Roads Congress. In this connection, progress already made by the Central Board of Irrigation and Power and the I. & S. Ministry should be studied.

5. Proposal to arrange a P.W.D. Ministers' Conference

The Council agreed to suggest to the Government of India, the desirability of arranging a P.W.D. Ministers' Conference as early as possible in order to consider subjects relating to Highway administration and development. The services of the Indian Roads Congress would be available to the conference if the Government so desired. Some of the subjects which the Council considered sufficiently important for bringing before the P.W.D. Ministers are:

(1) **Road Finance:**

(a) Shortage of foreign exchange hampered bridge building programme, although the amount of foreign exchange required for this purpose is a modest one. Adoption of prestressed concrete for bridges results in economy both in cement and steel. The quantities of high tensile wire to be imported for this type of construction is much less than ordinary steel which is also in short supply and has to be imported in large quantities.

(b) The benefits of highway transport are many and varied and they impinge upon several groups of beneficiaries in different ways and in different degrees. It is desirable that revenues are derived from these beneficiaries. Some suggestions towards this end are:

(i) All revenues derived from road taxation are more or less being ploughed back into road development; but this is not sufficient and funds should also be made available from general revenues as roads are a public service of National benefit.

(ii) Development of rural roads is important. But funds being very limited, it is desirable to tap some other sources of income for this purpose. It is estimated that if a tax of Re 1 per bullock-cart per month is levied, the total revenue from 102 lakhs of bullock-carts in the country would be about 12 crores of rupees per annum.

Alternatively, equivalent subsidy may be earmarked by Government for development of rural roads.

(iii) Betterment tax should be levied on property as is done in some other countries. Assessment is based on the value of land and improvement. This betterment levy is only imposed for a limited period; i.e., up to such time as the expenditure on the road is redeemed by the tax after which betterment levy ceases.

(iv) Non-lapsable funds for the construction and maintenance of roads should be provided in all States. Such a step will enable the Road Engineer to plan his projects on a more rational and scientific basis.

(2) **Road Administration:**

(i) Creation of Highway Departments in the States.

(ii) Chief Engineers should also be Secretaries in all State P.W.Ds. If it is considered necessary to keep the post of Chief Engineer and Secretary separate, technical men should be appointed as Secretaries.

(iii) The engineering service of local bodies should be provincialized.

(3) **Road Transport Matters:**

(i) The present road vehicle capacity will not suffice to carry the present traffic plus the annual growth of road transport. It is, therefore, necessary that the manufacture of goods vehicles is speeded up.

(ii) Restrictions on road transport should be lifted as per provisions of the Motor Vehicles Act.

(iii) Permissible laden weights should conform to weights as authorised in the programme of vehicle manufacture.

(iv) Semi and full truck-trailer combinations should be allowed on 2-lane carriageways subject to speed limits where necessary.

(v) Widening of the existing roads and improving their carrying capacity deserve serious consideration and required funds have to be made available for this purpose.

(4) **Passing of Highway Bills for States and Prevention of Ribbon Development:**

(5) Establishment in cases of cities having Corporations, of traffic engineering cells in the engineering set-ups of the concerned corporation. In cases of other cities, the problems relating to traffic engineering at those places should be referred to the State Chief Engineers for advice. The office of the Chief Engineers should be staffed with suitable specialists in this line.

(6) **Prevention of Encroachments**

Highway authorities should be vested with necessary authority to take direct action for prevention of encroachments and unauthorized utilization of road land.

The council, however, felt that this list of subjects was not exhaustive and Council members should send in their further suggestions in writing.

6. Changes in the Memorandum of Association, Rules and Regulations of the Indian Roads Congress

The Council approved the necessary amendment to Rule 5-d of the Memorandum of Association, Rules and Regulations of the Indian Roads Congress in order to provide for the enrolment of Honorary Associate Members. The revised Rule 5-d is given below:

5. The Society shall consist of.....

* * * *

d. **Honorary Members.**

Such persons and organizations who on account of their being in the opinion of the Council sufficiently distinguished or interested in roads may be elected Honorary Members and Honorary Associate Members respectively of the Society by the Council.

7. Recommendations of the Stabilized Soil Roads Committee

The Council generally endorsed the conclusions (vide Appendix) of the Stabilized Soil Roads Committee which was set up by the Indian Roads Congress at the instance of the Council of Scientific and Industrial Research to inspect the stabilized soil roads in the Punjab and other places and to assess the usefulness of the technique on the basis of service value given by

these roads in relation to the first cost and subsequent maintenance, and the background of prevailing conditions.

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

The Committee was likely to meet again shortly and arrange a visit of stabilized soil roads built in the South. Further recommendations of the Committee including the use of soil-cement for base course will be circulated to the members of the Council after the members of the Committee inspect the stabilized soil road work done in the South.

8. Ceylon Government's proposal for Indian Roads Congress Session

The Council greatly appreciated the proposal of the Government of Ceylon sent through the Government of India to hold one of the Sessions of the Indian Roads Congress in their country. The Council felt that it was desirable to hold a Session in Ceylon as this would enable the Highway Engineers of both the countries to come together to discuss problems of common interest. They, however, expressed the view that owing to the shortage of foreign exchange, the number of delegates for the Ceylon Session may be limited to 150 against the normal attendance of about 300 delegates.

9. Draft standard form for recording Traffic Census in non-urban roads

The Council discussed the draft Standard form for recording Traffic Census on non-urban roads and decided that the Convenor of the Specifications and Standards Committee should see if any changes in the forms were necessary in the light of comments of the members of the Council particularly in regard to the adoption of a uniform system for classification on laden weights of the various types of vehicles in consonance with the standards adopted by manufacturers and the Ministry of Commerce.

10. Eleventh International Road Congress to be held at Rio de Janeiro, Brazil in September/October, 1959

In view of the foreign exchange difficulties at present, it was felt that the Government of India may not consider sending a big

delegation to the Eleventh International Road Congress at Rio de Janeiro. But in view of the fact that Highway Engineering is developing as a specialised science and latest methods of road design and construction will be discussed at the said Conference, the Council decided that the following resolution should be forwarded to the Government of India :

> "Being fully conscious of the foreign exchange difficulties with which the country is faced at present, the Council of the Indian Roads Congress yet feel that a large delegation of Highway Engineers be sent to attend the Eleventh International Roads Congress to be held at Rio de Janeiro, Brazil, in September/October 1959, as the Council are of the opinion that participation of Indian Highway Engineers in the deliberations at such International gatherings, where latest methods of road design and construction are discussed, would be of very great help to the country as a whole when India is embarking upon still greater road projects especially when road communications have come to play a vital role in the developing economy of the country."

Further, the Council decided that the Government of India should be requested to nominate the Indian Roads Congress as the National Committee for selection of delegation of Highway Engineers to the Eleventh International Road Congress in the same way as the Central Board of Irrigation & Power is appointed as the National Committee for selection of delegations of Irrigation and Power Engineers to various International Conferences.

The Council also suggested that the delegation may preferably consist of a sizeable number of both official and non-officials and that the names of the delegates considered suitable may be forwarded to the Government of India. It was necessary to ensure that the selection of delegates is broad based so that the delegation which is sent to attend the International Road Congress has a National character.

11. Commentaries on Bridge Code

The Council decided that there was no objection to the issuing of commentaries on Indian Roads Congress Bridge Code by certain competent Institutions and individuals. But it was necessary that they should take the necessary permission from the Indian Roads Congress in the matter and give necessary acknowledgments for reproduction of any matter from the Bridge Code.

It was also decided that the legal implications, if any, should be examined and the matter referred to the Executive Committee before any permission in the matter was accorded.

12. Printing of Sections II & III of the Bridge Code

It was explained that Section II of the Code was expected to be finalized during the present meeting of the Bridges Committee. After this was done, Section III of the Bridge Code would be taken up.

13. List of Road-Making Machinery and its Manufacturers

The Council decided that the Road Making Machinery and Mechanization Committee should be requested to prepare for publishing in the next issue of the Indian Roads Congress Journal—a list of all big and small machinery manufacturers, suppliers and dealers in different parts of India along with their addresses and the types of the machinery sold by them. Such a list would be a useful source of information to members of the Indian Roads Congress in the course of their work.

14. Membership of the Indian National Group of the International Association for Bridge and Structural Engineering

The members of the Council agreed to give their active support in increasing the membership of the International Association for Bridge and Structural Engineering (Indian National Group).

15. Membership of the Indian Roads Congress

The Council noted that the Chief Engineers of States have been requested to advice their engineers to become members of the Indian Roads Congress. Efforts should be continued to increase the membership of the Society. It was further suggested that publication of more technical literature in small pamphlets will popularise the Indian Roads Congress and lead to increase in membership.

16. Appointment of the Technical Secretary, Indian Roads Congress

The particulars of the applicants whose nominations were received from various State P.W.Ds. etc., were placed before the Council. They expressed the view that the response received so far was unsatisfactory. It was decided that the post may be

advertised. The particulars of all the applicants may later on be placed before the Executive Committee for final decision. Retired persons might also be considered for this post.

17. Progress about arrangements of the Twenty-third Session

The Chief Engineer (Highways), Andhra Pradesh explained the progress made about the arrangements in connection with the Twenty-third Session of the Indian Roads Congress to be held in Hyderabad in January 1959. As regards the dates of the Session he stated that he was trying to persuade the Osmania University authorities to make available their Hostels for the Indian Roads Congress delegates between the 5th and 15th January, 1959 so that it may be possible to hold the Indian Roads Congress Session during that period.

18. Second All-India Road Development Plan

The Second All-India Road Development Plan succeeding the Nagpur Plan and involving a total expenditure of Rs 4,700 crores in 20 years beginning from 1961 was informally discussed.

A committee consisting of the President, Indian Roads Congress, the Consulting Engineer (Road Development), Sarvashri U. J. Bhatt, S. R. Mehra, D. C. Sharma, M. S. Bisht, N. S. Gupchup, B. V. Vagh, K. K. Nambiar and Dr. F. P. Antia was appointed to consider the Plan in the light of the informal discussion at the Council meeting. It was also agreed that, broadly, the Committee may review the following aspects of the Plan and offer suggestions.

(i) Size-Total cost-Finance-Loans-Basis of distribution of expenditure ;

(ii) Milage Targets-Distribution between various categories and basis thereof ;

(iii) Municipal roads.

19. Resolutions of thanks

(i) The Council of the Indian Roads Congress expressed its sincere thanks to the Government of Bombay for inviting the Indian Roads Congress to hold its 52nd Council meeting at Bombay and for the arrangements made for the meeting.

(ii) The Council expressed its desire that the President should convey the thanks of the Council to Shri S. K. Patil, Minister of Transport and Communications, Government of India for inaugurating the Council meeting and for his very encouraging Address.

(iii) The Council expressed the desire that their thanks should be conveyed to Shri H. P. Sinha, Consulting Engineer (Road Development) and his officers for the assistance they gave in organizing the meeting ; to Shri U. J. Bhatt, Chief Engineer, P.W.D., Bombay and his officers particularly to Shri A. B. Haval, Executive Engineer, P.W.D., Presidency Division who acted as the Local Organizing Secretary, for the excellent arrangements made by them in connection with the meetings and inspection tours.

(iv) The Council also expressed thanks to Atomic Energy Department, Milk Commissioner, Bombay, M/s. Burmah Shell and M/s. Premier Automobiles Ltd., for the inspections arranged by them for the members.

(v) The Council thanked the management of the Indian Merchants' Chamber of Commerce for placing the Hall of their Building at the disposal of the Indian Roads Congress on the 9th August, 1958.

(vi) The Council thanked the Director of Publicity, Bombay, the All-India Radio and the Press for covering the proceedings of the Council.

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

Appendix

Recommendations of the Stabilized Soil Roads Committee

At the request of the Council of Scientific and Industrial Research, the Indian Roads Congress constituted a special committee called "the Stabilized Soil Roads Committee" to inspect the Stabilized Soil Roads laid in the Punjab and other places and to give an assessment of the usefulness of the technique on the basis of service value given by these roads in relation to the first cost and subsequent maintenance, and the background of prevailing traffic, climatic and subgrade moisture conditions. The Committee was then to make necessary recommendations for different areas in the country.

Accordingly the members of this Committee inspected the stabilized soil roads in the Punjab in April, 1958. After inspection of surfaces, the Committee expressed the view that the technique of stabilized soil road construction adopted in the Punjab had been a success and that the same specification could be adopted in other States also, under similar conditions and circumstances. The conclusions arrived at by the Committee are given below:

(i) With a two-coat surface treatment over a priming coat, but without stone graft, a stabilized soil road built according to Mehra's method is considered capable of carrying upto 200 tons of mixed traffic per day.

(ii) With a two-coat surface treatment over a stone graft (no priming coat being necessary in this case) a stabilized road built according to Mehra's method is considered capable of carrying upto 500 tons of mixed traffic per day.

(iii) Where good hard stone is economically available, a graft should invariably be given even though the prevalent traffic may be less than 200 tons per day. This would allow for development of traffic upto 500 tons per day. The stone ballast used for this purpose should be one inch gauge and the quantity used should be 8 to 10 cu. ft. per 100 sq. ft., the criterion being complete coverage of the surface with stone ballast.

(iv) Where stone is too costly and the traffic is in no case expected to be more than 200 tons per day, grafting may be omitted and a priming coat used instead before surface dressing.

(v) Wherever a road is built with stone graft, the other specifications (i.e., with primer only) should also be laid in a short length (about a mile) for observing the comparative performance of the two specifications.

(vi) As regards the total thickness of the crust the Committee was of the view that it should be properly designed taking into consideration the various factors involved like water logging etc. In ordinary cases, the Committee was of the opinion, that the crust thickness of a stabiliezd soil road should correspond in strength to the normal water-bound macadam specification prevalent in the locality.

(vii) In water logged areas some form of effective capillary cut-off should be provided, whether by adopting a high embankment, or a sand blanket course, or a bituminous water-proof coating, etc. Wherever the sub-soil water level was between zero to six feet below the formation level of the road the area should be considered as water logged.

(viii) The Committee was of the view that the pre-requisites for the successful large scale application of the technique of soil stabilization to road construction were:

(a) availability of personnel trained in the technique for constant supervision;

(b) field laboratory for controlling the execution; and

(c) a State Testing and Control Laboratory for initial design and reference during execution.

In the interest of economy in road construction the Committee recommended the adoption of stabilized soil in road works.

The C. S. & I. R. were financing some "Pilot Projects", about one mile in length in each State, with the object of propagating the idea. It was suggested that this should be followed by the Central Government (Ministry of Transport & Communications, Roads Wing) financing the construction of about 30 miles of stabilized soil roads in each State and that thereafter the Planning Commission may be persuaded to consider financing the construction of 150 miles of such roads in each State.

The Consulting Engineer (Road Development) stated that the Ministry of Transport could consider assisting the States by giving grants-in-aid to meet 50 per cent of the initial cost of the

earth embankment and the crust of a stabilized soil road built to approved specifications, upto a maximum length of 30 miles per State. The States would be required to keep complete and separate records of the specifications and costs of construction and maintenance of these roads and submit periodical reports to the Central Government for purposes of research.

The Committee, however, stipulated that the stabilized soil specifications under consideration should be considered for adoption only in such localities where the cost of the crust, including surface dressing was at least 25 per cent less than that of the normal surface-treated water-bound macadam specification in force in the area.

The Committee expressed the hope that after the success of the technique had been demonstrated by road construction with Central aid and with the funds provided through the Planning Commission, the States would, in their own interest, build more and more roads according to this technique out of their own funds.

The Committee also suggested, as a separate issue outside its terms of reference, that unsurfaced stabilized soil roads built to the specification discussed in the foregoing paragraphs, should be built in villages where the traffic was not more than 50 tons per day. These roads also should be built under proper field laboratory control and should be maintained as experimental roads by the Public Works Department who should keep proper construction, maintenance, and traffic records for purposes of research. Such records should be supplied periodically to the respective State research centres.

With a view to proposing suitable amendments in these specifications for stabilized soil road construction in areas with high rainfall, experimental projects should be undertaken quickly, each about five miles of roads, to suitably modified specifications to be given by the C.R.R.I. The funds for these experimental works should be provided by the Central Government.

Areas with an annual rainfall of 60 in. or above were to be considered as areas with high rainfall.

The Committee also approved in principle that every State P.W.D. (B. & R. Department) should employ one materials engineer, if not more, to exploit the local materials to the best advantage and to ensure the supply of specified materials for the construction of low-cost roads.

Photo 1.
A VIEW OF THE COMPLETED BRIDGE OVER BETWA RIVER AT JHARARGHAT

Paper No. 206

"CONSTRUCTION OF AN R. C. CANTILEVER HOLLOW GIRDER BRIDGE OVER BETWA RIVER AT JHARARGHAT"

By

P. N. SRIVASTAVA,* B.Sc., C.E., M.I.E., A.M.A.S.C.E.

CONTENTS

SYNOPSIS

The Paper describes the investigations, salient features of design, and the construction of an R. C. hollow box girder bridge over the Betwa river in Jhansi District in mile 25 of N. H. 26. The bridge consists of 31 spans, 66 ft 8 in. each, of hollow girders continuous over three spans with 12 ft cantilevers on either side of which 42 ft 8 in. suspended spans rest over cast steel rocker and roller bearings. The bridge has open foundations resting on solid rock. The abutments, wing walls and piers are of coursed rubble masonry in 1 : 5 cement mortar. Features regarding centering and shuttering for hollow girders and their concreting are deseribed, so also the construction of approaches of the bridge.

* Superintending Engineer, P. W. D., Buildings and Roads, Uttar Pradesh.

1. INTRODUCTION

1.1. Betwa is an important river of Uttar Pradesh. Flowing in its upper reaches in the rocky terrain of Madhya Pradesh it enters the State of Uttar Pradesh on the south-west of Jhansi district and joins the Yamuna near Hamirpur district. Almost in its entire length in this State, there is not a single high level road bridge across the river, though it intercepts quite a few roads. The most important road that crosses the river is the Jhansi-Saugor road, National Highway No. 26, which is an important inter-State arterial link between Uttar Pradesh and Madhya Bharat (now Madhya Pradesh) and further onwards with Bombay. This crossing is 25 miles south of Jhansi town. The absence of a permanent high level bridge on such an important highway was a serious bottleneck to the advancement of trade and commerce in the area. Apart from this, the construction of this bridge has also great strategic importance.

1.2. Before the construction of the bridge the traffic on this road used to pass over a submersible causeway, the crossing being known as Jhararghat. Due to the Sukhwan Dukhwan weir, Fig. 1, about seven miles downstream, primarily intended for irrigation purposes, the causeway remained submerged right up to the month of January, thereby serving for less than six months in a year. For the rest of the year, communications were, maintained by a toll-free ferry service which was able to carry up to 5 tons. It was, however, not possible to run ferry boats throughout the rainy season because, firstly, there are rock outcroppings in the river bed and, secondly, the velocity of water becomes very swift in floods and it ia not safe to ply boats.

1.3. **Traffic difficulties :**—There were intervals when neither the causeway nor the ferry service was in operation and the traffic had to be diverted along the Babina Talbehat fair weather road, 26 miles long, which crosses the river Betwa at Sukhwan Dukhwan over a causeway which is being maintained by the Irrigation Department. This causeway also does not remain open for all hours of the day. The limitations of such an arrangement and the hardship and inconvenience caused to the growing traffic can very well be imagined. Moreover, the construction of the Mata Tila Dam six miles upstream of the existing causeway, when completed, would store sufficient water to feed the Sukhwan Dukhwan weir all the year round and, as such, the water level at Jhararghat would always remain high and the existing causeway would go altogether out of action due to a depth of 16 to 20 ft of water. A high level permanent bridge over the Betwa at Jhararghat had, therefore, become an absolute necessity.

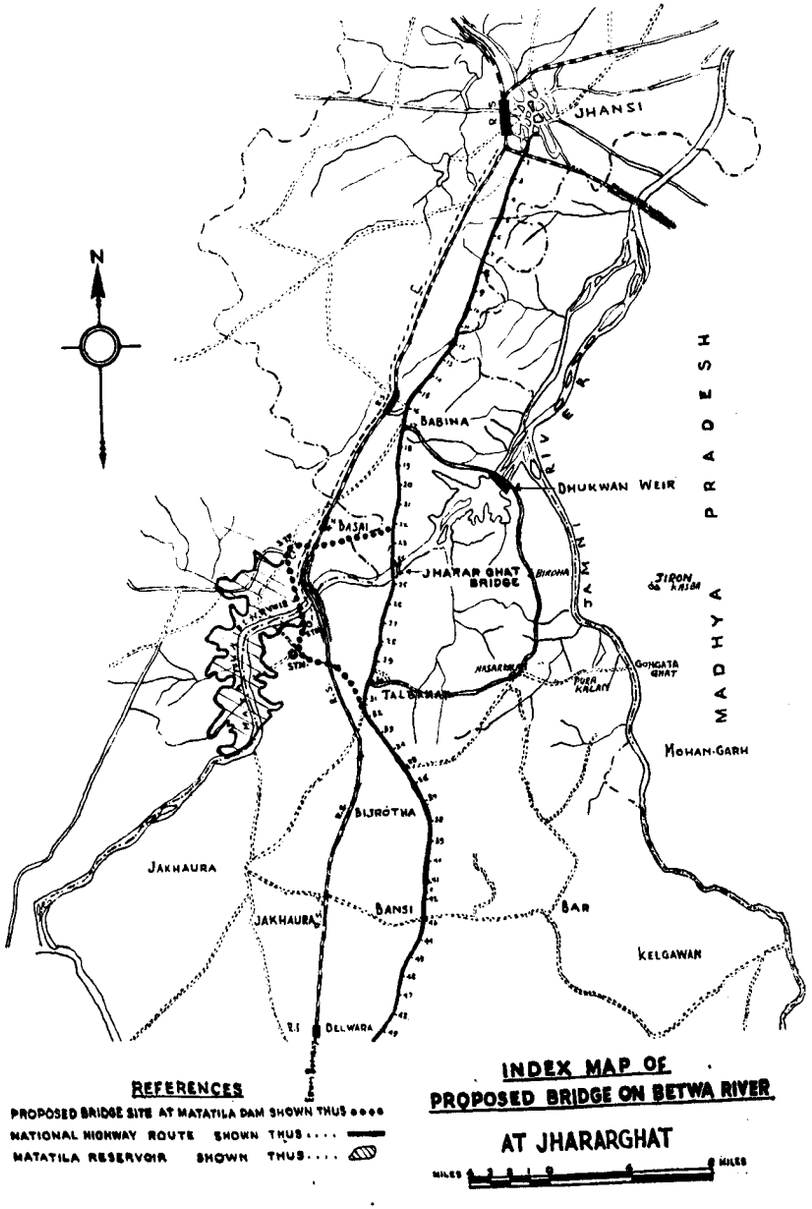


Fig. 1.

2. INVESTIGATIONS

2.1. Detailed investigations for a suitable site had already been carried out as a result of which several sites were selected. At one time it was proposed to combine this bridge with the Mata Tila Dam, or alternatively, construct the bridge at the site of the Sukhwan Dukhwan weir. All these possibilities were thoroughly examined and it was finally decided to construct an independent high level bridge at Jhararghat, 500 ft downstream of the existing causeway, as this was considered to be the most suitable site.

2.2. The river at this site has no tendency to meander and erode its banks. The bed of the river consists of granite and dolerite rocks. Tests were carried out in the P.W.D. Research Station at Lucknow on rock cores cut by diamond drill at site, and the suitability for founding piers and abutments directly on the bed rocks was confirmed.

3. WATERWAY AND TYPE OF BRIDGE

3.1. There had been conflicting reports about the high flood level of the Betwa river at the site of the bridge and after several investigations it was considered that the high flood level of 921.78 was reasonably correct. According to this high flood level, the depth of water above the bed of the river worked out to about 45 ft at the site of the bridge, and a corresponding discharge of 570,000 cusecs was obtained. The required waterway for this discharge worked out to 1,850 running feet.

3.2. The type of the bridge proposed was a high level reinforced concrete hollow girder structure continuous in three spans. It was worked out that the hollow girder design was more economical than the ordinary T-beam construction. The bridge consists of a total number of 31 spans of 66 ft 8 in. centre to centre. The spans are continuous on four piers with 12 ft cantilevers on either side. The simply supported beam on these cantilever ends is also of box type and is 42 ft 8 in. in length. The arrangement of the spans is shown in Plate I.

3.3. Tenders for the work were called sometime in the month of March 1955, with the clear understanding that the bridge had to be completed within two working seasons. Some construction difficulty was anticipated as the Sukhwan Dukhwan weir remained closed up to the end of January, and till then there was generally 20 ft of water at the site and no work on foundations could possibly be done during that period. The contractors had, therefore, to leave a margin, while submitting

tenders, for the short working period. The work was actually started on 1st December, 1955 and the last batch of concrete was poured on 20th November, 1957.

4. FOUNDATIONS

4.1. The foundations created the usual difficulties. It was anticipated that firm rock would be encountered immediately after removing the top disintegrated portions. When about 4 ft of blasting had been done, it was noticed that the final strata containsd several fissures and, in certain cases, these fissures were found to go very deep specially near the banks, i.e., under pier Nos. 3, 4, 13 and 29 and the abutments, Photos 2 & 3. After careful geological investigations, it was finally decided to go deeper and these rocks were further blasted to additional depths of 6 to 10 ft at places.

4.2. In pier No. 30 it was seen that firm rock was encountered in half the length of the pier only, whereas in the other half there was a gap of about 4 ft which did not have rock at all. However, after digging these foundations to the requisite depth of 3 or 4 ft, the gap was scooped of all loose materials and filled in to a depth of about 3 ft with concrete and R.C.C. top slab was laid over this gap, whereas ordinary plain concrete was put on the other portions. There were certain cracks in the rocks the depth of which could not be ascertained and the rocks were very close to each other leaving hardly any space between them. These rocks were firm rocks and the cracks were considered structurally ineffective for the foundations. However, in order to safeguard against any future trouble due to settlement, dowel bars $\frac{3}{4}$ in. diameter were put in by boring holes into the rocks to a depth of one foot, Photo 4, and these dowel bars were placed projecting 1 ft into the solid concrete of the foundations.

4.3. It was not possible to blast the rocks exactly to the shape of the base of the foundation concrete and as such they were blasted as nearly to the shape of the foundations as could possibly be done. In most of the foundations water came in profusely into the foundations through side cracks. The foundations had to be dewatered before putting in the gelignite for blasting the rocks. Removing of hard rock was done by drilling holes by pneumatic drills and then blasting. Soft rocks were removed by rock drills. In deep foundations, specially those of pier No. 30 and the Lalitpur side abutment, foundation concrete was poured by chutes as shown in Photo 5. Cement concrete 1:3:6 was used in the foundations throughout. The masonry used was coursed rubble stone in 1 : 5 cement and coarse sand mortar.

5. SUBSTRUCTURE

The masonry in abutments, wing walls, and piers is coursed rubble in 1 : 5 cement and coarse sand mortar. The piers have a batter of 1 in 24 and the abutments and wing walls 1 in 12. The size of the rubble stones used in the masonry was specified as 6 in. minimum thickness, the length as twice this and the width at least $1\frac{1}{2}$ times. The entire masonry has raised cement pointing. R.C.C. caps 3 ft thick are laid with double reinforcement on the top of the piers and abutments. Another salient feature of the substructure masonry is that at every 5 ft height 9 in. to 1 ft concrete bands 1 : 3 : 6 are laid with facing of coursed rubble masonry. This feature was introduced as very long bond stones in granite could not be procured.

6. BEARINGS

6.1. Details of bearings (rocker and roller and plate) are shown in Plate II. The roller and rocker bearings are specially designed for taking up the entire expansion of the box girders. These are of cast steel of hardness as laid down in Indian Roads Congress Bridge Code and, on actual test, the results obtained on some of the samples are given in Appendix 1. Two types of bearings are provided, viz., rocker and roller-cum-rocker bearings. One set of rocker bearings is provided over one pier in each set of the continuous beam. On the remaining three piers of each set roller-cum-rocker bearings are provided. The position of both the types of bearings is noted on Plate I. Bottom plates of each bearing are fixed in the capping slabs of piers and abutments with $1\frac{1}{2}$ ft long bolts and top plates into the main beams, Photo 6.

6.2. Each roller bearing consists of two rollers 5 in.diameter, with one base plate and two rocking plates as shown in Plate II, plus the rocking arrangement. The plates have lugs which prevent the rolling beyond the requisite horizontal movement of $1\frac{1}{4}$ in. on either side of the centre line. This gives a maximum variation in the size of the beam of 2.5 inches. This is calculated to be adequate for the entire expansion of the three continuous spans. Over the cantilever ends where the suspended spans rest, ordinary plate bearings of the same cast steel specification are provided as per details given in Plate II, and since each of these bearings would carry only the load of half the suspended span, it was considered that plate type bearings would be quite adequate.

7. SUPERSTRUCTURE

7.1. Design

As already mentioned, reinforced cement concrete hollow box girders continuous over three spans and having cantilevers at both ends worked out to be the most economical design. The fact that the foundations were resting on firm rock was the chief consideration in adopting continuous beam design. The bridge consists of 31 spans of 66 ft 8 inches. The superstructure is of box girder type with three 9 in. ribs, $5\frac{1}{2}$ in. soffit slab at the bottom and 8 in. deck slab at the top. The main girders are continuous on three spans with two 12 ft cantilevers on either end. Resting on these ends are suspended spans 42 ft 8 in. long. In the end spans, one cantilever has been omitted.

An outline of the design of the bridge is given in Appendix 2.

7.2. Main Beams

The main beams are designed for Class AA loading which gives adverse conditions for bending moment and shear. However, it was determined that where two lanes of Class A loading produced severe effects the beam was safe for these.

The cross beams and stiffeners are designed for Class AA loading of the wheel type after assuming the wheel loads as point loads, longitudinal distribution being neglected. The tracked vehicle though heavier cannot be treated as a point load and after distribution does not load the cross beams so much as in the first case.

The main beams are three 9 in. wide ribs varying in depth from 4 ft 9 in. at the centre to 6 ft 9 in. at the support and carrying 8 in. thick decking slab. These main girders are stiffened at the bottom by a $5\frac{1}{2}$ in. thick vault or soffit slab. Further stiffening is achieved by providing cross beams at about 13 ft 4 in. distance. The main reinforcement of the main beams is eight $1\frac{1}{2}$ in. diameter bars arranged in four rows of two, three rows being at the bottom and one at the top. Out of the six bars at the bottom, four are bent up at different points towards the supports.

Articulation point:—In the cantilever portions, due to articulation points, additional reinforcement is provided and, in order to accommodate this additional reinforcement, the width of concrete is increased to 12 inches. Two-legged stirrups $\frac{3}{4}$ in. diameter and $\frac{1}{2}$ in. diameter are provided at 5 and 6 in. centres.

7.3. Suspended Spans

These are designed on the same lines as the main beams and consist of hollow box type structure, their length being 42 ft 8 in. and their thickness 9 inches.

Articulation point:—The suspended beams are resting on the cantilevers of the main beams with a common bearing of the two beams of about 15½ in. at half their thickness. The points of suspension of these beams are specially designed and great care, both in design and construction, has been exercised at these articulation points to ensure full development of strength of the structure both for shear and bond. The width of beams at these articulation points is increased from 9 in. to 12 in. Extra diagonal reinforcement bars are put in to take up any uncalculated shear in the structure and also to strengthen the points and supports. The details of reinforcement at these points are shown in Plate III.

7.4. Deck Slab

This is designed for Class AA loading, moment for which is maximum when one track of a 70-ton tank is placed symmetrically about the centre line of the span. In the case of the cantilever portion of the deck slab, since the wheels of Class AA cannot come on this slab, the live load is maximum when one of the 12,500 lb wheel of Class A loading is 6 in. away from the kerb.

The deck slab is doubly reinforced both at the top and bottom. The depth of the deck slab worked out to 8 in. In plan, the slab is longitudinally continuous over all the cross beams and in width over the three main beams. The slab also projects as a cantilever to a distance of 2 ft 8 in. on either side. The structure is monolithic. Details of reinforcement are given in Plate IV.

7.5. Cross Beams

In each of the three spans and two cantilevers, 18 cross beams are introduced primarily to stiffen the main beams and support the deck slab.

The thickness of these cross beams is 9 in. except those at the supports and ends of cantilevers where they are 12 in. and 20½ in. respectively. These beams are reinforced with 1⅛ in. bars and 1½ in. diameter bars as main reinforcement. Two legged stirrups ½ in. diameter are placed at 4 to 6 in. spacing. Details of the cross beam reinforcement are given in Plates III and VII.

Photo 2.
Open foundations

Photo 3.
Open foundations

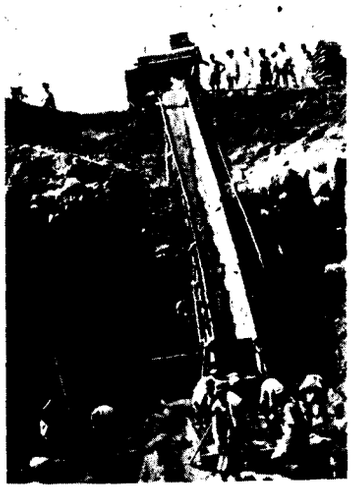


Photo 5.
Pouring of concrete by chutes

Photo 4.
Dowel bars ¾ in. dia. blowing holes into the rocks

Photo 6.
Roller-cum-rocker bearing

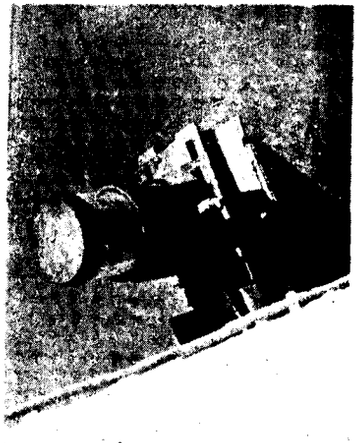


Photo 7.
Sand buckets under centering trusses

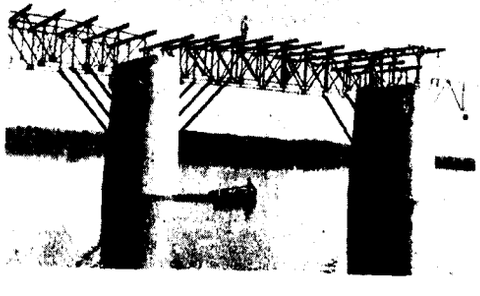


Photo 8.
Truss centering in position

7.6. Soffit Slab

The bottom or soffit slab of the boxes has a uniform thickness of $5\frac{1}{2}$ in. and two-way reiforncement at bottom with $\frac{3}{8}$ in., $\frac{1}{2}$ in. and $\frac{3}{4}$ in. diameter bars spaced according to the intensity of the calculated stresses. The details of reinforcement are shown in Plate V.

8. CENTERING AND SHUTTERING

8.1. There were three main factors under consideration at the time of deciding the type of centering to be provided, viz.,

(1) height of the superstructure from the river bed,

(2) the fact that the depth of water due to the Sukhwan Dukhwan weir remains about 20 ft for about six months in the year, and

(3) very swift current during the rains.

8.2. The idea of providing the usual trestles in mid spans had to be dropped due to the above factors. The choice remained between steel truss centering and wooden truss centering and finally steel trusses were adopted on account of considerations of facility of removal and refitting and elimination of chances of swelling and contraction due to weather conditions. For supporting the trusses, stone brackets were projected from pier and abutment masonry at the time of construction. Over the projections, sand buckets were placed which received wooden pistons, Photo 7, attached to the trusses. These sand buckets had to be introduced to facilitate lowering of the trusses for removal. The weight of each truss was approximately $1\frac{3}{4}$ tons and one truss was placed under each main beam, i.e., 3 trusses in a span, Photo 8. In all, 27 trusses for 9 spans had to be fabricated. All fabrication work was done at site. On top of the trusses, R. S. joists were fixed at 4 ft centres for joining the three trusses of each span together and for supporting the shuttering. In view of the heavy weight of each truss, it was manufactured in three equal sections which were joined together with bolts and nuts. All other joints were welded.

8.3. Hoisting of the trusses was done with a mechanically worked winch in conjunction with tripod and pulley. These winches and tripods were placed in the bed of the river in dry season but, when there was water in the river, the machines had to be fitted on boats and worked from there.

For lowering the trusses, a similar device was used but, in addition to this, iron hooks of $\frac{1}{4}$ in. bars were specially embedded in the soffit slab concrete for this purpose. Details are given in Plate VI.

8.4. Shuttering

Since this was a box type of girder design, a huge amount of shuttering material had to be provided. For bottom or the soffit slab, as also the deck slab, steel plates $\frac{1}{8}$ in. thick and 4 ft by 2 ft were stiffened with angle irons on four sides in the centre by means of welding. The side shuttering had to be manufactured of kailwood planking lined with thin G.I. sheets. All supports for the shuttering were also of kailwood scantlings. In order to keep the side shuttering of the beams in correct position, iron bolts of $\frac{1}{2}$ in. diameter with cement concrete spacers were provided about 4 ft apart.

The shuttering had to be erected in three operations:

(1) For soffit slab and bottom portion of beams up to fillet level.

(2) After concreting of the soffit slab, shuttering for sides of all the main and cross beams up to top fillet level.

(3) After concreting of the beams, shuttering for the deck slab and cantilever portions.

In practice, it was noticed that the third item took about 10 days, whereas item 2 could be done in about two days, and item 1 in about a week.

The entire time taken in removing centering and shuttering from one set of spans and fixing in another set was about two weeks. This, of course, did not include the time taken under items 2 and 3 above.

9. CONCRETING

9.1. For each set of three spans and two cantilevers, concreting was done in five stages:

(1) In the first stage the entire soffit slab with fillets of the beams was laid.

(2) In the second stage the main beams were concreted over all the four supports extending up to one-fourth on either side in each span. All cross beams falling in these lengths were also concreted in this operation. Concreting in this stage was done only up to bottom of the top fillets of the beams.

(3) In the third stage the remaining portions of the main beams and the remaining cross beams were concreted.

(4) In the fourth stage, deck slab over the area, beams of which were concreted in the third stage, was laid.

(5) Remaining portion of the deck slab was laid in the last stage.

All these operations are shown in Fig. 2.

9.2. Concrete was mixed by mechanical mixers and was taken to site by coolies. Occasionally, when the lead was long, concrete was transported by trolleys running on rails and pulled by mechanically worked winches. When the bed of the river was dry, one of the mixers was installed in the river bed and the mixed concrete was hauled up by mechanically propelled hoists. After placing, the concrete was vibrated with electric pin-type vibrators. Concrete with slumps of 3 to 4 in. was used and the quantity of water required varied between $5\frac{1}{2}$ to $6\frac{1}{2}$ gallons according to weather conditions and moisture and sand.

9.3. Kerb and Railing

With a view to utilise minimum width of the bridge and for aesthetic consideration, R.C.C. kerb and railing are provided.

The kerb is $16\frac{1}{2}$ in. wide and 9 in. high. The railing consists of R C.C. posts of average 8 in. by $7\frac{1}{2}$ in. cross section and 3 ft 1 in. high, rounded at top, and 6 ft 8 in. apart. These are joined together with three horizontal rails 7 in., 6 in. and 6 in. high and $4\frac{1}{2}$ in., $2\frac{1}{2}$ in. and $2\frac{1}{2}$ in. thick.

The kerb, posts and bottom rail were cast at site but the upper two rails were precast and placed in position when the vertical posts were being concreted. The horizontal rails are further strengthened with vertical struts two in each panel. Details are given in Plate VII.

9.4. Wearing Coat

The clear width of the roadway over the bridge between the kerbs is 22 feet. For the wearing coat, the slab was laid in two

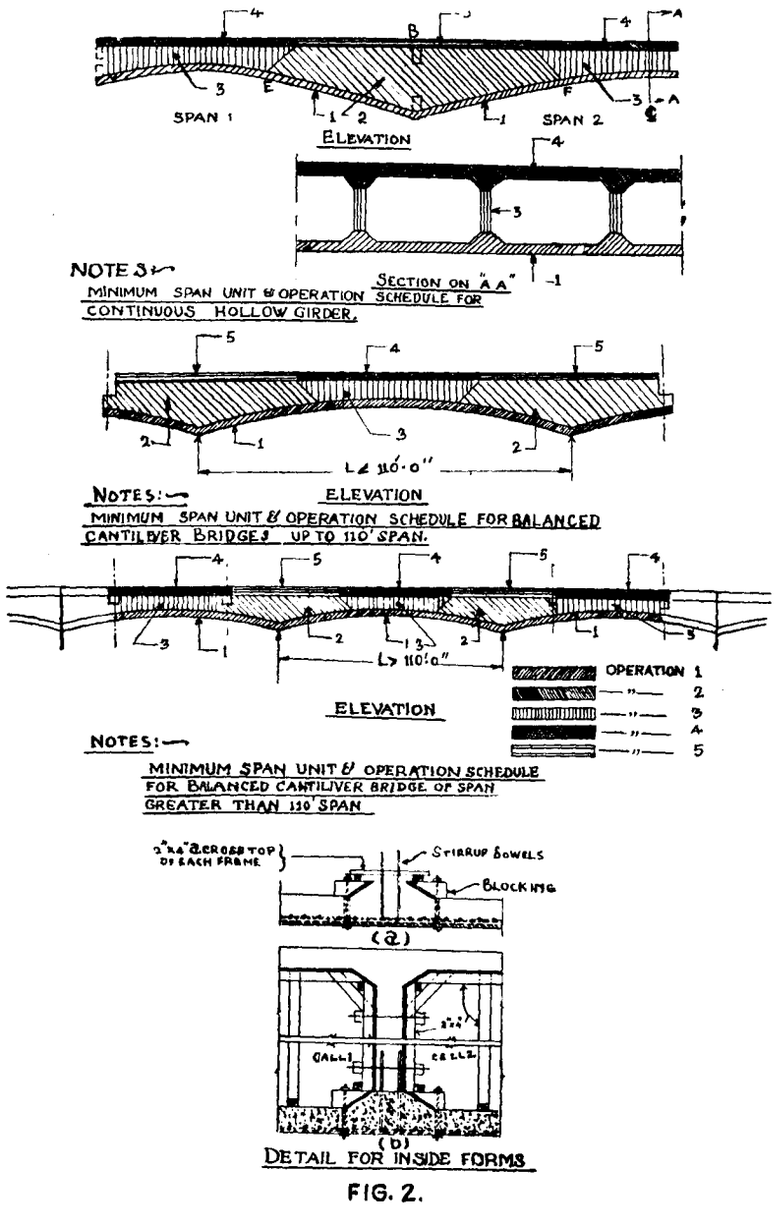


FIG. 2.

strips of 11 ft width each. The length of each bay was kept 32 ft on continuous spans and 21 ft on suspended spans. The cross slope in the roadway is 2 inches. This was achieved by providing $1\frac{1}{2}$ in. slope in the R.C.C. decking slab and the remaining $\frac{1}{2}$ in. by making the wearing coat 3 in. in the centre and $2\frac{1}{2}$ in. on the sides. All joints in the slab are $\frac{3}{8}$ in. wide and are filled with Shalimar expansion jointing material.

In order to expedite the work, laying of the entire 22 ft width was done simultaneously but in order to keep the two strips separate, the sheets of the expansion jointing were placed in position in the centre of the roadway before laying of the concrete.

9.5. Expansion Joints

The expansion joints provided at the junction of the cantilevers and the suspended spans are $1\frac{1}{2}$ in. wide. At the level of the wearing slab, these joints are spanned with $\frac{1}{2}$ in. thick plate 4 in. wide flush with the slab and supported on 2 in. by 2 in. by $\frac{1}{4}$ in. angle irons. The plate is rivetted or welded on one angle iron and is free to move on the other. The area over which it will move on the bearing slab is filled with bituminous material.

9.6. **Curing:**—Curing was done by covering the fresh concrete surface with gunny bags and keeping it wet for 21 days continuously.

10. MATERIALS

10.1. **Cement:**—Fresh Portland cement was used on the job received from the various works, mostly from Kymore. Tests were carried on various consignments of cement and some of the results might be seen in Appendix 3.

It would be seen that the cement gave considerably good results. A small laboratory at the site of the work was also established for carrying out various field tests of cement, sand and ballast from time to time. The river water which was permitted to be used for the reinforced concrete work was also got tested for alkalies and it was found quite suitable for use.

Cement concrete test cubes 6 in. by 6 in. by 6 in. were cast every day that concreting was done and these were sent to the P.W.D. Research Station at Lucknow for compression tests. Some of the results of tests are given in Appendix 4.

10. 2. **Fine aggregate :**—Good coarse sand was available in the bed of the Betwa river near the site of the bridge. This was tested and found satisfactory for use in the concrete work. The fineness modulus of this sand worked out to 3.4. Results may be seen in Appendix 5.

10.3. The aggregates were finally chosen and after fixing the gauge the mix was designed by the Research Station at Lucknow.

Crushed granite $\frac{3}{4}$ in. gauge well graded was used for reinforced concrete all through. This was quarried from a site about $2\frac{1}{2}$ miles from the bridge towards Jhansi and situated only about two furlongs from the main road. The grading of coarse aggregate was done as per Appendix 6 giving best results.

10.4. **Water :**—Electric pumps were installed in the river for pumping water for various operations as well as curing.

10.5. The following materials were used in the construction of the bridge :

(1)	Mild steel of different sizes for reinforcement		620 tons
(2)	Mild steel for centering and shuttering		50 ,,
(3)	Cast steel in bearings	...	65 ,,
(4)	Cement	...	2700 ,,
(5)	Masonry stone	...	4.0 lakh cu. ft.
(6)	Granite stone ballast	...	1.5 ,,
(7)	Petrol and lubricants	...	20,000 gallons
(8)	Timber for shuttering, etc.	...	20,000 cu. ft.
(9)	Explosives for blasting	...	10,000 lb
(10)	Coarse sand	...	2.5 lakh cu. ft.

11. APPROACHES

When the site of the main bridge structure was approved, detailed surveys for construction of approaches were carried out both on Jhansi and Lalitpur sides.

11.1. Jhansi Side Approach

11.1.1. On Jhansi side approach it was found from local enquiries that a considerable length of the existing road got submerged during heavy floods and the depth of water in certain reaches was as much as 8 ft or more. When '*L*' sections were completed, it was found that the road was actually much below the H.F.L. of the Betwa. The estimate was, therefore, framed for raising the entire length of the approaches to 2 ft above H.F.L. and this length worked out to 4,400 ft.

11.1.2. As mentioned before, the width between the kerbs of the bridge is 22 ft. The width of metalled surface starting from either end of the bridge is also 22 ft and is gradually reduced to 12 ft in a length of 700 ft on either side. The top of bank in these reaches is 42 ft wide and narrows down to 38 ft. The final approved alignment of Jhansi side approach consists of :

(a) First 200 ft straight length from the end of the bridge.

(b) A curve of 1,000 ft radius, 650 ft long having transition lengths of 130 ft on either side.

(c) Straight length of 50 ft.

(d) Second curve of 1,000 ft radius, 530 ft long and with transitional lengths on either side.

(e) The rest of the alignment is absolutely straight.

11.1.3. Provision for Cross Drainage

In the existing road there were two small culverts of 3 ft span each which were more or less balancing culverts and one minor bridge having two spans of 15 ft each. The latter was across a well-defined nullah which discharged into the Betwa about two furlongs on the downstream side of the bridge. The possibility of diverting the nullah along the length of the approach road with a view to discharging it on the upstream side of the bridge was examined, but it was found that there was a marked high range of hillocks made up of solid granite rocks between the nullah and the bank of the Betwa, and it was calculated that the cost of digging a new nullah would be prohibitive. A minor bridge was, therefore, provided over the nullah.

As good rock was met at a depth of 8 to 10 ft from the bed of the nullah, the foundations of the minor bridge were taken down to that depth. All masonry of abutments and wing walls was specified to be of coursed rubble in cement and sand mortar.

As there was acute shortage of steel, this bridge was designed as an arch bridge. Since good ballast and sand were available at very reasonable rate, an arch of plain cement concrete blocks worked out to be the cheapest. The two other culverts of 3 ft span each were more or less balancing culverts, as stated above, and it was, therefore, decided to restrict the height of their abutments to 4 ft above floor level, although the height of bank at those sites was between 15 to 20 ft. This design was very much cheaper than the usual high abutment type. Plain cement concrete blocks, 3 ft by 2 ft by 1 ft 3 in., were cast on the top of the centering in alternate panels. The second set of the remaining panels was cast a week later. The blocks for key were also cast in situ a week after that.

11.1.4. **Earthwork**:—About 5 million cu. ft. of earthwork had to be done in Jhansi side approach and had to be completed within a record time of eight months. The tract from where earth was taken was mostly rocky with the result that in some cases earth had to be carried from a distance of about 1,000 ft. In addition to human labour, ponies, donkeys and bullock carts had to be engaged. The compaction was done by wooden 'durmuts' and by wooden sheepsfoot rollers supplied by the Department. Most of the earthwork was completed before and during the rains and it was expected that there would not be much settlement in future years. It was noticed that settlement in the portions which were done before the rainy season was very little after the rains.

Stone boulder pitching was done in a length of 120 ft near the abutment of the main bridge and on the upstream side of the minor bridge. 'Sarpat' grass planting has been started on the side slopes of the bank to a height up to H. F. L.

11.1.5. **Metalled surface**:—Originally it was proposed to provide three coats of metal and two coats of surface dressing but, in view of the fact that the new embankment was liable to subsidence at places, it was considered not advisable to provide the final coat of metalling. Accordingly, one soling coat of 3 in. gauge stone 6 in. thick and one intercoat of $1\frac{1}{2}$ in. gauge stone metal $4\frac{1}{2}$ in. thick were provided, and only one coat of paint was given. Till the time of writing this Paper, no appreciable waviness was noticed in the surface, but final observations would be taken in October/November, 1958.

11.2. Saugor Side Approach

11.2.1. Selection of alignment on this side was comparatively easier as there were no obligatory points and the ground

was more or less level. The length of the approach road worked out to 2,400 rft. The top level of the embankment on this side is also 2 ft above H. F. L. The width of the road surface at the end of the bridge is 22 ft for the first 250 ft, after which it narrows down to 12 ft in a length of 700 ft.

The alignment is straight for the first 250 ft, after which a circular curve of 1,800 ft radius is provided in a length of 1,760 ft. The rest of the alignment is absolutely straight.

11.2.2. Cross Drainage

For cross drainage, only one small culvert of 3 ft span is provided. The height of embankment at the site of the culvert is about 13 ft and, therefore, working on the same principle as for the Jhansi side approach, a culvert with low abutments of increased length was found to be cheaper. Specifications for this culvert were the same as for the two smaller culverts on Jhansi side approach.

11.2.3. **Earthwork**:—Several types of earth from black cotton to good moorum were met with. In the initial stages efforts were made to avoid all black soil from coming into the embankment. But it was found that, in that case, good earth would have to be transported from very long distance and the cost would be prohibitive. Apart from the undesirable characteristics of bulging and contraction in black soil, one major defect which was difficult to avoid was hardness of the clods which were very difficult to break. It was found that the wooden sheepsfoot rollers, which worked quite satisfactorily on Jhansi side approach, were ineffective in black earth on this side. Clod breaking, therefore, was done with bamboo sticks and ramming with iron rammers and iron sheepsfoot rollers. Compaction by steam road roller was also resorted to several times.

The resources of the contractor on this side were not very satisfactory. Earth moving machinery was, therefore, obtained from the Chief Engineer's reserve at Lucknow and was employed to supplement the work of the contractor. One scraper coupled to a tractor and one grader were found to be sufficient for the job. Over 2.1 million cu. ft. of earthwork was done on this side approach.

Stone boulder pitching is provided near the abutment of the bridge both on the upstream and downstream sides to protect the bank from erosion. The metalled surface was constructed in the same way as on Jhansi side approach.

11.3. **Cost of approaches**:—Details of expenditure on approaches are given below :

			Rs
(1)	Earthwork	...	276,771
(2)	Bridges and culverts including pitching	...	70,303
(3)	Metalling of surface	...	28,617
(4)	Work-charged staff	...	530
(5)	Agency charges 7½ per cent	...	28,216
	Total Rs	...	404,437

12. COST OF THE BRIDGE

The total cost of the project including the approaches on either side worked out to Rs 27,47,437 and the cost of the bridge alone was Rs 23,43,000. The bridge was completed in record time considering the limitations in the working period due to the weir being closed and there being 20 ft of water in the river at the site of the bridge. This is the longest and the biggest road bridge in the State of Uttar Pradesh so far constructed by the State P. W. D.

ACKNOWLEDGMENT

This Paper has been written with the kind permission of the Chief Engineer, P. W. D., Buildings and Roads, U. P., Lucknow.

Appendix 1

TEST CERTIFICATE

Specification. Indian Roads Congress Specification.

	H. No.	Mn.	S.	P.	Si.	Cr.	Ni.	Mo.
Ladle sample analysis	4607A	—	.030	.043				
	4608A	—	.018	.043				
	6738A	—	.041	.058				
	6759A	—	.023	.045				
	6743A	—	.023	.034				

Heat No.	Section	Y.P. tons per sq. in.	Max. stress tons per sq. in.	Elong % on 2 in.	Bend test	Brinell hardness No.
4607A	Tensile piece C	—	40.0	25	Satisfactory	180/200
4608A	do.	—	39.2	22	do.	do.
6738A	do.	—	38.8	24	do.	do.
6759A	do.	—	40.4	15	do.	do.
6734A	do.	—	38.0	23	do.	do.

Remarks: Roller bearing P977 to P980

Tested in my presence.
Sd/-
Asst. Inspecting Officer, Bombay.

Sd/-
Chief Metallurgist.

(*Contd from prepage*)

TEST CERTIFICATE

Specification. Indian Roads Congress Specification.

	H. No.	Mn.	S.	P.	Si.	Cr.	Ni.	Mo.
Ladle sample analysis.	1525B	—	.026	.044				
	1564B	—	.027	.034				
	1579B	—	.030	.053				
	1568B	—	.032	.043				
	1593B	—	.022	.042				
	1635B	—	.022	.035				

Heat No.	Section	Y.P. tons per sq. in.	Max. stress tons per sq. in.	Elong % on 2 in.	Bend test	Brinell hardness No.
1525B	Tensile piece C	—	40.0	23	Satisfactory	180/200
1564B	do.	—	40.8	21	do.	do.
1579B	do.	—	38.0	21	do.	do.
1568B	do.	—	36.0	24	do.	do.
1593B	do.	—	38.8	25	do.	do.
1635B	do.	—	36.8	24	do.	do.

Remarks: Roller bearing P977 to P980

Tested in my presence.
Sd/-
Asst. Inspecting Officer, Bombay.

Sd/-
Chief Metallurgist.

Appendix 2

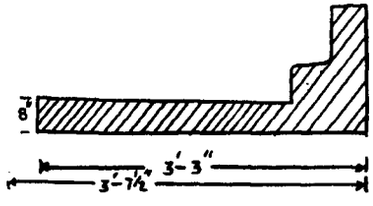
CALCULATIONS OF R. C. CANTILEVER BRIDGE OVER BETWA AT JHARARGHAT (DISTRICT JHANSI)

1. Design of Cantilever Portion and Deck Slab

(a) Cantilever Portion

Span = 3.25 + 0.37 = 3.62 ft

(i) Dead load moments of railing, kerb, wearing coat and deck slab = 16,600 in lb.

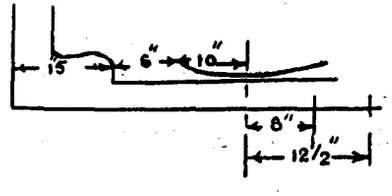


(ii) Live load moment:—This shall be maximum when one of the 12,500 lb wheels of class 'A' loading is 6 in. away from the kerb (wheels of class 'AA' cannot come on this slab).

From formula $e = K\,b + W$, we find width on which load acts and then live load bending moment = 39,400 in lb. Bending moment due to horizontal pressure on railing = 5,400 in lb.

Total B.M. = 16,600 + 39,400 + 5,400 = 61,400 in lb.

Depth = 6.2 inches.



Overall depth of 8 in. is O.K. with effective depth = 7 in. A_t = 0.56 sq. in. Provide 5/8 in. bars at 4½ in. centre to centre.

(b) **Deck Slab**

Average size of panel is 12 ft 7 in. × 7 ft 10½ in.

(i) Dead load:—Using Pigeaud's methods and allowing for continuity of spans,

M_a dead load = 6,480 in lb (M_a = moment along short span)

M_b dead load = 2,728 in lb (M_b = moment along long span)

(ii) Live load:—Class 'AA' tracked vehicle moment shall be maximum when one track of a 70-ton tank is placed symmetrically about the centre line of the span.

As above, M_a L.L. = 78,080 in lb

M_b L.L. = 31,040 in lb

Class 'AA' wheeled type loading

As above, M_a L.L. = 66,400 in lb

M_b L.L. = 20,000 in lb

For design purposes, values of moment from the two cases are: for short span = 66,400 in lb

long span = 31,040 in lb

(Value of moment along short span for tracked wheel is erroneous as full dispersion of 12 ft long track is not considered).

Therefore, D.L. + L.L. (short span) = 72,880 in lb

D.L. + L.L. (long span) = 33,768 in lb

Therefore, D = 6.95 in. ($Q = 126 = \frac{1}{2} CNJ$). Provide 8 in. overall.

A_t = 0.665 sq. in. Provide 5/8 in. bars at 4½ in. centre to centre.

A_t = (along long span) 0.33 sq. in. Provide ½ in. bars at 7 in. centre to centre.

Note:—In deck, however, this has been combined with girder steel.

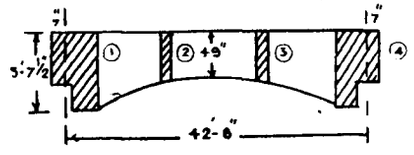
Shearing Forces in Slab :— These come out to be 5,300 lb in the short span and 1,270 in the long span. Therefore, shearing intensity = 74 lb per sq. in.

Bond shear = 185 lb per sq. in. (bars are hooked) – permissible.

DESIGN OF SUSPENDED SPAN

Dead Load

I. Point load from cross beams (decking, wearing coat, fillets) = 21,800 lb.



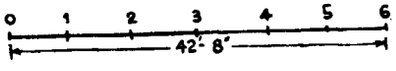
II. Point load from stiffeners (1 and 4) = 27,800 lb acting at 0.84 ft from free end.

III. **Uniform distributed load**.– (railing, road kerb, wearing coat, soffit slab, fillets, main girders) = 296,780 lb.

Net after deducting deck load already taken on cross beams and stiffeners 1 & 4 = 296,780 – 55,846 = 240,934 lb.

Dead load moment, live load moment, shear force as determined have been tabulated as below:

Note:—For calculating shear, no correction has been made for haunches as slope in haunches is nominal.



Section	D.L.M. Ft kips	L.L.M.		Total Max. shear				Total shear kips	Shear intensity lb per sq. in.
		Class 'AA' Ft kips	Class A Ft kips	D.L.M. + L.L.M.	Dead load	Class 'AA'	Class 'A'		
0	—	—	—	—	170	77	156	326	214
1	867	760	845	1713	101	57.6	119	220	160
2	1493	1370	1265	2863	62.6	28.7	85	147.6	114
3	1607	1580	1380	3187	Nil	Nil	54	54	43

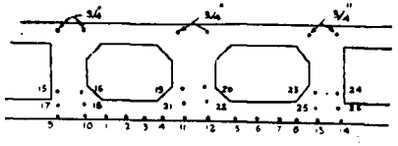
Section comes out as follows:

Shear intensity has been calculated by taking cover = 4 in. and J_d = 7/8 d, breadth = 27 in.

Reinforcement.- Maximum moment = 3,187 ft kips.

A_t = 44 sq. in. Provide 26 bars 1½ in. diameter.

Placing of reinforcement is as follows:



Note:—In the bars, 1½ in. (1 to 8) have been replaced by 32 Nos. ¾ in. bars. By superimposing resistance moment diagram on moment diagram bars have been bent as below:

Bar No.	Distance from support	Spacing	Bar No.	Distance from support	Spacing
S-26	4 ft	6 in.	S-24	8 ft 3 in.	1 ft
S-22	4 ft 6 in.	6 in.	S-20	9 ft 3 in.	1 ft
S-18	5 ft	9 in.	S-16	10 ft 3 in.	2 ft
S-25	5 ft 9 in.	9 in.	S-23	12 ft 3 in.	2 ft
S-21	6 ft 6 in.	9 in.	S-19	14 ft 3 in.	2 ft
S-17	7 ft 3 in.	1 ft	S-15	16 ft 3 in.	2 ft

Shear.—From shear envelopes it will be observed that the bent up bars take into account all diagonal tensions. However, provide nominal ½ in. two-legged stirrups at 6 in. centre to centre up to 6 ft from support and 12 in. centre to centre in rest of the span.

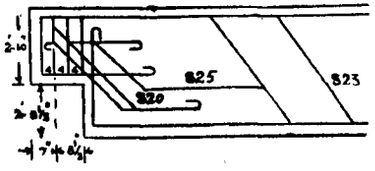
Bond.—This is found to be safe in bond. Stress = 87 lb per sq. in. Stresses in various sections are found to be within limit.

Design of Articulation (Suspended Span)

Checking the cantilever portion for bending and shear,

Moment at A = 2,771,000 in lb. Width of beams = 27 in.

Therefore D = 26.3 in. Actual depth = 34 in. and effective = 30 in., and hence safe.



Maximum shear = 326,000 lb.

Shear taken by 3 Nos. ½ in. stirrups at 6 in. centre to centre = 375,625 lb. Hence safe. Still it is better to decrease spacing of stirrups to 4 in. in the first foot.

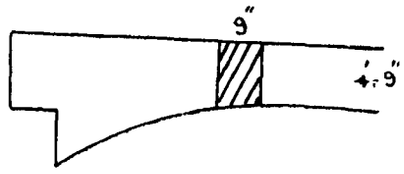
On account of sudden deduction in depth, the weakest section is likely to be across an all included plane through the corner. On finding stresses, it is found necessary to introduce 3 Nos. 1½ in. bars bent up. This is then safe in shear and bond.

Design of Cross Beams (Suspended span)

Dead Load and Live Load

Section	Dead lead moment	Live load moment
end support	− 210,500 in lb	− 610,500 in lb
mid span	+ 99,400 in lb	+ 433,700 in lb
mid support	+ 267,000 in lb	− 614,000 in lb

Maximum steel required is 0·3 per cent = ·003 × 9 × 57 = 1.539 sq. in. Provide two bars 1½ in. both top and bottom. This is more than what is required for the above bending moment.



Shear Stress = 100 lb per sq. in. Use $\frac{1}{2}$ in. two-legged stirrups at 6 in. centre to centre up to $2\frac{1}{2}$ ft from support and then provide in the centre at 12 in. centre to centre.

Bond Stress = 130 lb per sq. in. Safe.

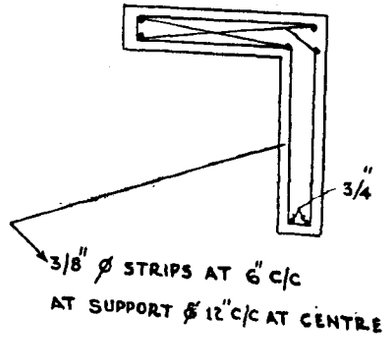
Stiffener.—This does not take any live load and shall be designed for self load only. Dead load = 170 lb per running foot.

D.L.M. (support) = 15,650 in lb.

D.L.M. (mid span) = 6,000 in lb.

A_t = 0.34 sq. in.

Nominal steel at 3 per cent = 0.5 sq. in.



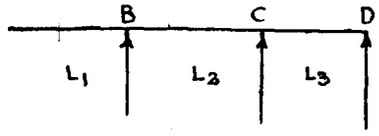
Provide 2 Nos. $\frac{3}{4}$ in. bars both top and bottom. Also provide $\frac{3}{8}$ in. stirrups at 6 in. centre to centre at support and 12 in. centre to centre at centre.

DESIGN OF MAIN BEAMS

Live Load

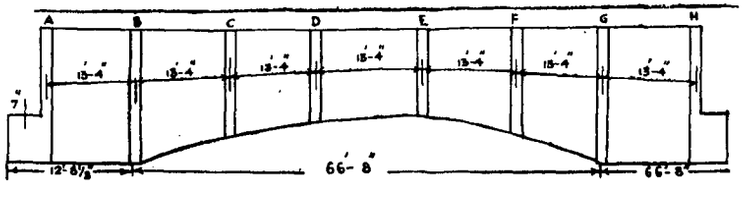
The main girder will be designed either for Class 'AA' loading (track type) or double lane of Class 'A' loading. Wheeled

type would give lesser moment. The problem will be treated by treating the continuous span separately and superimposing the most unfavourable effect of cantilever ends as suggested by Taylor and Thompson, Vol. III, page 184.



Referring to "Continuous Concrete Bridges" (Portland Cement Association, Illinois, pages 68 to 92), the live load moment at different points of span is as tabulated below:

Section	Class AA loading		Class A loading		Max. as from the two cases	
	Max. Pos.	Max.-ve	Max. Pos.	Max.-ve	Pos.	-ve.
A	—	—	—	—	—	-2060 AA
0.25 L1	1930	423	1818	—	1930 AA	423 AA
0.33 L1	2190	564	2044	330	2190 AA	364 AA
0.50 L1	2190	846	2075	495	2190 AA	190 AA
0.67 L1	1660	1128	1800	660	1800 A	1269 AA
0.75 L1	1320	1269	1233	742	1320 AA	1570 A
B	—	-1510	—	—	—	1510 AA
0.25 L2	1380	1030	980	1115	1380 AA	1115 A
0.33 L2	1660	875	1282	960	1600 AA	960 A
0.5 L2	1870	542	2130	654	2130 AA	654 A



Dead Load

Similarly moments dueto dead load have been calculated on the basis of "Continuous Concrete Bridges," Portland Cement Association, Illinois." These are now computed on the principle

laid down by Taylor and Thompson, page 171, and combined moments due to dead load and live load are determined as follows:

Section	D. L. Ms.	L. L. Ms.		Combined moment	
		Max. Pos.	Max. -ve	Max. Pos.	Max. -ve
A	-2745	—	-2060	—	-4805
0.25 LI	10	1930	- 423	1940	-1455
0.33 LI	440	2190	-1240	2630	-1022
0.5 LI	680	2190	- 864	2870	- 524
0.67 LI	52	1800	-1128	1852	-1102
0.75 LI	- 581	1320	-1269	1030	-1856
B	-3921	—	-1570	—	-5491
0.25 L2	- 881	1380	-1115	940	-1996
0.3 L2	- 341	1600	- 960	1430	-1301
0.5 L2	- 11	2130	- 654	2141	- 650

Note :—Moments of the same sign have been added, for opposite moment $\frac{1}{2}$ dead load has been added to live load.

Shear force determined on the basis of the above reference is tabulated below along with steel at various sections.

Note :—Cover for positive steel = 3 in.

Cover for negative steel = 4 in.

Section	B.M.	B.M.	Shear	Depth		Steel Provided	
	Max. Pos.	Max. -ve	kips	Positive	Negative	Top Ft. In.	Bottom Ft. In.
A	—	4805	490	78	77	26 $1\frac{1}{2}$	10 $1\frac{1}{2}$
0.25 L1	1940	1455	228	60.5	59.5	10	12
0.33 L1	2630	1022	162	57.5	56.5	10	21
0.5 L1	2870	524	36	54	53	6	21
0.67 L1	1852	1102	234	57.5	56.5	10	21
0.75 L1	1030	1850	286	60.5	59.5	18	19
B	—	5491	464	78	77	30	6
0.25 L2	940	1996	243	60.5	59.5	18	15
0.33 L2	1430	1301	185	57.5	56.5	10	17
0.5 L2	2141	650	0	54	53	6	18

In order not to reduce effective depth considerably only three ows of bars shall be provided in each rib. Out of them four in ach rib will be bent. For remaining portion shear stirrups will .ave to be provided.

Shear Stressses and Shear Reinforcement

Total shear taken up by bent up bars and web = 328,000 lb. Therefore, the remaining shear = 490,000 − 328,000 = 162,000 lb. This will be provided by using two-legged stirrups $\frac{3}{4}$ in. diameter t 5 in. centre to centre upto 5 ft on either side at supports A nd B, and for the remaining length use $\frac{1}{2}$ in. stirrups at 6 in. entre to centre.

Bond.—At support A it comes to be 57 lb per sq. in. (safe). Stresses at different sections of the beam on calculation come out o be safe.

Main Beam at End Spans

Live load moments are the same as above. Dead load moments are also the same as for main beam except for distribution of D.L.M. from cantilever end. After carrying out adjustments due to above bending moments come out as follows:

(Tabulated along with steel provided)

Section	D.L.M. & L.L.M. combined moment		Steel provided	
	Positive	Negative	Top	Bottom
	0	0	0	0
.25 L1	3814	—	—	45.6 sq. in. = 26 bars $1\frac{1}{2}$ in.
.5 L1	3878	—	—	30 bars
.75 L1	1098	1713	12 bars	8 bars
	—	6224	—	34 bars
.25 L2	688	2499	18 bars	6 bars
.5 L2	1998	917	8 bars	16 bars
.75 L2	968	2040	14 bars	8 bars
	—	5305	30 bars	—
.25 L3	1098	1714	12 bars	8 bars
.5 L3	2960	478	4 bars	2 bars
.75 L3	1980	1515	10 bars	14 bars
D	—	4805	26 bars	—

It is now apparent that very great modifications are needed for steel in the first span and very little change in the middle span.

The top girder will, however, be combined with the deck slab in the main span. All the steel has been provided with a view to keep the maximum bond stresses up to 200 lb per sq. in.

Eighteen ($1\frac{1}{2}$ in.) bars have been provided for the ribs. The rest of the steel in the soffit has been replaced by $\frac{3}{4}$ in. diameter bars in span 1. The steel provided for in the mid-span of L1 is 18 ($1\frac{1}{2}$ in.) bars and 48 ($\frac{3}{4}$ in.) diameter bars and in midspan of L2 is 18 ($1\frac{1}{2}$ in.) bars and 36 ($\frac{1}{2}$ in.) bars.

Shearing force will remain the same as in the main span except at support A. It will be rather less. But, for convenience, provide the same stirrups as in the main beam. Stresses in this beam are to be the safe.

DESIGN OF ARTICULATION, CROSS BEAM, AND CROSS BEAM FOR MAIN SPAN

Articulation —Maximum moment comes out to be 504,000 in lb. Provide 3 bars 1 in. on top and bottom.

Cross Beam —Cross beams B, C and D have all been designed on the basis of steel provided 0.3 per cent of section area.

Cross Beam B —Provide 2 Nos. $1\frac{3}{8}$ in. top and bottom; provide nominal stirrups of $\frac{3}{8}$ in. at 6 in. centre to centre at support and 12 in. centre to centre at centre.

Cross Beam C —Provide 2 Nos. $1\frac{1}{8}$ in. bars both top and bottom and provide $\frac{1}{2}$ in. stirrups at 6 in. centre to centre at support and 12 in. centre to centre at centre.

Cross Beam D —Provide two $1\frac{1}{8}$ in. bars and stirrups as in beam C.

DESIGN OF SOFFIT SLAB

It will be designed as a stiffener only, with 0.3 per cent of steel both ways.

Cross sectional area $= 12 \times 5.5 = 66$

$$A_t = 66 \times 0.003 = 0.198 \text{ sq. in.}$$

Provide $\frac{3}{8}$ in. bars at 6 in. centre to centre both ways.

This also complies with the reinforcement of flange steel of ribs.

Appendix 3

TEST OF CEMENT
REPORT OF TEST

Laboratory sample No. 113-56 Laboratory concrete Report of Sample. Name of material cement.

Source of material: Local used or to be used—for construction of Jhararghat bridge.

Examined for—Maximum density and physical tests of cement

Results:

1. Physical tests of cement No. 113-56

   D. of max.

   Normal consistency—26.8 per cent.

2. Fineness by B.S. Sieve No. 170—5.4 per cent.

3. Time of testing: Initial—145 mins.
   Final —265 mins.

4. Soundness by La. Chatiller app:
   — Nil

5. Tensile strength after 3 days. — 327 P.S.I.
   after 7 days. — 425 P.S.I.

Remarks:

The sample of cement is satisfactory.

TEST OF CEMENT

S. No.	Material from which sample taken	Date of sample	Date of test	Strength of briquette lb per sq. in.
1.	Neat cement	9/12	16/12	577
2.	,,	10/12	18/12	584
3.	,,	11/12	,,	590
4.	,,	3/12	20/12	595
5.	,,	15/1/57	22/1	580
6.	,,	16/1	24/1	585
7.	,,	17/1	24/1	610
8.	,,	28/1	5/2	575
9.	,,	18/3	26/3	595
10.	,,	19/3	,,	550
11.	,,	9/4	17/4	605
12.	,,	10/4	17/4	610
13.	,,	11/4	18/4	560
14.	,,	1/5	7/5	525
15.	,,	2/5	8/5	580
16.	,,	29/6	3/7	370
17.	,,	30/6	4/7	380
18.	,,	1/7	8/7	587
19.	,,	11/7	20/7	580
20.	,,	28/7	4/8	596
21.	,,	29/7	6/8	580
22.	,,	11/8	18/8	575
23.	,,	12/8	20/8	595
24.	,,	16/8	24/8	565
25.	,,	17/8	26/8	600
26.	,,	20/9	28/9	612
27.	,,	21/9	30/9	593

Appendix 4

TEST OF CEMENT CONCRETE CUBES 1 : 2 : 4

REPORT OF TEST

Laboratory sample No. 64–57/Cube. Laboratory concrete Report of sample (Name of material) concrete cubes size 6″ × 6″ × 6″. Examined for compressive strength of cubes :

Results :

S. No.	Identification mark.	Date of cast.	Date of test	Wt. in lb	Compressive strength in psi (more than 28 days.)
1.	P. No. 18	31-5-57	11-7-57	19.0	4584
2.	Soffit slab	12-5-57	,,	18.4	3681
3.	SUS. U. No. 3	19-5-57	,,	18.9	4890
4.	Beam U. No. 4	14-5-57	,,	18.4	4278
5.	P. No. 19	31-4-57	,,	18.6	4278
6.	Beam 4	15-5-57	,,	18.5	4334
7.	Beam 4	15-5-57	,,	19.2	4362
8.	Deck SU. No. 4	28-5-57	,,	19.0	4890
9.	SUS. U. No. 3	19-5-57	,,	18.6	4445
10.	Soffit slab	12-5-57	,,	18.4	3778
11.	Deck slab No. 4	28-5-57	,,	19.0	4792
12.	Deck slab U. No. 4	28-5-57	,,	18.6	3511
13.	Beam 4	19-5-57	,,	18.4	4237
14.	D.S.U. No. 4	29-5-57	,,	18.7	4376

Appendix 5

RESULTS OF TESTS FOR FINENESS MODULUS OF COARSE AND FINE AGGREGATES

Coarse Aggregate:

B. S. Sieve No.	Percentage wt. retained.
1½ in.	0
3/4 in.	5
3/8 in.	55
3/16 in.	95
No. 7	100
14	100
25	100
52	100
100	100
	650

F.M. 6.5

Limit is from 6 to 6.9. So aggregate is suitable.

Fine Aggregate:

B. S. Sieve	Percentage wt. retained
1½ in.	0
3/4 in.	0
3/8 in.	0
3/16 in.	5
No. 7.	35
14	60
25	70
52	75
100	95
	340

F.M. 3.4

Limit is from 2.9 to 3.5. So aggregate is suitable. The value of F.M. is on higher side.

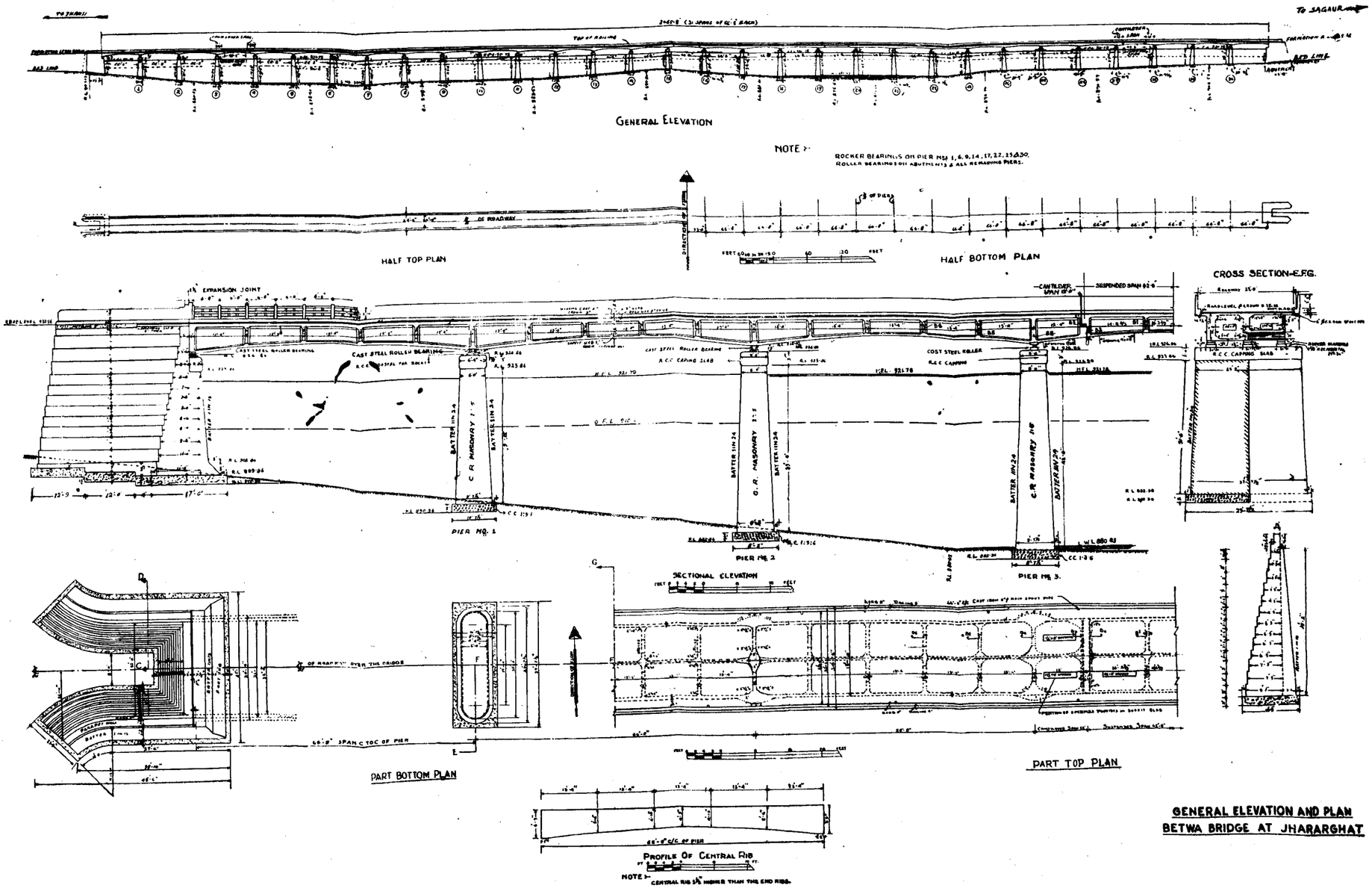
Appendix 6

GRADING OF COARSE AGGREGATE FOR R.C.C. TEST RESULTS

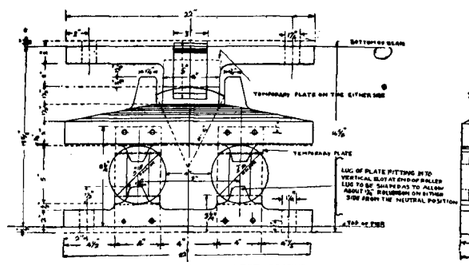
Grading of coarse aggregate:

Size	Sample					
	1	2	3	4	5	6
Passing 1 in. and retained on ¾ in.	33%	40%	45%	50%	60%	70%
Passing ¾ in. and retained on ½ in.	33%	30%	30%	25%	20%	10%
Passing ½ in. and retained on ¼ in.	34%	30%	25%	25%	20%	20%
Wt. of same vol. of mixed agggregate	10 lb 14 oz.	11 lb 10 oz.	11 lb 2 oz.	10 lb 4 oz.	10 lb 10 oz.	10 lb 4 oz.

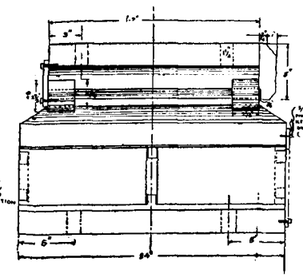
The densest comes to be No. 4 which has been used.



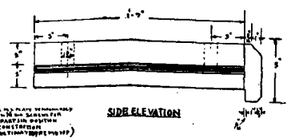
GENERAL ELEVATION AND PLAN
BETWA BRIDGE AT JHARARGHAT



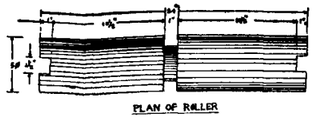
ELEVATION OF COMPLETE BEARING.



END VIEW OF COMPLETE BEARING

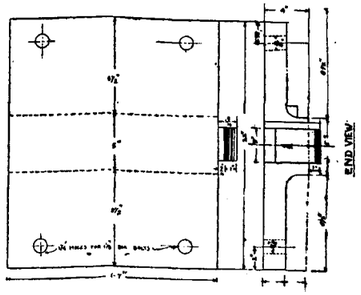


SIDE ELEVATION



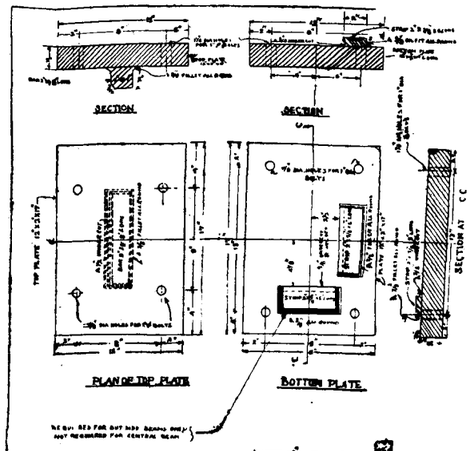
PLAN OF ROLLER

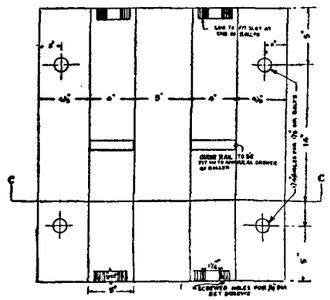
END VIEW



PLAN OF TOP PLATE

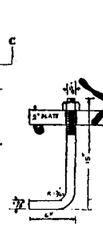
END VIEW



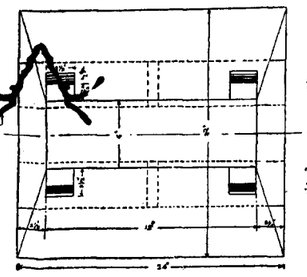


PLAN OF BOTTOM PLATE

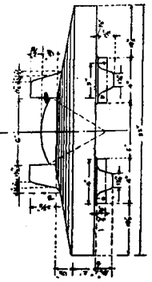
SECTION ON C.C.



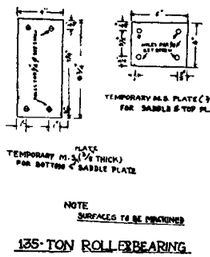
DETAIL OF ANCHOR BOLT SCALE 3"=1FT



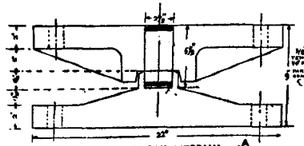
PLAN OF SADDLE PLATE



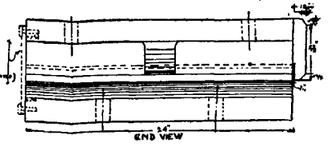
ELEVATION OF TOP PLATE



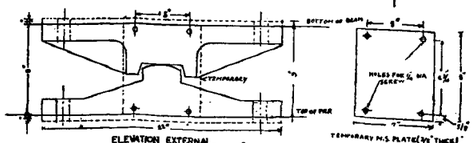
135-TON ROLLER BEARING



ELEVATION INTERNAL

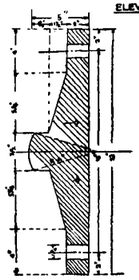


END VIEW

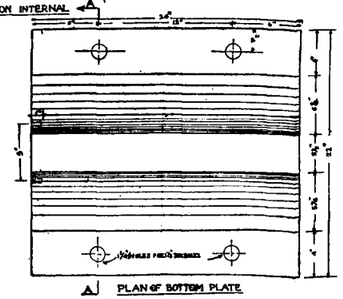


ELEVATION EXTERNAL

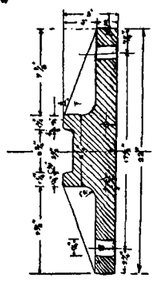
TEMPORARY M.S. PLATE (½" THICK)



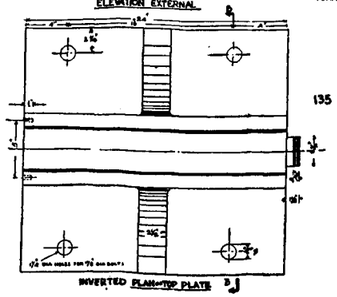
SECTION AT A-A



A PLAN OF BOTTOM PLATE

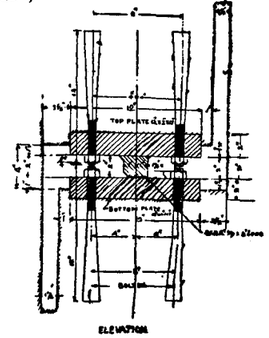


SECTION AT B-B



INVERTED PLAN OF TOP PLATE B

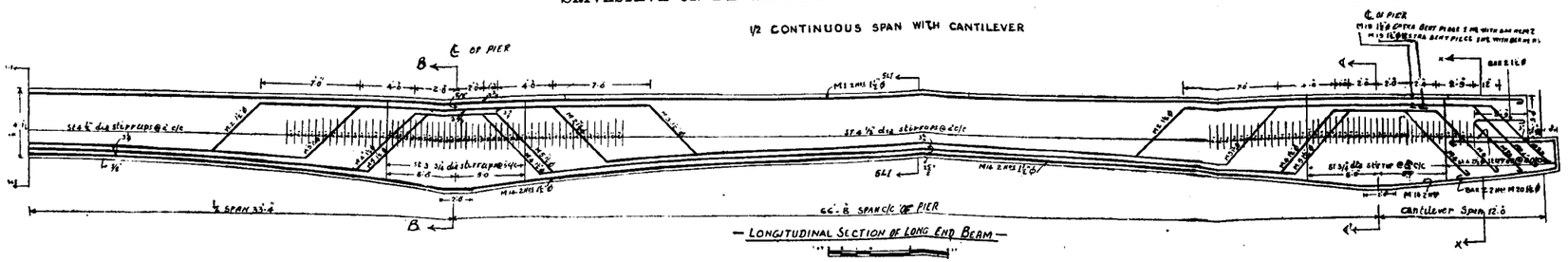
135 TON ROCKER BEARING

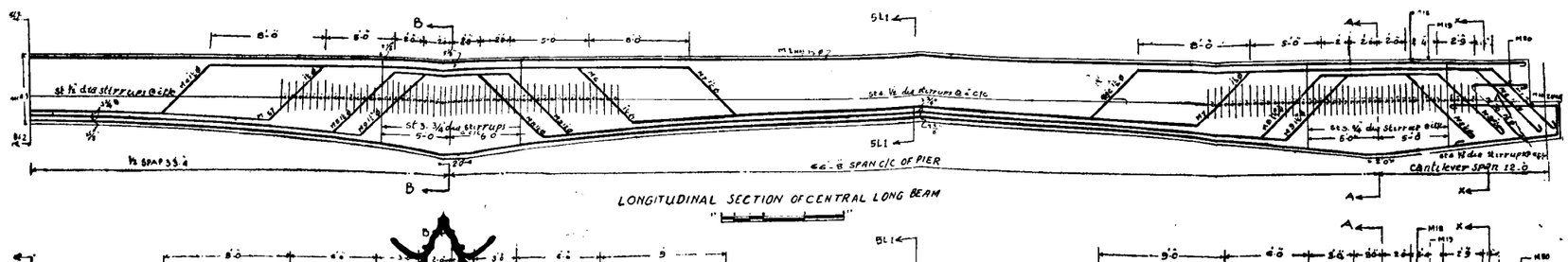


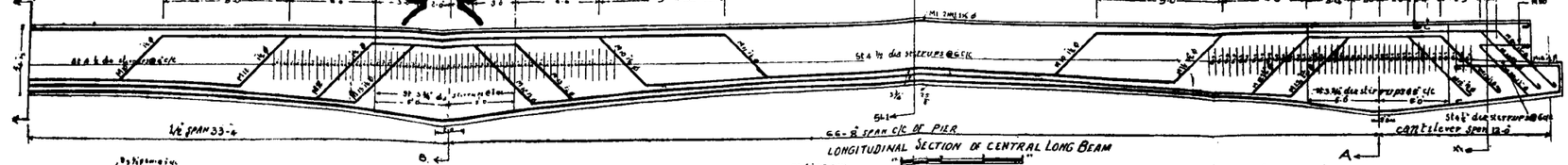
BEARING FOR SUSPENDED SPAN

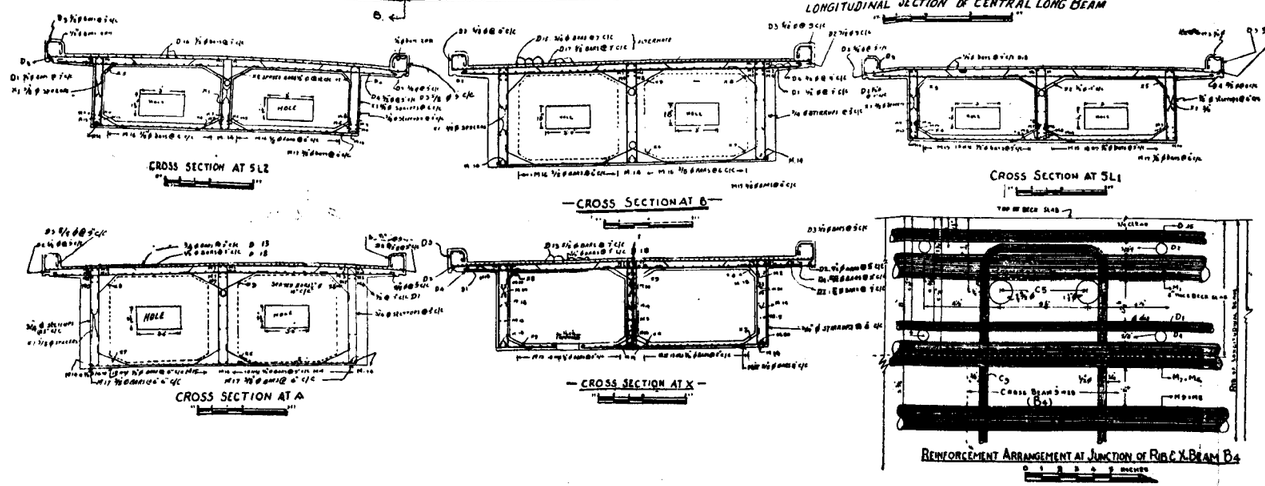
DETAILS OF ROLLER, ROCKER AND OTHER BEARINGS BETWA BRIDGE AT JHARARGHAT

½ CONTINUOUS SPAN WITH CANTILEVER



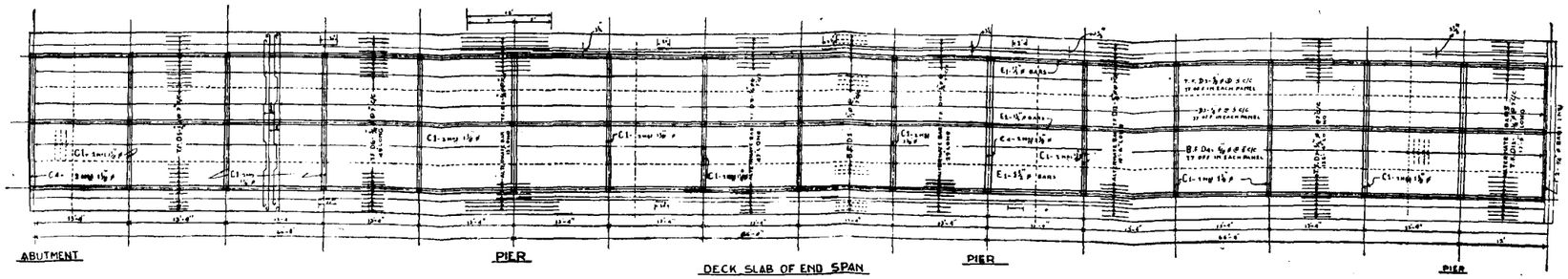


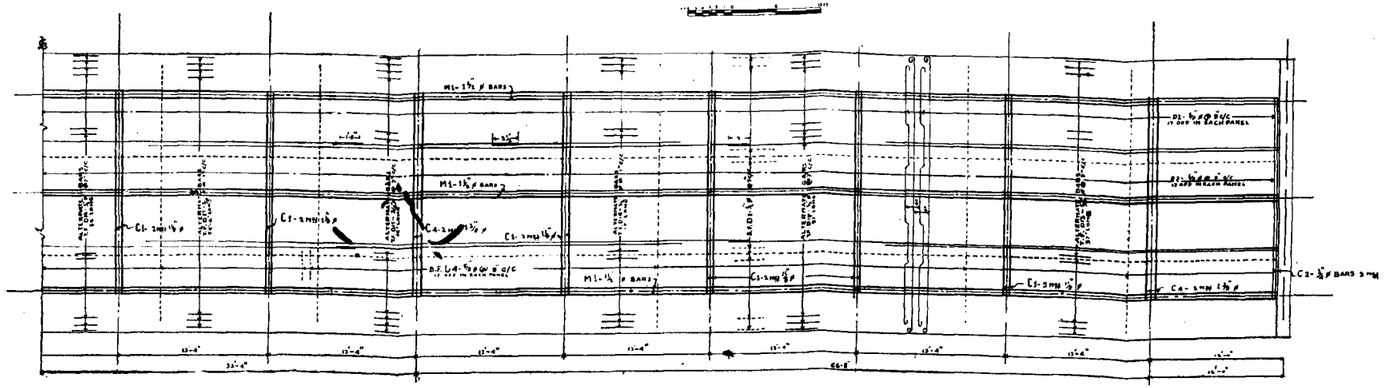


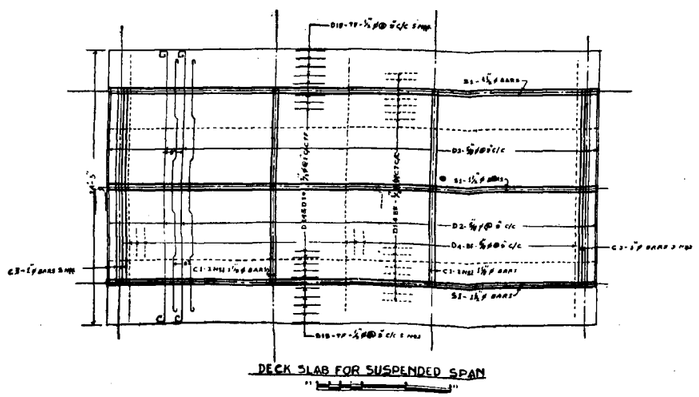


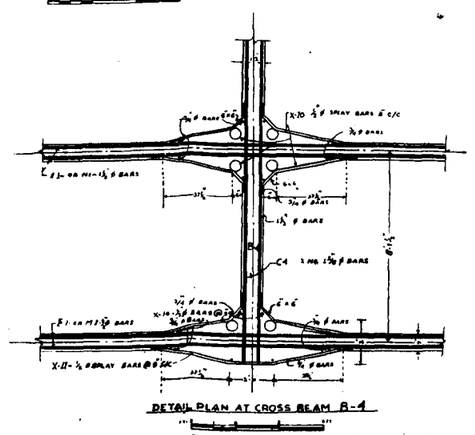
NOTE:- ALL SPLAY BARS MARKED
x 1 - x 9½ @ 12 c/c

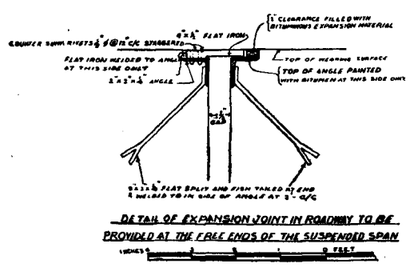
REINFORCEMENT FOR MAIN SPAN BETWA BRIDGE AT JHARARGHAT





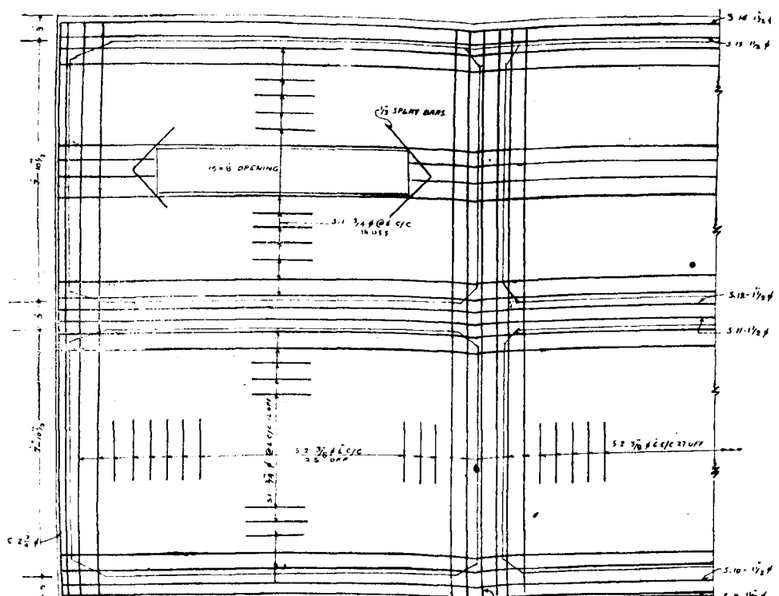


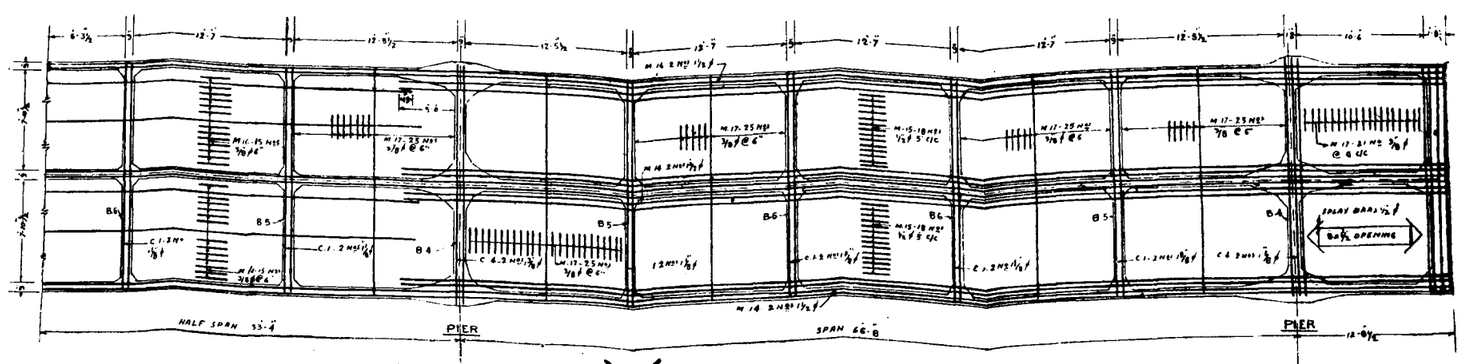




REINFORCEMENT FOR DECK SLAB BETWA BRIDGE AT JHARAR GHAT

PLATE V

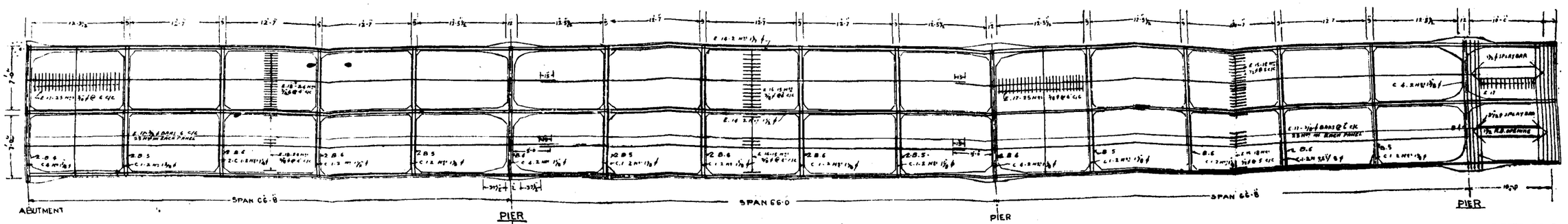




— SOFFIT SLAB UNDER MAIN SPAN —

— SOFFIT SLAB UNDER — — SUSPENDED SPAN —

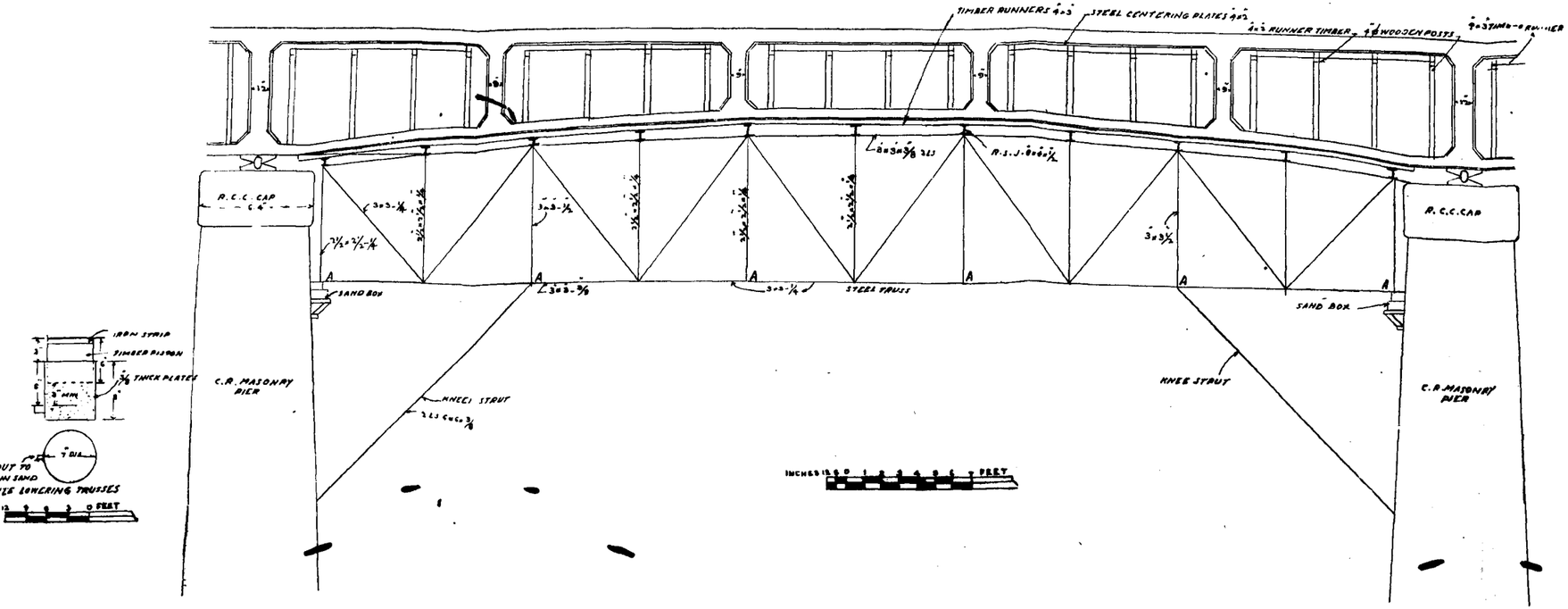
NOTE:—
TWO OPENINGS IN SOFFIT SLAB OF SUSPENDED SPAN TO BE LEFT IN EACH BAY AT OPPOSITE ENDS.

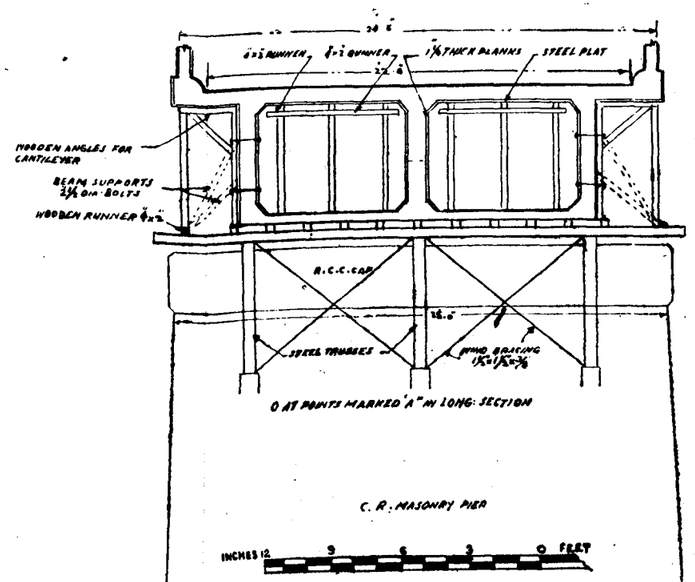


— SOFFIT SLAB UNDER END SPAN —

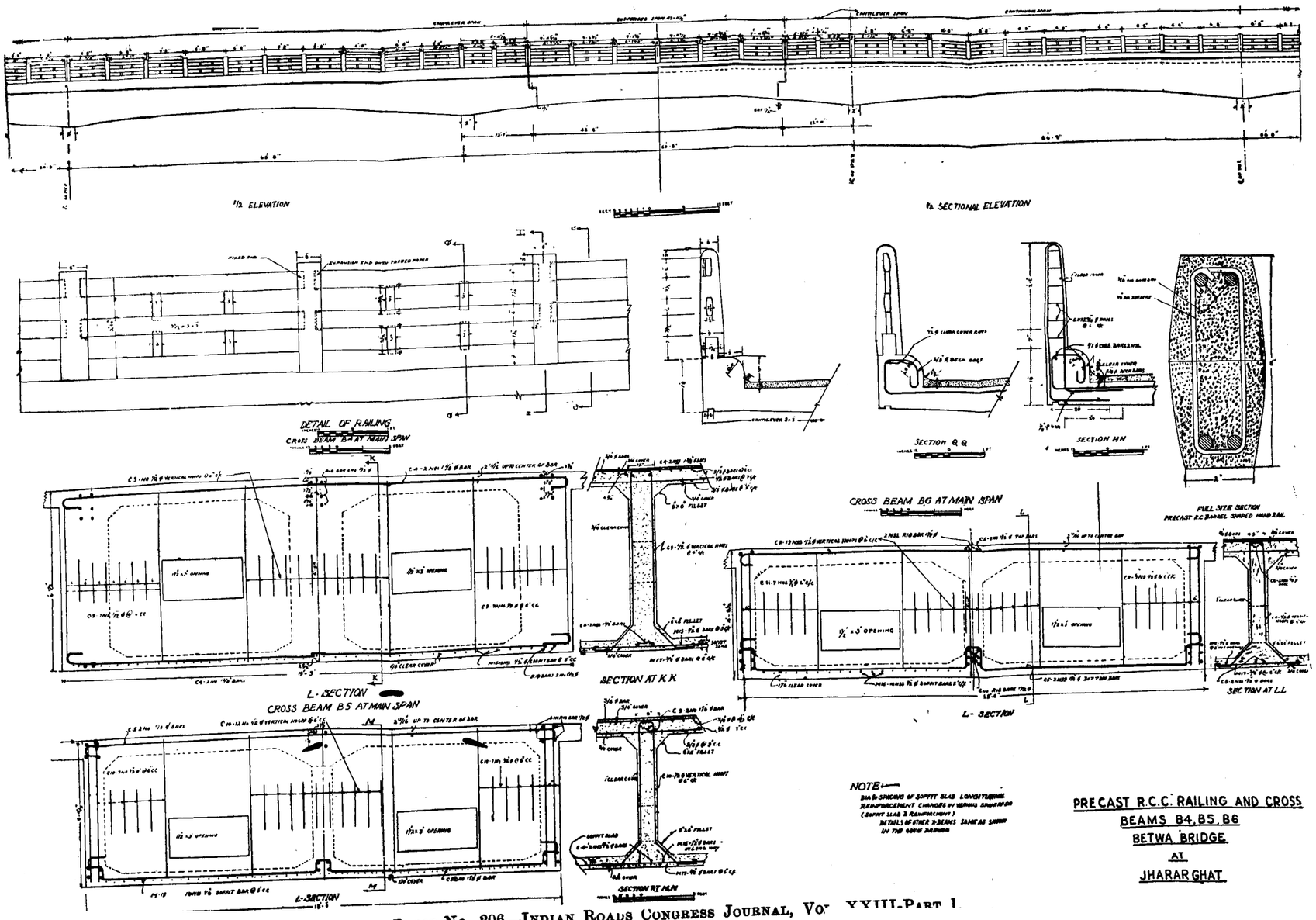
REINFORCEMENT OF SOFFIT SLAB
BETWA BRIDGE AT JHARARGHAT

PLATE VI





DETAILS OF CENTERING FOR SHUTTERING BETWA BRIDGE AT JHARARGHAT


½ ELEVATION
½ SECTIONAL ELEVATION
DETAIL OF RAILING
CROSS BEAM B4 AT MAIN SPAN
SECTION Q Q
SECTION HH
L-SECTION
SECTION AT K K
CROSS BEAM B5 AT MAIN SPAN
L-SECTION
SECTION AT M M
CROSS BEAM B6 AT MAIN SPAN
L-SECTION
SECTION AT L L
FULL SIZE SECTION
PRECAST R.C. BARREL SHAPED HAND RAIL
NOTE
PRECAST R.C.C. RAILING AND CROSS BEAMS B4, B5, B6 BETWA BRIDGE AT JHARARGHAT

Paper No. 207

"ADEQUACY ASSESSMENT OF HIGHWAYS"

By

D. G. BHAGAT,* B.E., M. I. H. E., M. A. S. C. E.

CONTENTS

* Deputy Consulting Engineer (Roads), Ministry of Transport & Communications, Govt. of India.

SYNOPSIS

The Paper gives proposed assessment ratings for the various elements of a road with a view to judge its adequacy. Detailed analysis of the factors involved in the rating system is given both in tabular and diagrammatic forms. Correction factors to be applied in the ratings are also explained. Hints for operation of this method of assessment in the field are given and a specimen condition rating for a road is appended at the end of the Paper.

1. ROLE OF HIGHWAYS

1.1. In the modern trend of march towards progress, highway facilities affect every phase of national activity. With the rapid development in travel characteristics, operational efficiencies, traffic intensities, increasing speeds, etc., the need for an improved highway system has become a factor of primary concern in the overall advancement of the country. The increasing realisation of the contribution made by and the service value of highway arteries in the advancement of multi-phased social, economic and cultural needs of the community has made it necessary to pay greater attention to the development and maintenance of an efficient highway system to cope with the requirements of both the present and the anticipated future needs.

1.2. Road consciousness has now become a live factor in the public mind. The automobile has come to be a vehicle of prime necessity and the urge for long distance transport and carriage of heavier loads has been steadily increasing. The road has, therefore, to keep pace with the ever-increasing demand for more improved facilities. Fortunately, road development being a continuous process, capable of progressive build-up of its surface, the road can efficiently meet with the increasing demands made upon it from time to time without any loss of its value at any stage of its condition.

2. NEED FOR ADEQUACY ASSESSMENT

2.1. Development Aspect

2.1.1. The present road system of the country, originally conceived to suit the earlier requirements of light and slow moving traffic, is now becoming inadequate, structurally as well as functionally. It is out of tune, both in respect of its quality and quantity. Increasing demands and delayed improvements have not been an unusual characteristic in the road policies followed hitherto. The highways are wearing out faster than the

rate at which they can be reconstructed or strengthened and full-scale developments to proper engineering standards to meet even the existing requirements will be an uphill task, looking to the financial commitments involved therein.

2.1.2. A comprehensive country-wide long-term development plan to suit the nation's needs anticipated during the next 20 years is soon to be embarked upon. The pace of development of the country's resources and production targets is expected to accelerate, and the demands on both the efficiency and sufficiency aspects of the highway facilities are bound to be insistent. It is, therefore, obvious that the road development programme should be conceived boldly, planned properly—both technically and economically, phased scientifically and executed efficiently in accordance with the availability of funds. The latter will inevitably be considerably short of the requirements and the planning must, therefore, be formulated both with care and caution. Priorities must be based on relative urgencies of the various projects of improvements and constructions. Advance planning is the key to safe and adequate highway system. Hence, for a proper appreciation of the task, it is essential, as a first measure, to have an engineering assessment of the adequacies of the existing road surfaces on a realistic and factual basis. These values could then be equated with the functionary importance of roads and a comparative chart of priorities prepared for the purpose of programming. Such an evaluation, based on a comparable yardstick, will be of invaluable guidance in the formulation of project priorities and costing estimates for upgrading and improvements. It will also serve to give an indication of the cost of improvement of the country's present inadequate road system.

2.2. Maintenance Aspect

2.2.1. It is seen that maintenace costs in different parts of the country vary substantially even for the same category of roads. It is realised that these costs are largely influenced by conditions of the road structure, traffic, weather, drainage, soil and availability of road-building materials. But it is clear that, in essence, the maintenance costs must be related to the actual conditions and requirements obtaining along the various roads.

2.2.2. Maintenance usually consists of :

(1) **Ordinary repairs**—comprising items like road gangs, collection of materials for patches and other normal attentions, arboriculture, repairs to masonry structures and roadside buildings, etc.

(2) **Renewals**—split into items like collection of materials, consolidation, supply of binder, etc., for retreading work and for preservation of road surfaces, gravelling berms, etc.

(3) **Special repairs**—referring generally to the works required in respect of damages from floods of abnormal or exceptional character, minor improvement works relating to the geometry and profile of the road, etc.

2.2.3. Ordinary repairs required for upkeep of the road profile can be fairly uniform for different categories of surfaces and usually amount to about one fourth to one-fifth of the total maintenance costs. The items under special repairs can be estimated individually fairly accurately. Experience has shown that the cost of special repair works generally is of the order of about 10 per cent of the total maintenance grant. The work of renewals is, however, the main item requiring roughly 2/3rds of the maintenance grant. From rational considerations, the maintenance allotments under this head should, to the maximum possible extent, be allocated for defined works with the object of achieving, as far as possible, progressive uniformity of the carriageway along each route. A long-term programme for this purpose would be helpful and each work should fit in with it and, for this purpose, different types of specifications to suit the conditions at site should be adopted.

2.2.4. In this way, it will be possible to distribute maintenance grant with maximum economy for maximum output. It is, however, necessary in this respect to have as a guide a properly correlated evaluation of the actual conditions of the various road surfaces and the requirements they are to meet with, and this can be done by adopting a systematic comparable rating procedure.

2.2.5. It could probably be argued that the actual maintenance costs could furnish a comparable clue in respect of the upkeep requirements of the roads. The average maintenance costs spread out in fairly large spans of 3 to 5 years would no doubt give some broad indication of the average condition of surfacing, but they are not a direct index of the overall adequacy conditions of the various elements of the road structure as actually obtained at site. Even this average is governed by various variable factors like new developments in the growth of traffic volumes and patterns, orientation of industries and development of catchment areas, upgrading and reconstruction programmes adopted, etc., which substantially change the usage aspect of the road from year to year and from section to section. A uniform correlated assessment on the basis of maintenance costs is, therefore, neither realistic nor dependable.

3. BENEFITS OF ASSESSMENT SYSTEM

3.1. A uniform assessment system for evaluating the performance characteristics and adequacies of the various components of the existing road structures, based on a common and comparable datum, would thus give a proper appreciation of the comparative utility values of the road both from the considerations of maintenance and future upgrading. Apart from furnishing a comparative technical yardstick for an estimate of road sufficiency values of the highway system, based on current statistics, such a rating procedure will also have the following advantages :

(1) Elimination of unassessible factors like personal judgment in the assessment and rating of highway values.

(2) Reducing to minimum extraneous considerations and expediences of local pressures for highway planning and construction.

(3) Helping in the correct and rational assignment of priorities for future programming and phasing of reconstruction according to accepted standards.

(4) Assesssment of the return obtained from the annual financing for the performance ability of road for providing quick, safe and economic movement of traffic.

(5) Measuring at regular intervals the progress made in the elimination or correction of various deficiencies met with from time to time.

3.2. The administration can have genuine satisfaction of protecting the investments made in roads by timely renewals and replacements and by taking such measures as will improve the service efficiency of road surfaces. Legislative bodies responsible for finding finances will also get an overall and realistic picture of the current state of the highway network on a State basis and this will ensure that the available funds are allocated for doing the greatest good.

3.3. The assessment system thus affords a realistic, technical and logical approach to the problem of adequacy determination of roads and ensures utilization of funds for the greatest benefit of the highway user. It may be stated that the principle of determining of sufficiency ratings for highways was originally developed by the Arizona State in U.S.A. in 1946 and since then nearly 20 States have successfully followed it.

4. ASSESSMENT RATING

4.1. Outline of Elements

4.1.1. For getting a proper perspective of the worthiness of a road, relative adjudication of its various constituents and performance characteristics of its structure will be essential. By and large, the utility valuation of a road is judged broadly by four basic considerations, viz., (1) its physical situation, (2) structural sufficiency, (3) safety features, and (4) service efficiency. These factors have also further to be simultaneously correlated with the geometrics and functional purposes of the road, its topographical environments and drainage features, relative importance of the areas served, consistency characteristics, etc. Various components relating to the above aspects could be detailed and grouped under appropriate heads referred to above and evaluated with respect to a common datum. A system of marking would be the most suitable and practical way towards that purpose. A gradation rating for different conditions obtained under varying circumstances could be employed for each component and summation of the assessment values of the various components would give an overall index of the adequacy of the road.

4.1.2. In the final assessment, correction factors will further be necessary to allow for traffic patterns and volumes, economic significance and functional performance. The adjusted rating would then give an index of the adequacy of the road surface.

4.1.3. The adequacy assessment (AA) index of 100 would indicate a perfect highway and its breakdown amongst the various elements and their par values are indicated below :

TABLE I SHOWING THE ELEMENTS OF ROAD ADEQUACIES AND THEIR PAR VALUES

Element	Par value	Principal depiction
Group I — Situation		
(a) Location	4	Topography, physical features
(b) Right-of-way	2	Land width
(c) Height of formation	3	With reference to surface water level
(d) Drainage	4	Good, fair, poor, etc.
(e) Maintenance costs	3	In relation to average mile rate
(f) Architecture	4	General profile and appearance, arboriculture, etc.
Total	20	

Group II — Structural Sufficiency		
(a) Pavement	7	Condition with reference to patch repairs, retreading, etc.
(b) Subgrade	4	Adequacy, stability, etc.
(c) Shoulders	3	Type : metalled, paved, gravelled, etc.
(d) Life expectancy	4	Residual value of the surface course
(e) Consistency	2	Uniformity in general physical condition
Total	20	
Group III — Safety		
(a) Pavement		
(i) Profile	4	Efficiency in respect of driving
(ii) Texture	3	Freedom from skidding
(b) Side protections	4	Shoulder widths, railings, parapets, etc.
(c) Hazards at culverts	4	In respect of widths and load carrying capacities
(d) Traffic interference	4	Intersections, type of traffic, volume friction, etc.
(e) Sight distances	7	Limitations in visibility ranges
(f) Constant speed maintenance	2	M.P.H. range
(g) Consistency	2	General continuity in performance
Total	30	
Group IV — Service		
(a) Alignment:		
(i) Restrictions	6	Speed restrictions due to blind spots, bottlenecks, etc.
(ii) Negotiability	3	Nature—excellent, good, fair, etc.
(b) Formation width	3	In relation to standards
(c) Pavement width	4	
(d) Passing opportunities	4	Determined on a formula basis
(e) Rideability characteristics		
(i) Surface	6	Type—cement concrete, blacktop, water-bound macadam, etc.
(ii) Condition	4	Nature—excellent, good, fair, etc.
Total	30	
Grand Total	100	

Summation of the rated values assigned to different elements in accordance with their actual conditions as observed at site will give an overall index of the adequacy assessment of the road.

4.2. Correction Adjustments

4.2.1. The overall index will further need to be adjusted in order to account for the following influences:

(1) Traffic considerations

(2) Economic considerations

4.2.2. Traffic considerations

(a) **Type of traffic**—Due to varied nature of wear and tear caused to the road surface, resulting from its use by mixed type of traffic, an allowance seems necessary for balancing the variations. They chiefly arise from the operational effects of the fast-moving pneumatic-tyred vehicles and the slow-moving iron-tyred carts. The pneumatic tyred wheels spread the load uniformly on a larger contact area, though due to the speed factor their effect on road surfaces, particularly with water-bound macadam or lower type specifications, is pretty severe and curves up steeply with increasing speeds. The iron-tyred cart, on the other hand, because of its narrow tyres and wobbling wheels results in concentrated load intensity and knife-edge action, thereby inflicting greater distress and damage on the surface.

With a gross wheel load of 4,500 lb and contact area of 68.5 sq. in. for a pneumatic-tyred vehicle, the stress on the road surface would come to about 65.8 lb per sq. in., while in the case of a loaded cart wheel with contact area of 10 sq. in. and carrying a load of 1,400 lb, the stress would work out to 140 lb per sq. in.

Taking all factors into consideration in relative terms, it may broadly be surmised that on tonnage basis, the destructive effect of a bullock cart may be taken as twice that caused by a pneumatic-tyred vehicle. Hence for working out the overall volume of traffic, the census count of the iron-tyred vehicles may be multiplied by 2 and then added to the count of pneumatic-tyred vehicles. No distinction at this stage is, however, intended to be introduced in respect of the various types of pneumatic-tyred vehicles, as that would introduce a factor which is not likely to affect substantially the rated values.

(b) **Volume of traffic**—Purely on consideration of traffic, factors like:

(1) proportion of bullock cart traffic to the total traffic,

(2) intensities during peak and lean periods,

(3) daily, monthly and seasonal variations in traffic flow, etc.,

play a great part in determining the service efficiency of a road surface. For the purpose of comparison, however, average daily traffic struck from actual per-week traffic census taken at least twice a year during pre-selected periods may be taken as a workable basis. As stated above, the total traffic volume may be worked out by adding up the tonnage of pneumatic vehicles count and twice the tonnage of the count of non-pneumatic-tyred vehicles.

With a traffic lane width of 12 ft, a normal road with a water-bound macadam surface may be expected to carry satisfactorily traffic of about 800 tons per day and, with a three to four year renewal cycle, it should be possible for such a road to carry an overall traffic of about $4 \times 800 \times 365 = 12$ lakh (say) tons, before the surface would need a retreading. Assuming that, on rural roads, the non-pneumatic-tyred vehicles tonnage forms one-fourth of the total volume, the composite traffic volume of 800 tons per day would, roughly comprise about 500 tons carried by pneumatic-tyred vehicles and about 150 tons by iron-tyred carts.

Daily tonnage of 800 seems to be a reasonable basis for rating in relation to which compensation factor should be reckoned. Lower traffic indicates a lesser need for improvements and, consequently, a higher adjusted rating; correspondingly, higher traffic would earn a lower adjusted rating index. Curves showing the absolute AA index and the adjusted index with respect to different traffic volumes are indicated in the graph given in Fig. 1.

4.2.3. Economic Considerations

(a) **Population basis**—Use of road is directly related to economic conditions prevailing along the road. The importance of the places of origin and destination linked and the commercial activities current therein, the extent of transport of farm produce and receiving materials, in the "influence" areas commanded by these centres, etc., are some of the pertinent factors which will affect the type and mode of traffic generated at these places. An elaborate fiscal or economic survey in this respect does not seem necessary as, by and large, the population inhabiting these places will give a fair indication of the emanating traffic. It is truly said that highway traffic varies directly with the population of connected cities and inversely as a power of the distance

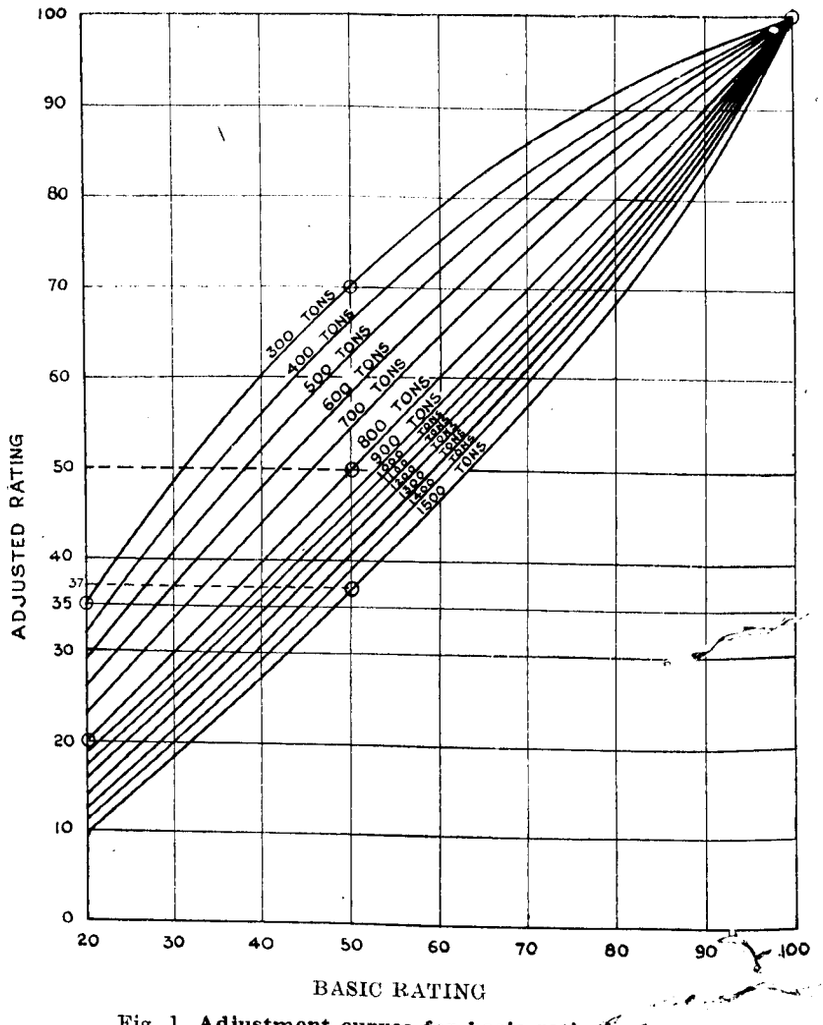


Fig. 1. **Adjustment curves for basic rating values**

between them, the index of power being one or more. The towns may be categorized under different population units and their rating distinguished by marking system, allowing from 10 marks for towns having a corporation to nil for towns with a population of less than 2,000.

(b) **Operational basis**—The type and intensity of traffic on a road, apart from the population centres linked by it, also depend upon the habitation pattern, extent of cultivated area and output therefrom, and the 'industrial' level in the area served by it. Knowledge of these factors can be helpful in computation of the relative significance of the functional values of roads and a rating system commencing with 10 marks for developed areas to 2 marks for arid wastes would seem to be fairly reasonable.

Thus knowing the relative values of the origin and destination centres and the functional values in relation to the areas served, the correction factor may be worked out from the following formula :

$$\frac{\text{Original station value} + \text{destination station value} + \text{functional value}}{10}$$

The number so obtained should be subtracted from the gross adequacy assessment index in order to get the adjusted index. With more intensive development and population concentration, the road adequacy will be strained in a greater measure and the compensating factor will naturally result in lowering the adequacy index of the road.

4.2.4. The correction adjustments both for traffic and economic considerations are somewhat arbitrary but, it is felt, that they would work well in practice.

4.3. Functional Characteristics

4.3.1. The road system in the country is composed of various classes of roads depending chiefly upon their functional characteristics. They are categorized as Express Highways, National Highways, State Highways, Major District Roads, Other District Roads, and Village Roads. They have varying standards which have been designed chiefly to satisfy the functions they have to perform. The standards recommended for the various categories of roads are detailed in Annexure 1.

4.3.2. It is obvious that different classes of roads will have their own par values. The development of a road system is of a progressive nature and, in view of the financial limitations, attempting an ideal at the outset is not possible. It would, therefore, be more rational and practical to accept "tolerant" standards with reduced AA values going up to 2/3rds of the absolute. The indexing of the absolute and tolerant values for

the various classes of roads is suggested as under :

Class of road	Par value	Tolerant value (2/3rds)
Express Highways	100	66
National Highways	90	60
State Highways	80	53
Major District Roads	70	47
Other District Roads	60	40
Village Roads (Classified)	50	33

4.4. Schematic Charts

4.4.1. A chart showing the categorization of the various elements considered necessary for estimation of the adequacy of a road, their par values and an assesment rating for each element under different conditions and environs obtained at site on a sliding per cent scale is given in Annexure 2. It also shows the manner in which the various adjustment factors should be applied. A diallic chart showing a pictorial representation of different elements and their par values is shown in Annexure 3.

4.4.2. As explained above, the rating has been broadly split into four parts, viz., situation, structural sufficiency, safety and service. Under this four S categorization system of assessment, the lowest rated road would usually warrant a highest priority in the maintenance programmes. These programmes are usually prepared on region or State-wise basis and the adequacy indices would generally determine the order in which the roads should be attended to. The condition ratings have also a vital place in the formulation and development of the improvement plans. The "Priority Index" for these plans would, however, depend upon the relative importance of the 4 categories in respect of each other, in the context of the possible requirements of the future needs. Under normal circumstances where the four categories would demand balanced consideration, the directly worked out adjusted assessment index would set the priority role. There can however be conditions where one or the other category would necessitate greater weightage, and under such circumstances the summation formula would have to be suitably modified.

4.4.3. A specimen rating sheet recording a condition survey of a 20.0 miles length of National Highway No. 2 beyond Delhi is shown at Annexure 4. It illustrates the manner in which the

condition rating of the various elements affecting the adequacy of the Highway can be determined and its adequacy index assessed. The section is at present maintained in a satisfactory condition.

4.4.4. It will be seen from the assessment chart that some component items are repeated under more than one category as they have an important bearing on the characteristics of such categories. On analysis, the marking of par values of various elements in respect of their component characteristics generally conforms to the following order :

(1)	Physical (surface, foundations, drainage, etc.)	22
(2)	Design (alignment, gradients, width, etc.)	32
(3)	Safety (consistency, intersections, etc.)	20
(4)	Service (traffic, community service, etc.)	14
(5)	Economics (roadside conditions, maintenance, etc.)	12

4.5. Factors not Considered

4.5.1. One main factor which has not been considered in the adequacy assessment studies relates to climatic conditions, particularly the rainfall. The item of drainage under Category I covers this aspect indirectly but the item of surfacing is directly affected by the temperature and rainfall factors, more particularly the latter. It is, however, felt that this aspect is more related to the design feature of the road crust and should be duly considered while prescribing specifications for surfacing and not for assessing service values and performance characteristics.

4.5.2. The scope of this study has chiefly been confined to the assessment of the condition of culverts only and no account has been taken of the condition of minor and major bridges. In the formulation of road projects, culverts form an integral part of the road work while the minor and major bridges are considered as specific schemes requiring individual considerations even though they form very important components of roads particularly in respect of their service and safety features. A road otherwise conforming satisfactorily by itself to the requisite standards and having a high AA index can still be rendered ineffective if a crossing is left unbridged, thereby causing interruption in the free use of the road. Such cases should be considered separately on merits. Actually, separate condition-surveys should be undertaken in respect of bridges and precise observations made in relation to their salient characteristics such as :

(a) Obsolescence because of age ;

(b) Structural failing ;

(c) Substructural failing;

(d) Floor conditions;

(e) Roadway narrowness;

(f) Miscellaneous—sight distances on approaches, etc., frequent accidents, vertical distance limits, condition of side protections, and other deficiencies.

4.5.3. The monetary factors have also been excluded from the qualitative evaluation as these are strictly beyond the purview of this analysis. This question is strictly related to the problem of costs of constructions and will arise only after the works to be taken up are decided upon. This will undoubtedly depend upon the results of adequacy assessments, but the formulation of projects will be a subsequant step and this will obviously cover the question of costs.

4.5.4. The load carrying capacities of vehicles have also not been accounted for in the rating chart as this question is not, at present, directly related to the assessment factors mainly because of the existing road crusts being generally inadequate for the traffic intensities. Besides, adequacy requirement in this respect is also simultaneously linked with the condition of bridge structures. Introduction of factors not fully of practical significance might affect the overall assessment without any consequential advantage, and as such, their consideration has been excluded.

4.5.5. In some of the States in the U.S.A., traffic carrying capacity and accident rates occupy a distinctive place in the determination of the sufficiency ratings for highways. It is, however, felt that conditions in this country, particularly in respect of rural roads, are quite different. The roads are not being, by and large, utilized to full capacity and considerable scope still generally exists in many cases for larger volumes of traffic being able to go over the roads.

5. ASSESSMENT OF ROAD LIFE

5.1. The element of the life value of a road structure has been included in the assessment procedure. Road life study is a subject by itself requiring elaborate work of detailed character and it is not the intention to give its intricate exposition in this Paper. Only a broad outline, in so far as it relates to the question of getting a rational assessment of the road surface adequacy, is given here. Experience and personal judgment are necessary for a fair estimation of the probable salvage value of each component of the road crust at any stage.

5.2. The economic life of a road may come to an end by reason of actual physical destruction, deterioration causing mounting repair costs, obsolescence, normal wear and tear by passage of time or a combination of these factors. The performance characteristics of road surfaces are, therefore, largely influenced by the type, nature and age of the structure, its location and usage, traffic, rate of renewals and replacements, method and extent of ordinary and special repairs carried out from year to year, and the amount spent thereon. Life expectancies of the various types of crusts at any particular stage have an important bearing on the adequacy assessment of surfaces at that time and should be judged as rationally as possible.

5.3. This approach is essentially required for roads having higher type of surfacing, viz., water-bound macadam, black top, and cement concrete. It is true that, in India, the black top and cement concrete types of surfaces have been adopted on a measurable scale only recently and enough information or technical data in respect of their actual life expectancies and residual values is not available.

5.4. Broadly, the road crust consists of surface course and base course. For determining the salvage percentage of a road during any year, residual values will obviously need to be estimated separately for these two courses in the road structure. The salvage value of a structure, at any stage, normally, depends upon the percentage of the recoverable material to the total quantity of the material put therein. No hard and fast mathematical hypothesis will, however, be practicable in the case of road works. These values are influenced largely by the following factors :

(1) Method of retirement : whether by resurfacing, replacement, abandonment, or continuance to full life.

(2) Type of surface under consideration.

(3) Age of the construction.

(4) Nature of replacements.

(5) Previous cost of construction and replacement.

(6) Changes made from time to time in the structure of the crust in respect of its width, thickness, etc.

5.5. The base course will clearly have a higher residual value since there is little loss of its material due to the fact that when the road is resurfaced, the reconditioning applies mostly to the surface course. The old base is undisturbed and is retained as the base course for the new surface course. The adequacy

value of this component has, therefore, been excluded from the adequacy assessment computation.

5.6. As regards the surface course, large salvage value is indicated if the quantities lost by reason of traffic and weather influences are generally replaced periodically by proper maintenance. Otherwise, the salvage value should be related to the age of the surface, initial cost and annual maintenance cost. The average life expectancy of the surface course can be divided into two stages :

(a) "Service" period up to which the surface can be utilized efficiently with suitable periodic renewals and thereafter incorporated in the fresh surface layer that would be put on it at the end of the period; and

(b) "Maximum" period wherein the road is not intended to be salvaged but is allowed with normal maintenance to last till its full utilization.

5.7. The maximum life may, broadly, be assumed to be about $1\frac{1}{2}$ times the service life period, and the residual value at the end of the service life period may be assessed at about 25 to 50 per cent. On that consideration, the two phased periods for the three categories of surfaces mentioned above and their probable residual values at the end of the first phase may broadly be assumed as under :

TABLE 2. SHOWING THE LIFE EXPECTANCIES OF DIFFERENT TYPES OF ROAD SURFACES

Type of surface	Specification assumed for the surface course (excluding bases and sub-bases)	Service Phase		Maximum period Years	Nature of maintenance
		Period Years	Residual value of surface course Per cent		
W.B.M.	6 to 7 in. thick	12	50	18	3 in. w. b. m. renewal every 9 to 12 years as necessitated by traffic requirements.
Black top	Light treatments: 2 coat surface dressing or thin chipping carpet with seal coat	16	40	24	Seal dressing every 3-5th year depending upon intensity and type of traffic.
Cement concrete	4 to 5 in. slab over metalled base	24	25	36	Normal attention.

The "service" life spans assumed above are not based on any technical or analytic study, but are adopted generally in the comparative cost estimates. It is, however, likely that with the adoption of recently developed scientific techniques for designs, constructions and quality controls, these life spans could probably be appreciably enhanced.

5.8. Typical "survival" curves indicating the year-wise percentage rating of the residual values of the surface course during the service period and the maximum period are given in Fig 2.

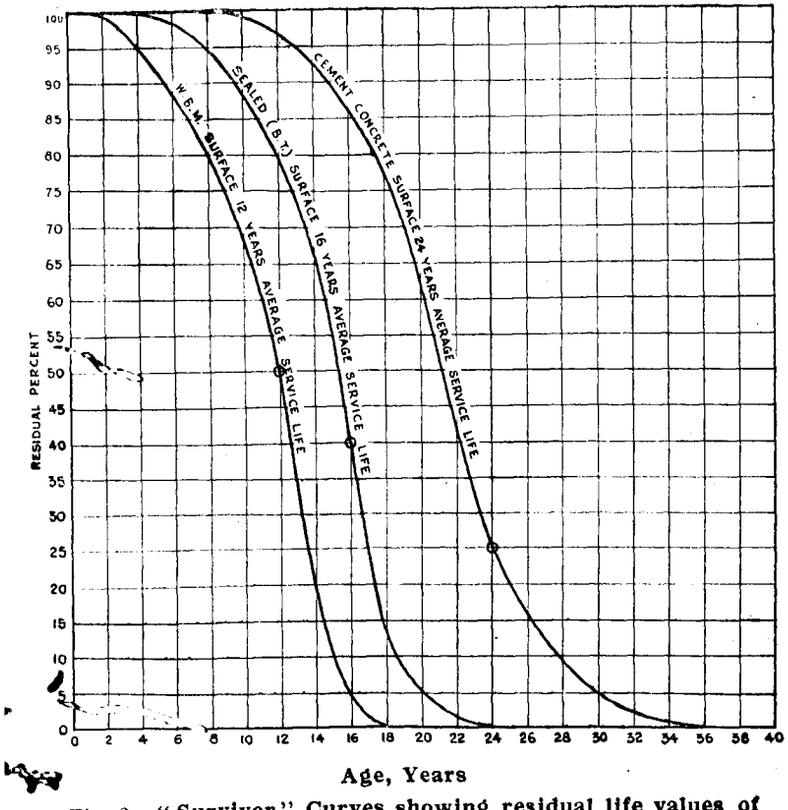


Fig. 2. "Survivor" Curves showing residual life values of road surfaces

These curves have generally been based on the studies on industrial property retirements—carried out at the Experiment

Station of the Iowa State College in the U.S.A. It may, however, be emphasised that these curves are intended only to serve as a general guide. For a correct and scientific evaluation of the residual values of road surfaces, proper detailed studies of the economics of investments, their utilization aspects and other factual data will be necessary.

6. FIELD PRACTICE

6.1. For rating purposes, the road should be divided into suitable sections. These should, as far as possible, be homogeneous in nature from end to end both in usage and construction. They should have fairly uniform physical characteristics, traffic conditions and structural features. The demarcating lines should preferably fit in with administrative boundaries – such as district, taluqa, tehsil, division, subdivision, municipal, etc., changes in traffic patterns and volumes and in topography, etc. A workable unit from the rating point of view should normally be not less than 5 miles or exceed 20 miles in length. It is also advantageous during observations, particularly where there are more than one lane of traffic, to alternate, if possible, the directions of travel so as to get a proper perspective of the qualities and appearance of the highway in both the lanes.

6.2. Opinions can differ in regard to the employment of field parties for assessment work. One field party specifically assigned to cover the entire work will no doubt eliminate personal factors and prejudices but at the same time this could lead towards rigid standardization without reference to the influences of the local conditions, and this may not give balanced conclusions. What is required is to minimise personal bias and, for this purpose, it would be desirable to introduce objective measurements for computation of assessment values wherever possible. Experience and familiarity with the native conditions of the regions where the roads are situated are also amongst the important merits which the survey parties must possess for obtaining correct and quick appraisal of the environs and rational rating of the condition surveys of the roads. It would probably be advantageous to start with one party and, later on, after sufficient practical experience and basic know-how of the assessment technique is gained, the work can be distributed among more parties.

6.3. It is not unusual that the annual retreading programmes are at present framed in very short reaches strictly on renewal cycle basis. This limits the utilization value of a road as a whole. For economic and efficient execution, it is desirable to formulate the programmes both for execution and maintenance on the basis of appreciably long reaches having distinctive characteristics in their order of precedence. The priorities should be based on a technical assessment of their relative performance adequacies. It is well-known that continuity of improved highway stretches has considerably greater service value than in the case where the same milage is spread out in several intermittent good sections separated by unsatisfactory or poorer reaches.

6.4. Assessments of road adequacies should be determined periodically, say, every two or three years, though annual assessment would be desirable if the position in respect of funds and technical personnel permits. The data to be collected should be simple, easily understandable and readily accessible. The system should also be sufficiently flexible to have a fairly comprehensive application without sacrificing reliability and validity.

6.5. It is desirable to start the work of adequacy assessment of the country's road system as soon as possible and an experienced staff should be detailed for this purpose. Economics of survey operations should be considered in relation to the correctness of the data required and suitable proformas should be evolved in order to get the most practical and reliable assessment results.

7. MAINTENANCE OF RECORDS

7.1. For facilitating quick understanding of the engineering analysis of the data collected and easy interpretation of the results, the condition survey data should be illustrated graphically by means of pictorial graphs, simplified charts, strip maps etc. They should indicate the up-to-date position in respect of adequacies and deficiencies of the various elements individually, and the measures taken from time to time for upkeep of the surface. Such a record would eventually furnish life history of the road and also indicate the possible trends along which the future development of the road is likely to take place.

7.2. These pictorial charts and maps will aid in better appreciation and acceptance of the facts so presented. The administrators, legislators and public will be enabled to come to early conclusions in respect of the various aspects of highway sufficiencies and their performance values.

7.3. The observed ratings during different observation periods, for a road, can also be depicted by a diallic chart as shown in Annexure 3. It has expanding rings and can thereby

be made continuous and readily referable. The factual information shown therein would give a pictorial view of the condition evaluation of the road and will enable the progress made during different periods in correcting deficiencies in respect of any particular element being easily assessed. An up-to-date record of improvements on roads can thus be maintained.

8. WORDS OF CAUTION

8.1. It may be emphasised that the suggested adequacy assessment system is intended only as a tool for preparing realistic programmes and not to serve as a substitute for planning. The results are not intended to be followed slavishly without regard to the other factors which require due consideration and recognition. Personal judgment and knowledge of particular locations, special circumstances and administrative requisites must function as necessary adjuncts in assessing the relative values under the AA system.

8.2. Besides, in the overall assessment of adequacy values, the importance of equitable distribution of constructional programmes in various State units has also a specific significance which must be appreciated.

8.3. It is true that the rating chart in its make-up may need appreciable modifications to cover various other elements which affect road performance values. It is also likely that the relative emphasis on the various elements in respect of their par values and the categorisation aspect may have to be varied to suit specific requirements under certain conditions. The system now suggested is intended to serve only as a guide. It could be further improved upon as more and more factors relating to the structural and performance characteristics of roads come into play.

8.4. It is, however, clear that various items of the different categories of the adequacy elements must have a sizeable complex and should be related to objective standards, the value of which can be computed with fair accuracy. The system now suggested does aim at such a realization. The element of consistency included in the rating is, however, difficult of such assessment and it has, necessarily, to be rated on the basis of subjective estimation and personal discretion. In an overall exposition, however, the result is not likely to be appreciably affected by it.

8.5. It can also be argued that the objective assessment of highway adequacies is based on present day expectations of the

surface, while they were actually designed and constructed originally on different standards. This has been specifically well taken care of under "structural adequacies". The sufficiency values of the road crusts in relation to the requirements expected to be satisfied or fulfilled at the time of assessment will clearly indicate the extent of their performance efficiencies, and this would enable preparation of appropriate schemes for their further strengthening or upgrading, wherever necessary.

9. CONCLUSION

9.1. Adoption of a uniform and methodical yardstick for comparative evaluation of the prevailing conditions of roads subject to varying features of geography and traffic, structural make up and geometry is considered very necessary as such an assessment would be a valuable guide in preparation of planned maintenance programmes and priority-based long range development plans of the country's highway system.

9.2. The suggested Adequacy Assessment (AA) System envisages grouping of various elements normally affecting the efficiency and performance ability of a road under four main headings, *viz.*, situation, structural stability, safety and service and assigning marks to them in proportion to their relative importance taking hundred as the ideal total. The actual condition survey of the road would necessitate evaluating each element on rated basis, thereby arriving at a gross index. Correction factors in order to account for varying traffic patterns, functional characteristics of the road and economic significance of the areas served would give an adjusted adequacy index. The AA System would indicate the relative value of the condition of the road.

9.3. The factual assessment system of the type now proposed apart from giving the adequacy value and overall physical return of the road assets will eliminate from the estimate of road condition, personal errors, prejudices and local pressures, will indicate the rate of progress made in corrections of deficiencies and help the administrators and legislators to realise whether the monies spent on road works are being utilised for the greatest benefit to the road user and getting maximum return for the investments made. It is also simultaneously necessary to ensure that the condition data is based on objective measurement and collected by field parties having adequate experience and familiarity with the local condition, avoiding rigidity and exercising correct "imagineering."

9.4. The statistical information so collected should necessarily be recorded in simple easily readable and readily accessible manner in the form of pictorial charts, graphs and strip maps and in this respect a specimen diallic chart showing the pictorial representation of the condition assessment and capable of being brought up-to-date has been instanced.

9.5. Finally, a note of caution is necessary. The assessment procedure is to serve only as a guide and not intended to be slavishly followed. It cannot replace planning proper but is meant to be used only as a tool. It must necessarily be simple and flexible and should be capable of modification and adjustment to suit the condition actually prevailing from time to time. Where necessary, weightage to the par values assigned to the elements should be valid and additional elements introduced when required. But whatever system is adopted it should furnish a uniform and measurable yardstick.

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Annexure 1

Recommended Standards for Roads

A. On Classification Basis

1. **Right of way: Land width, Building line—controlled width**

(All dimensions in feet)

Class of Road	Open areas and agricultural country				Urban (Built up) & industrial areas		
	Width of road land		Building lines (overall width)	Control lines (overall width)	Width of road land		Building (or set back) line: width of strip beyond road boundary
	Normal	Range			Normal	Range	
1	2	3	4	5	6	7	8
National & State Highways	150	100 to 200	200 (240) *	440	200	100 to 200	10 to 20
Express Highways	250	200 to 300	—	—			
Major District Roads	80	80 to 120	160	300	100	100 to 150	10
Other District Roads	60	60 to 80	80 (100) *	120	40	40 to 60	—
Village Roads	40	40 to 60	80	100	30	30 to 50	—

See note II (i) on next page.

Explanatory Notes

1. **Land widths**

(i) The standards for land width refer mainly to new construction. In the case of existing roads, standards for building lines and control lines are to be adopted and enforced as far as possible.

(ii) In heavily embanked portions averaging 3 ft or more in height, the land width should be correspondingly increased. The extra width shall be to the nearest ten feet.

(iii) In curves extra land width is also to be provided for, as required.

If. Building Lines

(i) Where the existing or proposed land width is equal to the width between building lines, as indicated in the statement, the building lines shall be set 20 ft from road boundary lines in the case of National and State Highways and 10 feet in other cases.

(ii) The standard suggested is the minimum. Higher standards are to be adopted where necessary. In curves, the building line on the inner side shall be at an increased distance from centre, to secure adequate sight distance.

2. **Formation Widths**

		In plains (widths in feet)	In hills (widths in feet)
(a)	National Highways	38	24
(b)	State Highways	32	24
(c)	Major District Roads	24	22
(d)	Other District Roads	24	22
(e)	Village Roads	16	8 (for animal traffic)

Note :— Widening of the formation width on curves with sharp radii is necessary. The extra width on curve to be provided as under:

Radius of curve in ft	Extra width of formation
100 ft and less	8 ft
101—200	6 ,,
201—300	4 ,,
301—500	2 ,,
Above 500	Nil

B. Engineering Basis

Width of Soling

(a) Normal — One foot more than the width of wearing surface.

(b) On high banks or close to bridge approaches, and metalled dips. — Full width or 2-lane width whichever is less.

Width of Pavements — As per Annexure 5

Profile

(a) **Crust Camber**

(i) Concrete surface — 1 in 72

(ii) Black top surface — 1 in 60

(iii) Water-bound macadam and gravel — 1 in 48 to 1 in 36.

(b) **Cross Slope**

In the case of dual carriageways, camber is not provided but instead, a uniform cross slope in the outer direction is given for drainage purposes as shown below :

(i) Concrete surface	1 in 72
(ii) Black top surface	1 in 60
(iii) Water-bound macadam and gravel	1 in 48 to 1 in 36

(c) **Berms** — As for road crust.

(d) **On curves** — No camber but superelevation over the whole width.

(e) **Outer slope**

(i) Banks up to 2 ft height	Minimum 2 : 1 Desirable 4 : 1
(ii) Banks above 2 ft height	Natural slope of soil

6. **Horizontal Curve Standards**

(i) Speed Standards

	Speed—miles per hour	
	Flat or rolling country	Hilly or mountainous country
1. N. H. & S. H.	50	30 *
2. M. D. R.	40	25 *
3. O. D. R.	30	20
4. Village Roads	20	15

(ii) Radius of Curves

Ruling and absolute minima.

Note :— On all curves, the largest possible radius should be provided.

	Flat or rolling country			Hilly country & restricted localities	
Speed m.p.h.	Radius in feet		m.p.h. Speed	Radius in feet	
	(b) Ruling minimum	(a) Absolute minimum		(d) Ruling minimum	(c) Absolute minimum
50	1,000	800	30	400	300
40	800	500	25	300	200
30	500	300	20	200	150
20	300	150	15	150	100

* Where practicable.

(iii) Superelevation (e) and crust camber $e = \frac{3V^2}{80R}$ subject to a maximum of 0.067 (= 1/15).

Note :—Superelevation, where provided, shall not be less than the camber appropriate to the type of surface, namely :

(i) Concrete pavement	1 in 72
(ii) Black top surface	1 in 60
(iii) Water-bound macadam	1 in 36 to 1 in 48

(iv) Extra widths of pavement in curves for all speeds.

Radius of curve (ft)	Upto 200	201 to 500	501 to 1,000	1,001 to 1,500	Above 1,500
Extra width	4	3	2	1	Nil

Note :—The above Table is for one lane (12 ft) and two-lane (22 ft) pavements.

7. **Vertical Curve Standards**

(a) **Gradients**

	Ruling	Limiting	Exceptional*
Plains	1 in 30	1 in 20	1 in 15
Hills	1 in 20	1 in 15	1 in 12

(b) **Correction in grades at curves**

New Roads

Grade compensation shall be provided at all horizontal curves as per formula $\frac{100 + R}{R}$ subject to a maximum of $250/R$, R being the radius of the curve in ft, and the compensation being in percentage. Reduction in grade being effected from the ruling gradients.

Existing roads :—Corrections in grades may be resorted to only in such reaches where the length involved exceeds 500 ft.

(c) **Sight distances**

The sight distance at every point of a highway should be as long as possible and shall not be less than the following :

(i) Absolute Minimum Sight Distances (stopping distances)

* For short distances not exceeding 300 ft in a mile.

Design speed in m.p.h.	Minimum sight distance in feet Flat country	(Stopping distance) Hilly country
15	—	90
20	120	120
25	—	160
30	200	200
40	300	—
50	500	—

(ii) The minimum overtaking sight distance for two-lane roads shall be as follows:

Design speed in m.p.h.	Overtaking sight distance in feet
25	450
30	600
35	800
40	1,000
50	1,450

The length of the overtaking sections or zone shall not be less than three times the sight distance corresponding to the design speed of the road.

(iii) Roads with 4 or more traffic lanes should be constructed with dual carriageways with a median strip separating the traffic in opposing directions. Minimum overtaking sight distances as in the following Table should be provided.

Design speed in m.p.h.	Overtaking distances on dual carriageway in ft
25	250
30	350
35	450
40	550
50	700

(d) **Summit curves**

Summit curves should be parabolas. For overtaking sight distance, length of summit curve $-L = \frac{NS^2}{32}$ where $L>S$ and when $L<S$, $L = 2S - \frac{32}{N}$ where N is the algebraic difference in grades and S is the sight distance between height of eye and object 4 ft.

For non-overtaking sight distance, Length of the summit curve $L = \frac{NS^2}{13.28}$ when $L>S$ and when $L<S$, $L = 2S - \frac{13.28}{N}$ where N is the algebraic difference in grades and 'S' is the sight distance between height of eye 4 ft and object 4 in. high,

(e) **Valley curves**

Valley curves should be cubic parabolas. The length of valley curves $L = 2.5\ (V^3\ N)^{\frac{1}{2}}$ where 'V' is the design speed in m.p.h. and N is the algebraic difference in grades.

(a) **River crossings**

"Serious interruption" is stoppage of traffic for many periods exceeding 12 hours at a time on more than 6 days in the year or frequent stoppages of traffic for shorter periods.

In the case of village roads, interruption to traffic may be up to 3 days at a time and up to 6 times a year.

(b) **Clear dimensions**

(a) Culverts: (20 ft linear waterway and under): Full formation width.

(b) Bridges (linear waterway over 20 ft) minimum 24 ft clear between wheel guards for National Highways, State Highways and Major District Roads. Minimum 12 ft between wheel guards for other roads.

(c) Causeways — Minimum 24 ft between wheel guards.

(d) Headroom — 16 ft 6 in.

(e) Railings — Minimum 9 in. clear horizontally of wheel guards.

Annexure 2

Chart showing the condition rating system for Adequacy Assessment of Highways

I. Composition of Elements

Group I: Situations

	Proportionate % rating	Par value
(a) Location		4
(i) High elevations and Karewa lands	100	
(ii) Hilly and rolling sections	80	
(iii) Plains	60	
(iv) Waterlogged and high water table	40	
(v) Sand and barren areas	10	
(vi) Marshes	0	
(b) Right of way land width: As per standards		2
(i) Full	100	
(ii) Full—¾ths	80	
(iii) ¾ths—½	60	
(iv) ½—¼ths	40	
(v) Less than ¼ths	0	
(c) Height of formation		3
(i) Above saturation effects	100	
(ii) Subject to saturation effects	80	
(iii) Liable to submersion	50	
(d) Roadside drainage		4
(i) Good	100	
(ii) Fair	40	
(iii) Poor	0	
(e) Maintenance costs		3
(i) Higher than average	100-75 } Depending	
(ii) Average	50 } upon the	
(iii) Lower than average	25-0 } margin of difference.	

	Proportinate % rating	Par value
(f) Architecture		
(i) Profile and appearance (overall)		2
Good	100	
Fair	60	
Poor	0	
(ii) Arboriculture		2
Regular	100-75	
Irregular	50-25	
Non-existent	0	
Total par values		20

Group II: Structural Sufficiency

			Proportionate % rating	Par value
(a) Pavement	**W.B.M.**	**B.T.**		7
(i) Recently retreaded (metal)		(extent)	100	
(ii) Light patches	50 cu. ft/flg.	2½%	80	
(iii) Medium ,,	100 ,,	5%	60	
(iv) Heavy ,,	200 ,,	10%	40	
(v) Ruts	300 ,,	15%	20	
(vi) Broken up	>300 ,,	Requiring renewal	0	
(b) Subgrade				4
(i) No failure, adequately drained			100	
(ii) Casual irregularities			75	
(iii) Some failures, rutting, undulations			40	
(iv) Unstable condition, poor discharge			0	
(c) Shoulders, Bank slopes, Berms etc.				3
(i) Metalled or brick paved shoulders			100	
(ii) Gravelled ,,			60	
(iii) Earth ,,			20	
(d) Life expectancies				
Surface course: Residue % value on age considerations as per survivor curves				4

	Proportionate % rating	Par value
(e) **Consistency in the general physical condition**		2
(i) Uniformly consistent	100	
(ii) Consistent with occasional bricks	60	
(iii) Inconsistent	0	
Total par value		20

Group III: Safety

	Proportionate % rating	Par value
(a) **Pavement**		
(1) (Edges, bumps, holes, etc.)		4
(i) Complete freedom from defects that would cause accidents	100	
(ii) Cautious driving due to mixed traffic etc.	60	
(iii) Restricted driving	25	
(iv) Slow driving	0	
(2) Texture		3
(i) Non-skid	100	
(ii) Moderately smooth	50–75	
(iii) Slipping where wet	0–25	

	Plains	Hills
(b) **Side protections**		
(i) Shoulder width	2	1
(ii) Safety works (parapets, guard rails, guard stones, etc.)	2	3
Total par value	4	

	Proportionate % rating	Par value
Adequate	100	
At places only	75–30	
Nonexistent	0	
(c) **Hazards at structures (culverts) capable of carrying legal loads and wide:**		4
,, ,, but narrow	100	
Others	80	
	50	
(b) **Traffic interference**		
Intersections, mixed nature, volume friction, etc.		4
(e) **Sight distance**		
Restrictions at curves, grades, trees, bushes, structures, rock protrusions, etc.		7

	Proportionate % rating	Par value
(i) Upto 5 Nos. per mile: Minimum distance at any point 500 ft. for plains and 200 ft. for hills	100	
(ii) 6–10 ,, ,,	70	
(iii) 11–20 ,, ,,	40	
(iv) >20 ,, ,,	0	
(f) **Constant speed maintenance**		2
(i) 40 m.p.h. or more	100	
(ii) 40–25 m.p.h.	80	
(iii) 24-15 ,,	50	
(iv) <15 ,,	,,	
• (g) **Consistency**		2
Total par value		30

Group IV: Service

	Proportionate % rating	Par value
(a) **Alignment**		
(1) Speed restrictions resulting from curves, blind points, grades, bottlenecks, abrupt surprises, etc.		6
(i) < 1 per mile	100	
(ii) 2- 5 ,, ,,	80	
(iii) 5-10 ,, ,,	50	
(iv) 10-15 ,, ,,	20	
(v) > 15 ,, ,,	0	
(2) Negotiability		3
Excellent	100	
Good	60	
Fair	30	
Poor	0	
(b) **Formation width**		3
(i) As per standards	100	
(ii) Less upto one-fifth	80	
one-fourth	50	
one-third	20	
More than ,,	0	

	Proportionate % rating	Par value
(c) Pavement width		
22 ft or more	100	
18 ,,	80	
16 ,,	60	
12 ,,	40	
9 ,,	10	
< 9 ,,	0	
(d) Passing opportunity		
Rating per cent = [one-fifth of the conditions per cent of sight distance (III c) + alignment (IV a) + pavement width (IV c) + shoulder width (III b (i)) + (IIIb (i)) traffic volume factor.]		
[Traffic volume factor = $100 - \frac{T}{25}$ where T is the traffic volume in 24 hours.]		
(e) Ridability		
(1) Surface: (i) C. C., B. T. confalt	100	
(ii) W. B. M.	75	
(iii) Gravelled	60	
(iv) S. S. with B. T. dressing	40	
(v) S. S.	25	
(vi) Earth	0	
(2) Condition		
(i) Excellent	100	
(ii) Good	80-50	
(iii) Fair	50-25	
(iv) Poor	25- 0	
Total par value		30
Grand Total of par values		100

2. Correction Factors

(i) Traffic adjustments [T]

(a) Type of traffic: For working out the total traffic volume on a comparable basis, the traffic count of iron-tyred vehicles may be multiplied by two and then added to the pneumatic-tyred vehicles census.

(b) Volume of traffic: For comparison purposes the traffic volume is related to single lane accommodation. For carriageway widths of more than one lane the traffic census may be reckoned as under:

Single lane width	Full
Dual	3/4ths
Multiple	1/2

The correction factors to be allowed on traffic considerations are indicated in the curves given in Fig. 1 and are to be deducted from the absolute assessment adequacy index.

(ii) Economic adjustments [E]: As per following Table.

	Rating No.
(a) Population basis	
(i) For towns having corporations	10
(ii) ,, ,, with population of 1.0 lakhs excluding those under (i)	8
(iii) ,, ,, ,, ,, between 100,000 - 20,000	6
(iv) ,, ,, ,, ,, between 20,000 - 10,000	4
(v) ,, ,, between 10,000 - 2,000	2
(vi) ,, ,, less than 2,000	0
(b) Functional basis	
(i) For habited, developed industrial or intensively cultivated areas	10
(ii) For semi-developed, sub-urban residential areas	8
(iii) For hilly, inaccessible and fairly developed farmlands	6
(iv) Undeveloped cultivable areas and poor farmlands	4
(v) Abandoned lands and arid wastes	2

No. (to be deducted):

$$= \frac{\text{Origin Station Rating No.} + \text{Destination Rating No.} + \text{Functional Rating No.}}{10}$$

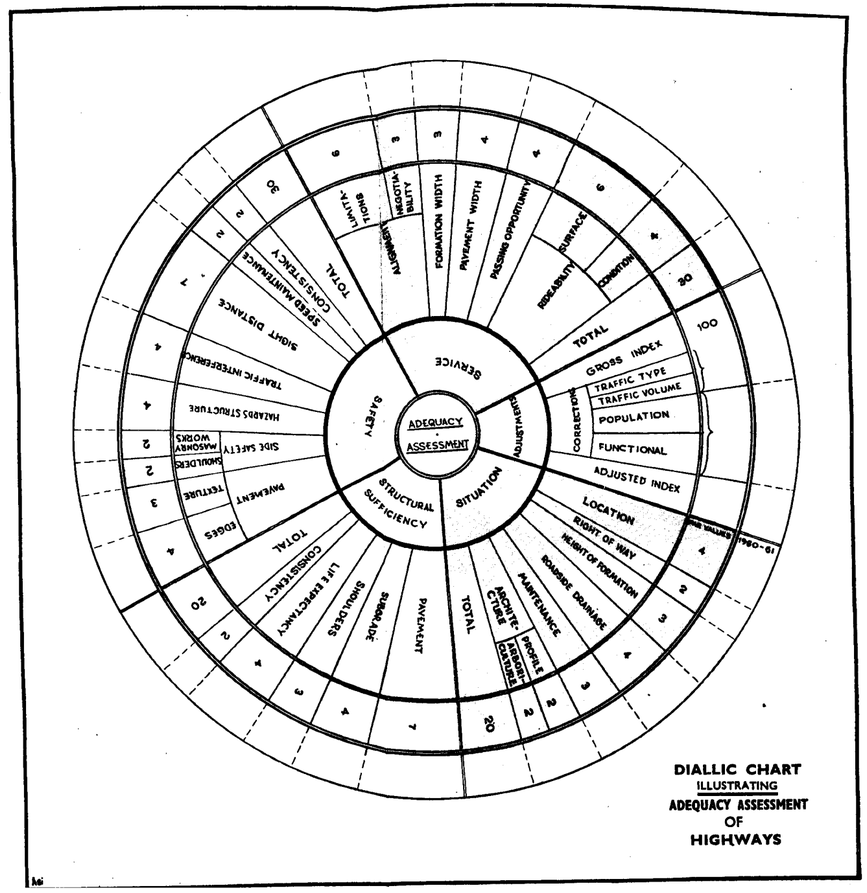
Adjusted Adequacy Assessment Index = I + II + III + IV - T - E.

3. Classification Index Values

The par and tolerant values for the different classes of roads to be as follows:

	Par value	Tolerant value (2/3rds)
X. Hs.	100	66
N. Hs.	90	60
S. Hs.	80	53
M. D. Rs.	70	47
O. D. Rs.	60	40
V. Rs. (Classified)	50	33
,, (Unclassified)	40	27

Annexure 3



Annexure 4

Specimen of a Condition Rating Sheet for Highway

Adequacy Assesement

Particulars of Road: National Highway *AB* (about 20.0 miles in length) has a dual lane sealed carriageway. It passes through developed agricultural area in plains and connects *X* — a town with a population of 5.0 lakhs with another town *Y* having a population of over 5,000. It carries an average traffic of 1,300 tons of pneumatic tyred vehicles and 200 tons of bullock cart; per day.

Element		Description	Condition per cent	Par value	Base rating
Group I: Situation					
(a)	Location	Plains	60	4	2.4
(b)	Right of way	Half of the standard	60	2	1.2
(c)	Height of formation	Liable to submersion	50	3	1.5
(d)	Drainage	Fair	40	4	1.6
(e)	Maintenance costs	Slightly higher than average	20	3	0.6
(f)	Architecture	Normal appearance	60	2	1.2
		Irregular arboriculture	35	2	.7
		Total	—	20	9.2
Group II: Structural Sufficiency					
(a)	Pavement	Light patches	80	7	5.6
(b)	Subgrade	No failure, adequately drained	100	4	4.0
(c)	Shoulders and bank slope	Gravelled	60	3	1.8
(d)	Life expectancies	Surface: Age 8 years	95	4	3.8
(e)	Consistency	Uniform	100	2	2.0
		Total	—	20	17.2
Group III: Safety					
(a)	Pavement Profile	Surface necessitating cautious driving	60	4	2.5
	Texture	Moderately smooth	60	4	2.5
(b)	Side protections	Shoulder widths	50	2	1.0

(c) Hazards at structures	Protective works adequate	100	2	2.0
	Culverts strong, but narrow	80	4	3.2
(d) Traffic interferences	Not heavy	—	4	3.0
(e) Sight distances	8 restrictions per mile	70	7	4.9
(f) Constant speed maintenance	About 35 m.p.h.	80	2	1.6
(g) Consistency	Uniform	—	2	2.0
	Total	—	30	22.0
Group IV : Service				
(a) Alignment	Speed restrictions : Av. 2 abrupt surprises per mile	80	6	4.8
(b) Formation width	Negotiability-Good	60	3	1.8
(c) Pavement width	Less by 8 ft	50	3	1.5
(d) Passing opportunities	22 ft	100	4	4.0
(e) Ridability	$\frac{1}{5}$ [70 + 80 + 100 + 50 + 40]*	68	4	2.7
	Surface R. T.	100	6	6.0
	Condition-Good	60	4	2.6
	Total		30	23.4
Gross "AA" Index [Group I + II + III + IV]			100	71.8

* $100 - \frac{T}{25}$ where T is traffic volume per day.

Adjustments :

(i) Traffic consideration :

Volume of traffic = $\frac{3}{4}$ (1300 + 200 + 200) = 12.750 say 1,300 tons.

Adjusted index (from curves) = 64

(ii) Economic adjustment :

Adjustment factor $\frac{8 + 6 + 10}{10} = 2.4$

To be deducted

Corrected adequacy Index = 64 − 2.4 = 61.6 say 62.0

Annexure 5

WIDTHS OF HIGHWAY PAVEMENTS

Recommended standards for width of pavements for various intensities of traffic

S. No.	Traffic classification	Nature of traffic	Average daily tonnage Tons	No. of lanes	Width of lane and total width of pavement Ft.	Type of pavement suggested	Shoulders for occasional traffic in lieu of additional lane type and width
1.	Very Light	Slow bullock cart traffic with a low percentage of motor vehicles	upto 300	1	10 ft min. 12 ft desirable	Gravel, moorum, stabilised soil, or water-bound macadam.	Nil
2.	Light	Mixed traffic with light motor traffic	300- 750	1	12	Water-bound macadam surface or soil stabilized surface with stone grafting and surface dressing.	,,
3.	Medium	Mixed traffic with a fair percentage of both pleasure cars and commercial vehicles	750-1500	1	12	Water-bound macadam surface with a bituminous treatment. Separate surfaced widths for slow traffic desirable.	Moorum, stabilized soil or metalled shoulders, 3 ft wide on either side.
4.	Heavy	Mixed traffic	1500-2500	2	22	(a) Bitumen, surface dressing or carpet treatment depending upon the traffic requirements. (b) Cement concrete.	3 ft metalled shoulders.
5.	Very heavy	Mixed traffic	2500-5000 (exclusive of cycles) Cycle track where cycles exceed 400 at peak hour	Dual carriageways each of 2 lanes		(a) Cement concrete or bituminous treatment as necessitated by traffic requirements. (b) Segregation of traffic with central reservation and footpaths. (c) Separate parking facilities.	
6.	Extra heavy	Mixed traffic	Over 5000 exclusive of cycles	Dual carriageways each consisting of : 3 lanes 10 ft.		(a) Cement concrete or bituminous carpet. (b) Segregation of traffic with central reservation and footpaths. (c) Separate parking facilities.	

Note:—In controlled access reaches, separate parallel service roads are necessary for the use of local traffic with the same specifications as mentioned above. They shall be located next to the main carriageway after leaving a verge or footpath of 10 ft width.

1. CHEMICAL STABILISATION OF SAND AND SANDY SOILS (LABORATORY EXPERIMENTS WITH SODIUM SILICATE AS STABILISER)
2. RAILING BARRIERS ON BUSY ROAD INTERSECTIONS — BEFORE AND AFTER STUDY

"CHEMICAL STABILISATION OF SAND AND SANDY SOILS"
(LABORATORY EXPERIMENTS WITH SODIUM SILICATE AS STABILISER)

By

R. N. Dogra & I. S. Uppal

SYNOPSIS

Laboratory investigations have been conducted to find out the suitability of sodium silicate as a stabiliser for sand and sandy soils as compared to the use of cement. It has been found that in the case of pure sand and non-plastic soils, use of even low quantities of sodium silicate gives better strength to the stabiliser mass than the use of higher quantities of cement. Use of sodium silicate also imparts better resistance to abrasion than the use of cement.

INTRODUCTION

Use of various binders like bituminous products, cement, resin, etc.[1], has been often recommended for the stabilisation of sand, but the quantities of such materials required or the methods employed for their mixing with sand, to attain satisfactory results, are generally uneconomical.

Recently the use of molasses[2] in conjunction with lime has been tried for the stabilisation of sand in the Central Road Research Institute, Delhi, but the results of this study also indicate that high percentages of lime and molasses are required to obtain the desired compressive strength and other properties of the stabilised mass. Solidification of sand with sodium silicate and calcium chloride has been recommended by some workers, but the process of injecting the two chemicals in the sand layers is rather complicated and has its own limitation. Laboratory investigations were, therefore, undertaken to study the behaviour of sodium silicate when used alone as a stabiliser for sand and sandy soils. Since, of all the stabilisers tried so far, cement has been found to be the best stabiliser for soils, the study was extended to its use in order to have comparable results.

Materials Used

The sand used was the washed pit sand, the mechanical analysis of which is given in Table 1. The stabilisers tried were (i) the commercial sodium silicate generally used in washing soap manufacture and (ii) the ordinary Portland cement.

TABLE 1

Mechanical analysis of sand	
B. S. Sieve	Percentage Passing
7	100
14	99.42
25	98.5
52	74.5
100	29.83

Sandy soils of varying sand contents were prepared by mixing clayey soil with the sand in quantities to yield mixtures of 90, 80, 60 and 50 per cent sand content (particles retained on 200 B. S. S.). The Atterberg limits of these mixtures are given in Table 2.

TABLE—2

Soil No.	Per cent sand content	L. L.	P. L.	P. I.
1.	90	Non-plastic		
2.	80	Non-plastic		
3.	60.1	22.6	17.5	5.1
4.	50.4	24.8	18.5	6.3

Preparation of Specimen Blocks

Requisite quantity of sodium silicate (1-10 per cent by weight of sand/soil) dissolved in optimum quantity of water was mixed in 200 gms. of sand/soil and the usual cylindrical blocks of 2.5 in. diameter were prepared in the modified Abbot compaction apparatus giving 40 strokes in each case. These were then allowed to set and dry for a fortnight in the sun and finally in the oven at about 50 degrees C. Blocks of cement-sand/soil were also prepared as usual in the same apparatus and allowed to cure under wet sand for a fortnight and then dried before testing. The optimum moisture varied from 10 to 13.5 per cent

(varying with the changing proportions of dry sand stabiliser in the mixture).

Tests Performed

The specimen blocks prepared above were tested for the following properties :

1. Compressive strength.
2. Resistance to softening action of water.
3. Resistance to abrasion.
4. Weathering cycles (wetting and drying).

Effect of Sodium Silicate and Cement on the Compressive Strength of Sand and Sandy Soils

The compressive strength was determined by means of the laboratory carver press and the load in lb per square inch required for initial crack and final failure of the blocks is indicated in Figs. 1 and 2. It would be seen from these results that in the case of pure sand the use of even 10 per cent cement did not give so much strength as was obtained with only 2.5 per cent sodium silicate. With the increasing proportions of clay in sand, however, the strength with cement steadily improved.

In the case of non-plastic mixtures, the strength of the blocks steadily improved with the increasing quantities of sodium silicate upto 7.5 per cent, while in the case of plastic soils the strength decreased with the addition of lower percentages of the chemical and improved as the quantity of the silicate was increased to 5 per cent and above.

Effect of Sodium Silicate and Cement on the Resistance to Softening Action of Water of the Stabilised Blocks

The specimen blocks were immersed under water contained in a glass trough and the observations made from time to time are indicated in Table 3. It could be seen therefrom that the pure sand blocks stabilised with even 1 per cent sodium silicate withstood this test very satisfactorily whereas those containing 2.5 per cent cement failed within a few minutes. Use of more than 5 per cent sodium silicate, however, did not yield satisfactory results. In the sand clay mixtures only 2.5 and 5 per cent of the silicate gave satisfactory results and further increase of this chemical led to early failure of the blocks. The blocks

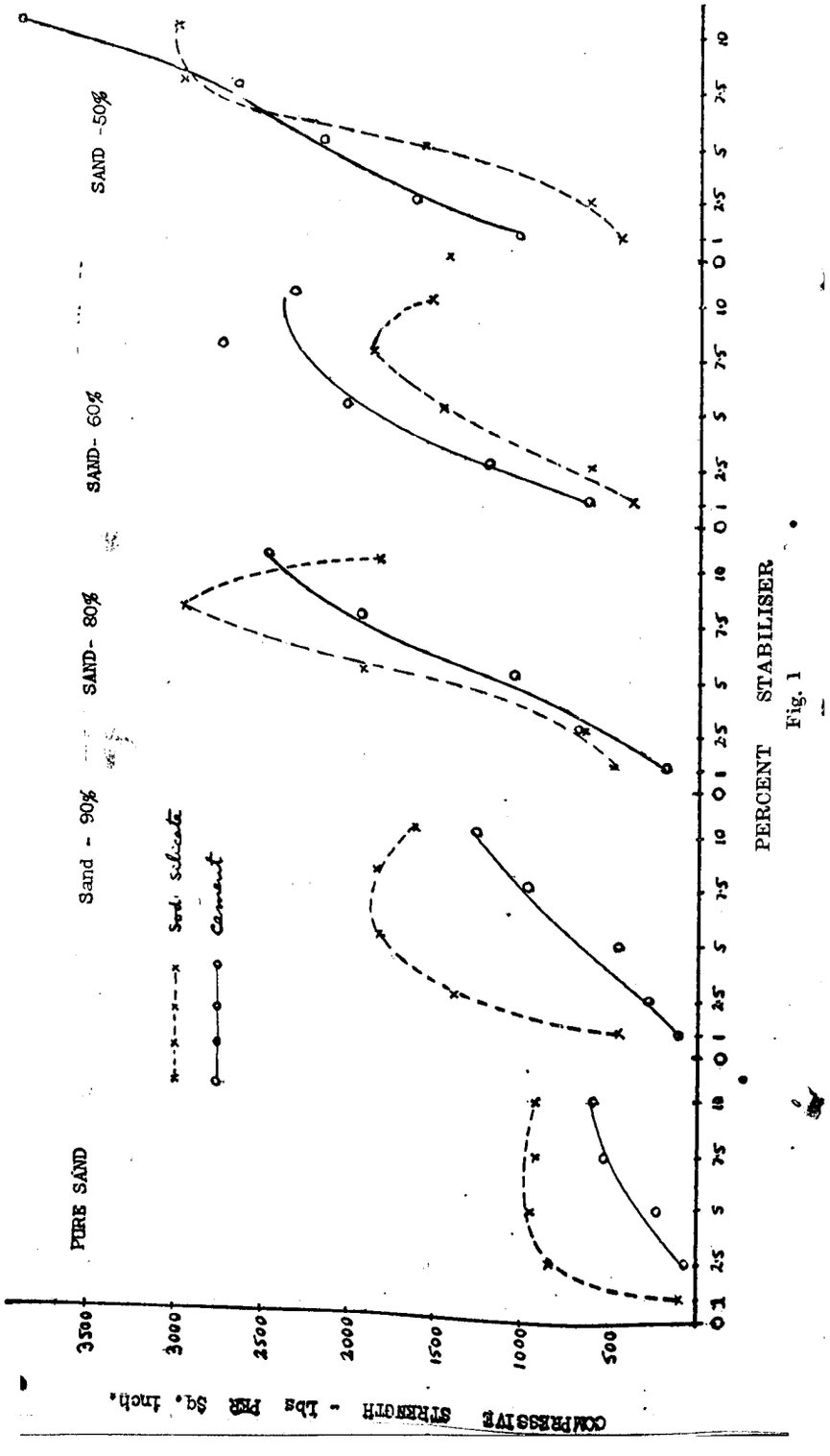
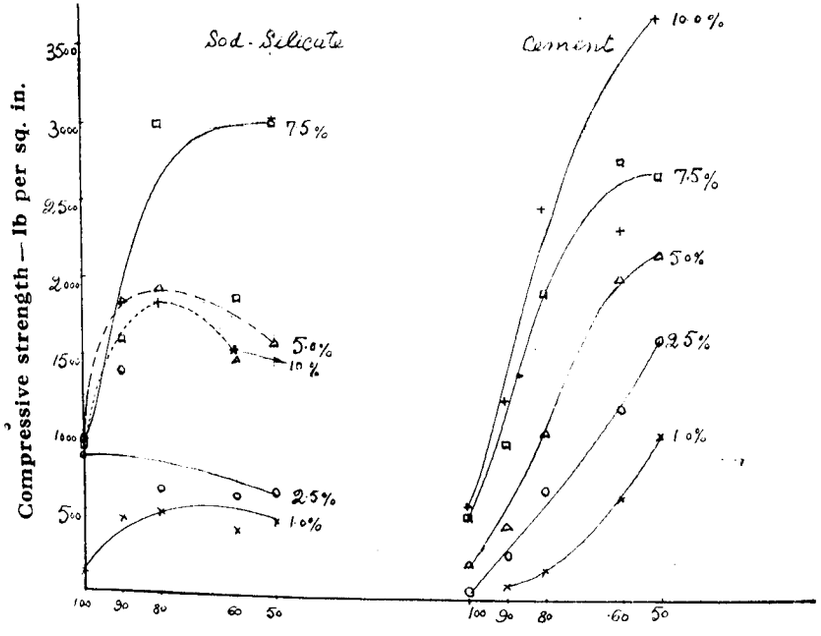


Fig. 1



Percentage sand in sand-clay mixture

Fig. 2.

containing 2.5 per cent and more cement were quite stable to the softening action of water. Photo 1 shows the condition of the silicate blocks after the test.

TABLE 3

Mixture	Per cent stabiliser used	Time of disintegration of block when kept under water	
		Sodium silicate	Cement
Pure sand	1.0	Remained intact for more than 4 days	All blocks dissolved during curing
	2.5	do	Eleven minutes
	5.0	do	Remained intact for more than 4 days
	7.5	One hour	do
	10.0	do	do

Mixture	% stabiliser used	Time of disintegration of block when kept under water	
		Sodium silicate	Cement
90% sand	1.0	1.25 hours	1.25 hours.
10% soil	2.5	Remained intact for more than 4 days	Remained intact for more than 4 days
	5.0	do	do
	7.5	do	do
	10.0	do	do
80% sand	1.0	2.25 hours	3.5 hours.
20% soil	2.5	Remained intact for more than 4 days.	Remained intact for more than 4 days
	5.0	do	do
	7.5	do	do
	10.0	do	do
60% sand	0	7 minutes	
40% soil	1.0	1.75 hours	2 days.
	2.5	Remained intact for more than 4 days	Remained intact for more than 4 days
	5.0	do	do
	7.5	Cracks appeared after two days	do
	10.0	do	do
50% sand	0	1.5 hours	
50% soil	1.0	10 minutes	9 hours 2 minutes
	2.5	Cracked after 24 hours	Remained intact for more than 4 days
	5.0	Remained intact for more than 4 days	do
	7.5	Cracked after one day	do
	10.0	do	do

Effect of the Sodium Silicate on the Resistance to Abrasion of the Block.

Resistance to abrasion was determined in the standard Dorey type abrasion machine, using coarse sand passing No. 10

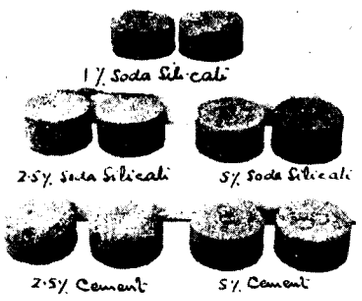


Photo 1.

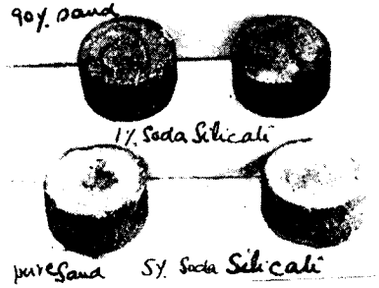
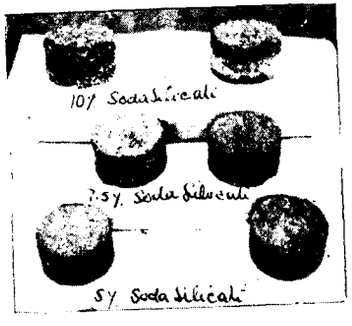


Photo 2.

100% sand



80% sand + 20% clay

90% sand + 10% clay

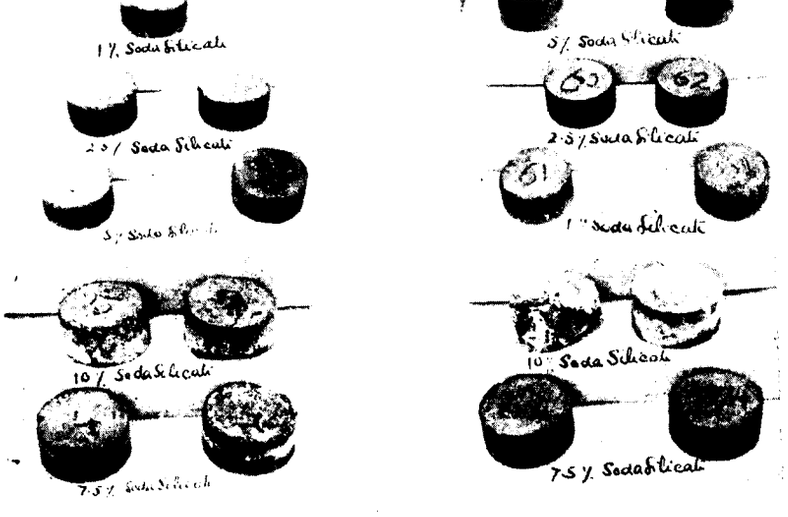


Photo 3.

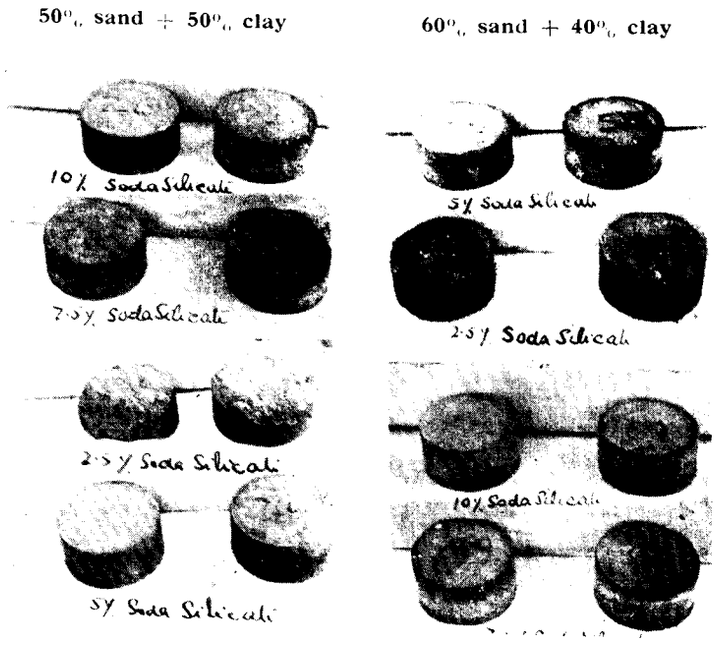


Photo 4.

and retained on No. 40 (U. S. Sieve). Percentage abrasion per square inch of the blocks tested is shown in Table 4.

TABLE 4

Mixture	Percentage abrasion per sq.inch.		
	% stabiliser	Sodium silicate	Cement
Pure sand	1.0	Finished in 3 seconds	All blocks dissolved during curing
	2.5	32.11	Finished in 1 mt 56 seconds.
	5.0	27.23	Finished in 4 mts. & 9 seconds
	7.5	20.51	33.52
	10.0	18.6	21.31
90% sand	1.0	Finished in 3 mts	Finished in 2 mts. 7 sec
10% soil	2.5	15.4	70.2
	5.0	12.1	43.3
	7.5	7.0	32.0
	10.0	6.3	26.2
80% sand	1.0	Finished in 2 mts.	Finished in 1 mt.
20% soil	2.5	60.8	Finished in 4 mts.
	5.0	5.5	54.2
	7.5	2.7	25.2
	10.0	1.1	15.5
60% sand	0	46.9	
40% soil	1.0	Finished in 2 mts. 30 seconds.	Finished in 5 mts.
	2.5	Finished in 5 mts.	44.2
	5.0	7.65	15.0
	7.5	7.45	4.0
	10.0	4.32	9.25
50% sand	0	28.2	
50% soil	1.0	Finished in 3 mts. 16 seconds.	35.0
	2.5	Finished in 5 mts. 18 seconds.	24.7
	5.0	4.45	12.7
	7.5	2.75	6.5
	10.0	5.2	5.23

It will be seen from the above Table that, on the whole, the use of sodium silicate in all the mixtures imparted better resistance to abrasion than when cement was used.

Resistance to Weathering

The specimen blocks were subjected to 12 alternative wetting and drying tests (wetting by immersion under water for 5 hours and drying in the oven at 70 degrees C. to constant weight for about 42 hours) and the loss in weight after each cycle was determined. All the blocks containing 5 per cent and more cement in the case of pure sand and 2.5 per cent and more cement in the case of sandy soils withstood the test satisfactorily with not more than 3 per cent loss at the end of the test (except when 2.5 per cent cement was used in the mixture containing 90 per cent sand, in which case the total loss went upto 7 per cent). In the case of silicate, however, the blocks of pure sand containing 5 per cent of the chemical withstood the test satisfactorily showing only 6 per cent loss at the end of the test. Lesser quantity of the chemical led to failure of the blocks after about 6 cycles, while with higher quantity of the chemical there was greater disintegration with each cycle. When the sand was adulterated with 10 per cent clay, the case of even lesser quantity of silicate gave encouraging results as the loss with 1 per cent sodium silicate after the 12 cycles was only 3.5 to 4 per cent. Higher quantities of the silicate in this mixture led to the rapid disintegration of the blocks. With higher proportion of clay in the sandy mixtures the use of sodium silicate did not give encouraging results so far as this test was concerned. The condition of the pure sand blocks containing 5 per cent sodium silicate and that of blocks prepared from 90 per cent sandy soil with 1 per cent sodium silicate after the end of 12 cycles is shown in Photo 2.

Effect of Ageing on the Properties of Sand and Sandy Soils Stabilised with Sodium Silicate—

Some specimen blocks prepared above were preserved (kept open in the room) for about 6 months and then subjected to compressive strength and slaking tests. The results are given in Table 5. Comparison of these results with those given in Figs. 1 and 2 and Table 3 will show that the compressive strength of the blocks considerably increased with ageing particularly with the addition of higher percentages of sodium silicate in soils richer in sand content. Resistance to softening action of water also improved with ageing. The condition of blocks after 5 days immersion in running water is shown in Photos 3 and 4.

TABLE 5

Mixture Sand : Soil	Per cent silicate	Compressive Strength lb per sq.in.		Resistance to softening action of water
		Initial cracks	Final failure	
100	2.5—10 per cent	—	—	All remained intact for more than 5 days in running water
90 : 10	1	400	500	do
	2.5	1600	1900	do
	5.0	2025	2450	do
	7.5	—	3525	do
	10.0	3500	3700	Cracks appeared after 28 hours
80 : 20	1	—	—	Cracked after 24 hours
	2.5	—	—	Intact for over 5 days
	5.0	1200	1866	do
	7.5	3000	3450	do
	10.0	3200	3225	Cracked after 27 hours
60 : 40	1	410	645	Intact for over 5 days
	2.5	480	690	do
	5.0	1650	1925	do
	7.5	1975	2425	do
	10.0	2525	3225	Cracked after 76 hours
50 : 50	1	270	403	
	2.5	400	520	Intact for 5 days
	5.0	856	1600	do
	7.5	—	3050	do
	10.0	2206	3000	do

ACKNOWLEDGMENT

Sarvshri O. P. Wason and M. M. Sharma, Research Assistants, assisted the Authors in carrying out these investigations.

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"RAILING BARRIERS ON BUSY ROAD INTERSECTIONS"

(Before and After Study)

By

TEJBIR S. KHANNA *

The Problem

On many intersections in urban areas it is difficult to control pedestrians. Pedestrians walk through intersections without paying attention to signals or cross-walks. This is due to lack of traffic safety education.

Queensway-Connaught—Circus intersection was the spot chosen for the study.

Discussion

This is a busy intersection with heavy rush of traffic of all types during the peak hours. It was observed that majority of the pedestrians at this intersection walked through carelessly causing danger both to themselves and to the vehicular traffic. They cared little for the crosswalks. (See Photo 1.)

Pedestrian count was taken on week days to find out the number of pedestrians walking properly (through the cross-walks) and those walking carelessly, i.e., without paying any attention to the cross-walks. The count was taken for all the four sides separately between 9-00 a.m. to 11-00 a.m. Only the pedestrians within 100 ft from the centre of the intersection were observed.

TABLE 1

Showing the total number of pedestrians and those walking carelessly

Side	Pedestrians walking carelessly	Total number of pedestrians observed	Percentage of pedestrians walking carelessly
North	195	268	72.9
East	135	183	73.6
South	218	415	52.5
West	318	473	67.2
Total all sides	866	1339	64.7

* Central Road Research Institute, New Delhi.

As may be seen from Table the percentage of pedestrians walking carelessly was very high, i.e., 164.7.

As a remedial measure it was suggested to instal railing barriers on all sides of the intersection along the curb of the roadway with openings on the cross-walks only. Difficulty arose on the East side (Scindia House) where the passage for the 'Allied Motor Company' could not be blocked. A certain portion of the curb along the roadway in front of the 'Allied Motor Company' was left open.

It was further suggested that the cross-walks should be brought closer to the centre of the intersection to bring them in line with the sidewalks along the intersection arms. This was also done at the time of fixing the railing barrier. The original plan and the plan with the two above mentioned added improvements are shown in Plate I.

After execution of these improvements a pedestrian count was again taken and is shown in Table 2.

TABLE 2

Showing the total number of pedestrians and those walking carelessly after the improvements have been executed on the site

Side	Pedestrians walking carelessly	Total number of pedestrians observed	Percentage of pedestrians walking carelessly
North	107	675	18.8
East	197	821	24.0
South	96	569	16.9
West	63	327	19.2
Total all sides	463	2392	19.3

With the reduced percentage of jay-walkers not only the traffic hazard has been reduced but intersection efficiency has also been increased.

There seems to be a necessity of further extending the railings on all sides which will further lower the number of jay-walkers.

Cost: The cost of the project was Rs 4,000 (Four thousand rupees).

Control of movement of pedestrians at busy crossings by means of railing barriers has also been tried at other places in India. The results of their experiences are recorded below:

Sri K. B. Carnac, City Engineer, Bombay Municipal Corporation

No statistics of "before and after study" were available on the above subject, but it had been observed that railing barriers put a good deal of restraint on the irresponsible and random movement of pedestrians. This had correspondingly improved vehicular traffic.

How this facility had influenced the accident rate could not be established as the accident records were not very convincing to deduce any correlation between the fixation of railings and the accidents.

City Engineer, Madras

At major street intersections with heavy vehicular and pedestrian traffic, experience had shown that complete physical restriction on pedestrians crossing the carriageway could best be accomplished by erecting guard rails at the kerbside with openings at suitable points for crossing. In busy commercial areas and near markets where there was temptation for the shopping crowds to use the carriageway and indulge in indiscriminate crossing, pedestrian guard rails had proved very effective.

2. During the last two years, the Madras Corporation had put up these barriers at nearly thirty busy street intersections and also along the entire length of two important roads where there was frequent congestion.

3. In the early stages there were protests from owners of shops facing these streets where pedestrian guard rails were erected but these gradually died down with the intervention of the traffic authorities.

4. There was no doubt as to the effectiveness of the guard rails in controlling disorderly crossing of the carriageway by the pedestrians and obstructing the smooth flow of vehicular traffic. The statistics of accidents, etc., supplied by the Deputy Commissioner of Police (Traffic and Licensing), Madras, are given in the statement attached.

5. The details of the type of guard rails adopted in Madras are shown in Fig. 1. This type not only looks attractive but is

PLAN OF R.C. RAILING USED AS PEDESTRIAN GUARD RAILS

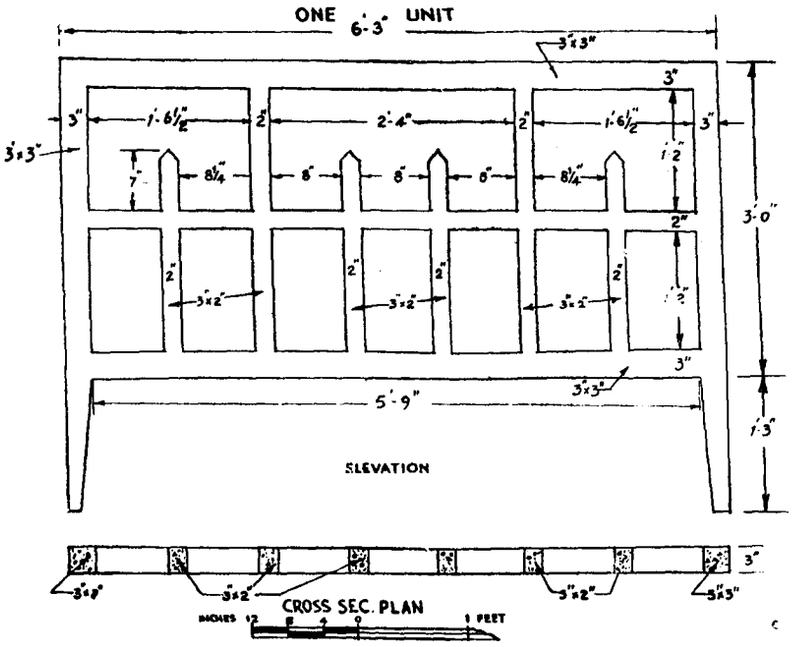


Fig. 1.

more effective than the conventional type of railing with horizontal members.

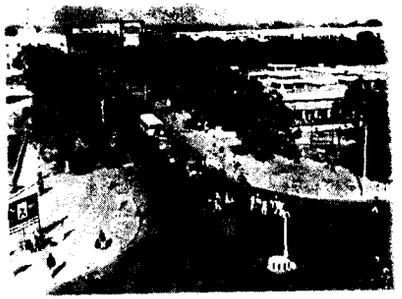


Photo 1.

Jay-walkers not caring to walk through the cross-walks New Delhi

Photo 2.

Pictures showing pedestrians walking through the cross-walks after installation of the Railing Barrier New Delhi

Photo 3.

Picture showing pedestrians walking through the cross-walks after installation of the Railing Barrier New Delhi

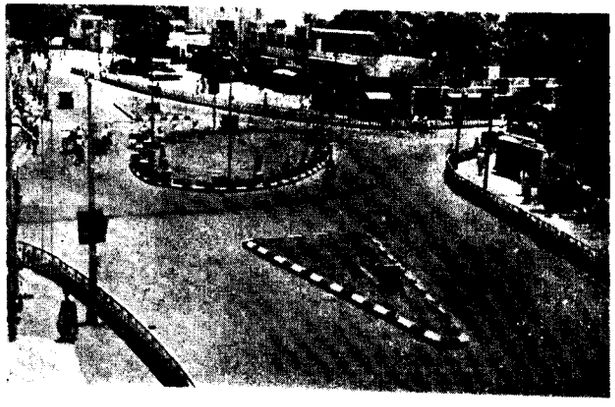


Photo 4.
Railing Barriers at a crossing in Madras

Photo 5.
Railing Barriers at another crossing in Madras

Photo 6.
Railing Barriers at a crossing in Calcutta

Statement showing the statistics of cases involving pedestrians which occurred on important road junctions and roads in Madras where railings have been provided for the pavement.*

Sr. No.	Name of the junction or street	1955	1956	1957
1	Mount Road—Thousand Lights	12	4	3
2	Mount Road—Gemini Round-about ...	3	1	...
3	Mount Road Post Office ...	...	...	...
4	Mount Road Durga ...	3	6	...
5	Mount Road Spencer Round-about ...	1	2	...
6	Mount Road Round Tana ...	12	3	5
7	General Hospital Road ...	8	8	8
8	Netaji Subhas Chandra Bose Road ...	12	14	10
9	Junction of Gandhi Irwin Road & Commissioner's Office Road Automatic signal ...	...	3	4
10	Poonamalle High Road ...	14	15	4
11	Gangadeswaran Koil Street ...	3	...	...
12	Doveton ...	...	...	...
13	Mint Junction ...	13	6	7
14	Rattan Bazaar Road ...	3	4	4
15	Triplicane High Road ...	12	15	4
16	Langs Garden Road ...	1	3	2
17	Junction of Pantheon Road & Commissioner's Office Road ...	3	3	1
18	Blackers Road ...	2	...	...
19	Pycrofts Road ...	8	8	8
20	South Beach Road—Marina ...	12	14	5
21	Luz Junction ...	2	3	5
22	Royapettah High Road ...	12	15	3
23	Brodies Road ...	3	...	...

* This information has been kindly supplied by the Deputy Commissioner of Police, Madras.

The Deputy Commissioner of Police, Calcutta

The railing barriers on the pavements had been installed at more than 15 important road-intersections in the City and suburbs of Calcutta. The sites were primarily selected on the basis of the consideration that concentration of pedestrians was appreciably heavy in addition to the flow of traffic being considerable there. The railing barriers had been found to be quite helpful from traffic point of view in the matter of ensuring safety for pedestrians. While it is admitted that greater road safety and prevention of road accidents very largely depends upon the extent to which the pedestrians adhere to discipline and display road sense, the presence of guard rails on pavements surely tends to encourage them to keep to the footpaths. It was seen that except for the purpose of crossing the road, road-users were using the pavement inside the railing barriers. There was, therefore, no doubt about the efficacy of railing barriers as a safety measure in a congested city where traffic is heavy.

Data and statistics for past years were not available. However, a statement showing cases of accidents reported in the areas having railing barriers for a period of 3 months relating to each guarded road-intersection is given at page 181. It would be seen that cases of collision between motor vehicles were considerable in number at some of these places.

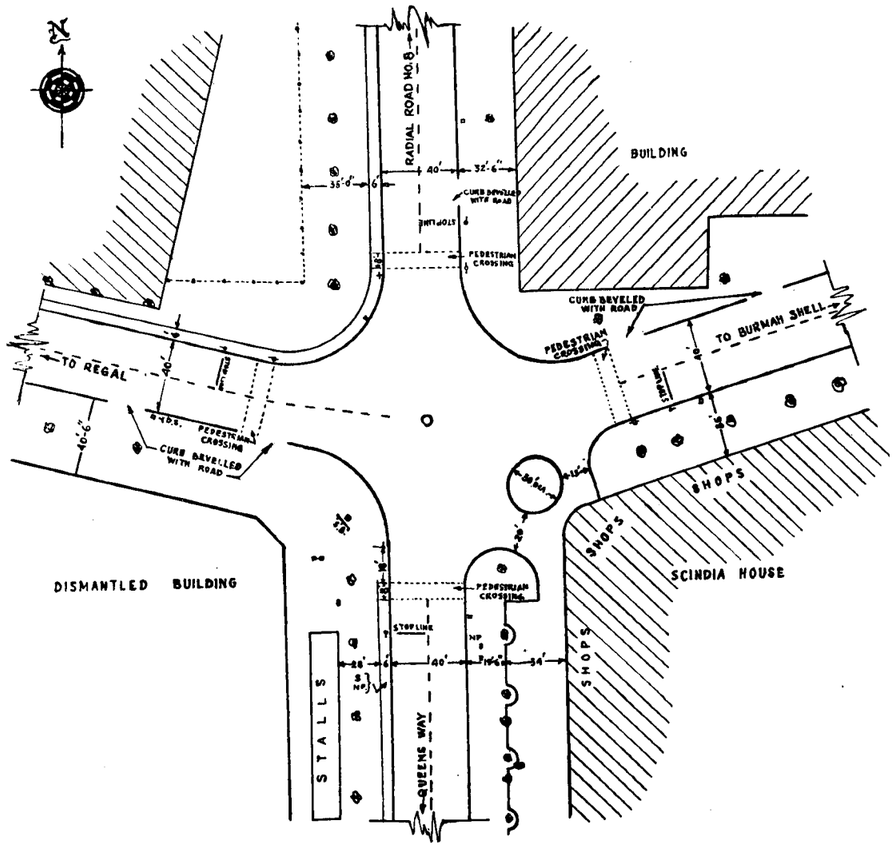
Cases of fatal accidents remained low. Cases of injury received by pedestrians in road accidents did not show any alarming trend, considering Calcutta's density of population and volume of traffic.

More and more guarded areas in cities like Calcutta, where traffic was considerably increasing in volume, were a real necessity from road safety point of view both for pedestrians and road-users.

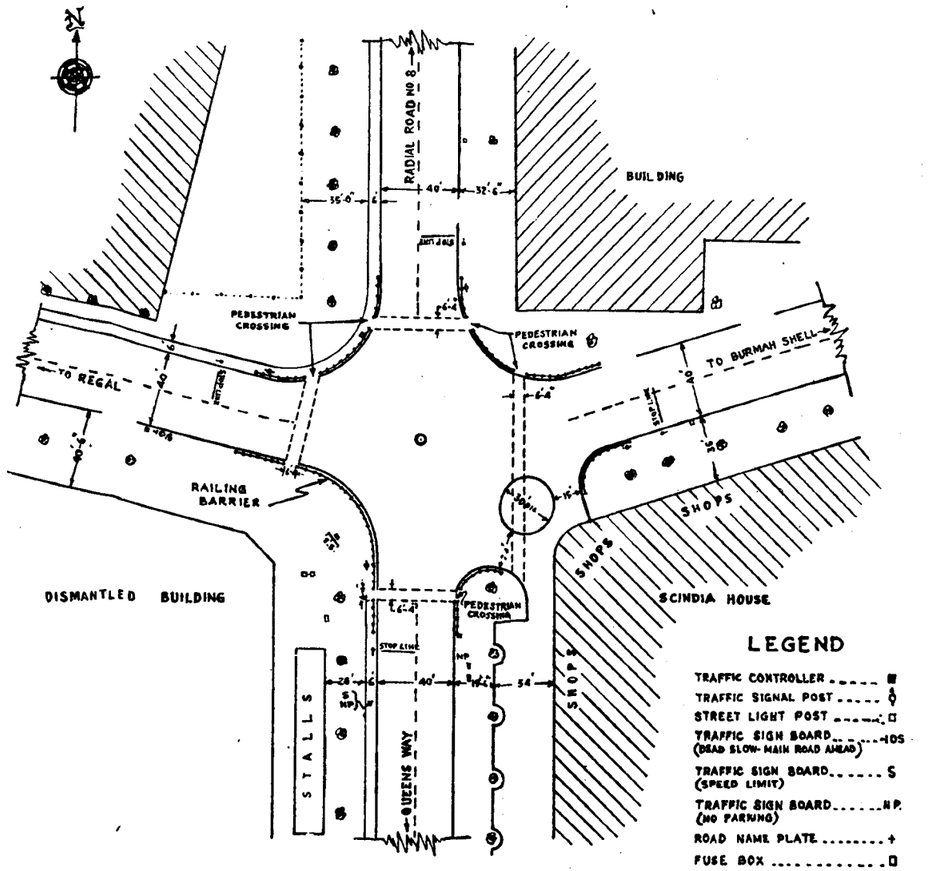
Traffic accident figures on certain street crossings of Calcutta where guard rails have been erected

	October, 1956			November, 1956			December, 1956		
	Death	Injury	Collision	Death	Injury	Collision	Death	Injury	Collision
1. Crossing of Central Avenue & Mission Row.	—	1	5	—	—	10	—	1	4
2. Crossing of Central Avenue & Colootolla St.	—	3	8	—	1	3	—	—	6
3. Crossing of Central Avenue and Harrison Road.	—	1	9	—	2	5	—	3	9
4. Crossing of Central Avenue & Balmukund Makkar Road	—	—	—	—	1	1	—	—	—
5. Crossing of Central Avenue & Grey Street	—	—	1	—	—	2	—	1	1
6. Crossing of Central Avenue and Jatindra Mohan Avenue	—	1	—	—	—	1	—	—	1
7. Belgachia Bridge	1	1	4	—	1	1	—	—	2
8. Shyambazar 5-point crossing	—	5	27	—	5	19	—	2	13
9. Crossing of Central Avenue and Beadon St.	—	2	7	—	1	3	—	1	15

PLATE I



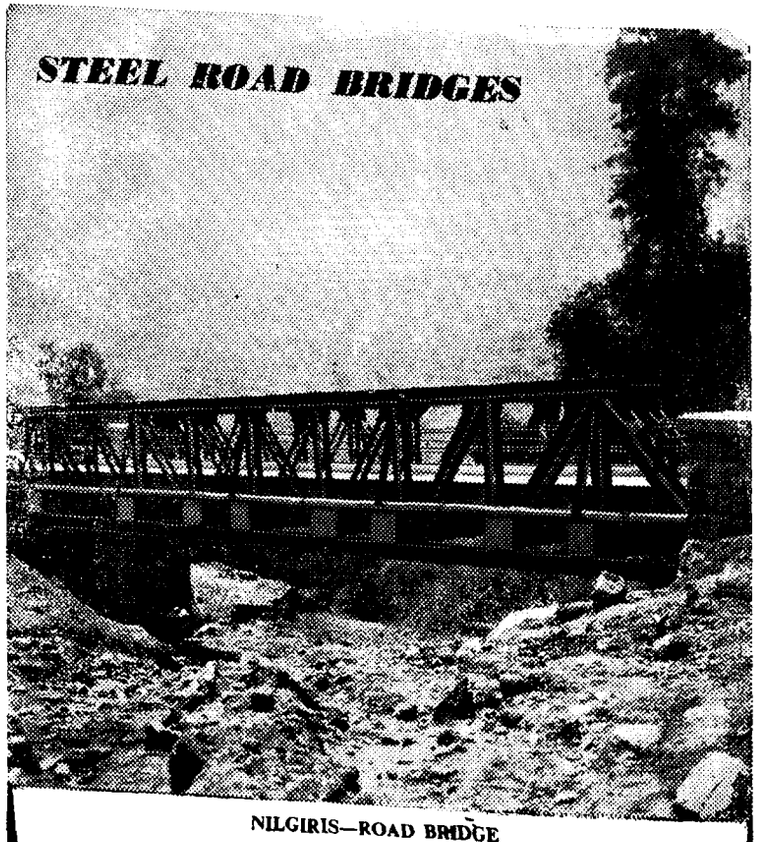
SITE PLAN
(EXISTING)



AFTER IMPROVEMENT
(RAILING BARRIER INSTALLED AND CROSS WALKS RELOCATED.)

LEGEND

- TRAFFIC CONTROLLER
- TRAFFIC SIGNAL POST
- STREET LIGHT POST
- TRAFFIC SIGN BOARD (DEAD SLOW- MAIN ROAD AHEAD) — DS
- TRAFFIC SIGN BOARD (SPEED LIMIT) — S
- TRAFFIC SIGN BOARD (NO PARKING) — NP
- ROAD NAME PLATE — +
- FUSE BOX
- ELECTRIC POLE
- SIGN BOARD
- TREE
- STOP LINE SIGN BOARD
- RAILING



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