Journal of the Indian Roads congress

1955-56

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

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. Mukherjee, Colonel.
Military Secretary to the President

INDIAN ROADS CONGRESS

ESTABLISHED : 1934 REGISTERED : 1937

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E. A. Nadirshah
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H. P. Mathrani
R. C. Roy
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Chief Engineer (Highways), Madras
Chief Engineer, Buildings & Roads, Punjab
A representative of Central Standards Office for Railways
A representative of the Poona Irrigation Research Station
A representative each from Lucknow, Madras, Karnal & Hyderabad Research Stations
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A representative of Engineer-in-Chief
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H. Sunder Rao

C. S. Anantapadmanabhan *Member-Secretary*

11. LOCAL COMMITTEE OF THE TEST TRACK DIVISION TO SUPERVISE DELHI-MATHURA ROAD TESTS:

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Consulting Engineer (Road Development)
A representative of C. P. W. D.—Shri M. L. Nanda
J. M. Trehan

12. CEMENT CONCRETE ROAD SURFACING SUBCOMMITTEE:

E. A. Nadirshah ... *Convenor*
K. K. Nambiar U. N. Mahida
Goverdhan Lal

The Consulting Engineer (Road Development) to the Government of India is an ex-officio Member of all Committees and Subcommittees.

INDIAN ROADS CONGRESS

NOTICES AND ANNOUNCEMENTS

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

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

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

2. **The complete Paper should be submitted as early as possible.**

From past experience it is observed that most of the Members send in their contributions just before the general Session, when the Congress Office is busy on work connected with the Session. As it takes a long time to get Papers printed in the Journal and as it is desirable that members should have time to study Papers well in advance of the date of the Session, it is hoped that Members will make an effort to send their contributions **within the next three months.**

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

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

4. **MEDALS**: The following Medals are available for award:

(i) **The Mitchell Medal**:

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

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

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

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

6. Rules and Regulations for the contribution of Technical Papers and the Award of Medals are published on pages 9-14.

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 OF THE CONTRIBUTION OF TECHNICAL PAPERS

3.1. The Standing Rules for guidance when contributing Papers, as now slightly amended, 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 the 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. FOBMULAE

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 members 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.

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

(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 Consulting Engineer (Road Development)'s Office, 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.

ALPHABETICAL LIST OF MEMBERS

Corrected upto 30-6-1955 and Roll No. 1950.

PATRON

Dr. Rajendra Prasad
President of Republic of India.

HONORARY MEMBERS

Sir Kenneth Mitchell, C.I.E., K.C.I.E.,
Beechwood, Wickhambrook, near New Market,
Suffolk, (England).

ORDINARY AND LIFE MEMBERS

(L.M. denotes Life Members)

Serial No.	*Roll No.*	*Name*	*State/Country*
		"A"	
1	1531	Abdul Ala, M.	Hyderabad.
2	1773	Abdul Azeez, K. V.	Madras.
3	1263	Abdul Rahman.	Andhra.
4	1742	Abhyankar, S. H.	Coorg.
5	1591	Abraham, M. C.	Ceylon.
6	684	Acharya, D. K.	Orissa.
7	850	Acharya, P. G.	Rajasthan.
8	768	Acharya, S.	Orissa.
9	721	Acherjee, F. C.	Govt. of India.
10	826	Adaviyappa, S.	Rajasthan.
11	242	Adke, A. S.	Bombay.
12	1655	Aga, A. K.	Bihar
13	1592	Agarwal, Balbir Singh	Uttar Pradesh.
14	1547	Agarwal, G. D.	Madhya Pradesh.
15	1389	Agarwal, K. C.	Uttar Pradesh.
16	1782	Agarwal, R. S.	Uttar Pradesh.

Serial No.	*Roll No.*	*Name*	*State/Country*
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18	711	Agarwal, Shyam Krishna	Uttar Pradesh.
19	1755	Agarwal, T. C.	Govt. of India.
20	957	Agarwala, D. R.	Uttar Pradesh.
21	781	Agarwala, R. P.	Bihar.
22	1060	Agarwala, M. G.	Uttar Pradesh.
23	634	Agarwala, R. M.	Uttar Pradesh.
24	1223	Agarwala, P. S.	Uttar Pradesh.
25	1397	Ahmed Ovaise	Uttar Pradesh.
26	1660	Ahuja, B. D.	Govt. of India.
27	1055	Aiyangar, R. A. Sampat.	Mysore.
28	452	Ajwani, J. M.	Bombay.
29	1388	Akalankan, N. A.	Madras.
30	341	Akhtar, S. E.	Bihar.
31	1856	Alam Singh	Rajasthan.
32	1427	Albert Mayer	U. S. A.
33	1800	Alexander. G.	Madras.
34	1637	Amanullah, N.	Bihar.
35	1779	Amar Singh.	Rajasthan.
36	821	Amarinderjit Singh	PEPSU.
37	1189	Amin, M. P.	Bombay.
38	1086	Aminbhavi, L. T.	Madhya Pradesh.
39	420	Amingad, A. K. (L.M.)	Hyderabad.
40	1884	Amrit Lal.	J. & K.
41	675	Ananda Rao, U.	Madras.
42	1251	Andavan, G. M.	Madras.
43	1725	Andhare, N. M.	Madhya Pradesh.
44	562	Annaswami, V. S.	Madras.
45	1285	Ansari, M. N.	Madhya Pradesh.
46	1241	Antia, K. F.	Bombay.
47	1927	Antin, M. C.	Bombay.

Serial No.	Roll No.	Name	State/Country
48	1414	Apte, K. V. (L.M.)	Bombay.
49	1522	Apte, M. P.	Bombay.
50	1873	Aramadhu, P. R.	Madhya Pradesh.
51	1905	Arjan Singh	M. E. S.
52	1332	Arjun Singh	Bihar.
53	1308	Arjun Thakur	Bihar.
54	1234	Arnold, G. J.	Govt. of India.
55	442	Arora, K. N.	Uttar Pradesh.
56	736	Asarpota, D. M.	Bombay.
57	1509	Aserappa, R. E. (Brigadier)	"Corps of Engineers".
58	588	Athawale, V. L.	Madhya Bharat.
59	76	Ayyar, A. Nageshwara (L. M.)	Madras.
60	109	Ayyar, Lakshman Venkata-Krishnan (L.M.)	Madras
61	98	Ayyar, K. Trimalaiswamy (L.M.)	Madras.
62	1599	Ayyar, V. V. Gopala Krishna	Travancore Cochin.
		"B"	
63	213	Bagchi, C. C.	Uttar Pradesh,
64	977	Bahl, D. R.	Govt. of India.
65	399	Bahl, M. L. (L.M.)	Bihar
66	836	Bais, Ram Singh	Rajasthan.
67	1842	Bajaj, Trilochan Singh	Bihar
68	1481	Bakeri, R. D.	Bombay.
69	897	Baksi, R. D.	Bihar.
70	1922	Bala Pershad	Hyderabad.
71	544	Balasubramanyam, M.	Madras.
72	1859	Balbir Singh, S.	Govt. of India.
73	68	Balwant Singh.	Punjab.
74	253	Bamji, H. F. (L.M.)	Bombay.
75	1839	Bandopadhyaya, P.	Bihar.

Serial No.	Roll No.	Name	State/Country.
76	1162	Banerjee, Ajit Kumar	Bihar.
77	85	Banerjee, M. G. (L.M.)	West Bengal.
78	1290	Banerjee, S. C.	Govt. of India.
79	1456	Banerjee, S. N.	West Bengal.
80	88	Banerjee, Tulsidas	Madhya Pradesh.
81	877	Banerjee, P. K.	Uttar Pradesh.
82	1133	Banerjee, S. K.	West Bengal.
83	962	Banerjee, J. K.	West Bengal.
84	910	Banerjee, S. R.	West Bengal.
85	1181	Bansal, K. L.	Uttar Pradesh.
86	929	Bansal, K. S.	Madhya Pradesh.
87	336	Bansor, H. S.	M. E. S.
88	1186	Bapat, M. S.	Uttar Pradesh.
89	1931	Barman, R. P.	Govt. of India.
90	1682	Baronia, L. R.	Madhya Pradesh.
91	1247	Barua, H.	Assam.
92	234	Barua, H. P. (L.M.)	Assam.
93	889	Barua, K.	Assam.
94	1579	Basant Lal	Rajasthan.
95	892	Basant Singh, S.	Punjab.
96	814	Basheer Ahmed.	Andhra.
97	51	Bashi Ram, S. (L.M.)	Punjab.
98	1872	Bassi Labh Singh	Punjab.
99	1510	Basu, B. B.	M. E. S.
100	1421	Basu, K. N.	West Bengal.
101	1514	Basu, S. C.	West Bengal.
102	383	Batlivala, H. S.	Bombay.
103	1602	Batni, K. B.	Govt. of India.
104	978	Batra, R. K.	Madhya Pradesh.
105	981	Battiwala, K. P.	Bombay.
106	1359	Baul, Raghudas	West Bengal.

Serial No.	Roll No.	Name	State/Country
107	1852	Bawishi, V. M.	Saurastra.
108	322	Bazaz, S. L.	Govt. of India.
109	57	Bedekar, V. P. (L.M.)	Bombay.
110	328	Behera, S. S.	Orissa.
111	1399	Benjamin, George	M. E. S.
112	204	Bennett, C. M.	Orissa.
113	1593	Berry, R. K.	Punjab.
114	1806	Bhaduri, B. N.	West Bengal.
115	266	Bhagat, D. G.	Govt. of India.
116	1463	Bhagwagar, K. D.	Bombay.
117	149	Bhalla, Prem Nath	Madhya Bharat.
118	1446	Bhalla, R. S.	Govt. of India.
119	1050	Bhambhani, B. I.	Bombay.
120	1929	Bhan, D. N.	J. & K.
121	1619	Bhandari, V. D.	Govt. of India.
122	14	Bhandarkar, G. P. (L.M.)	Bombay.
123	1747	Bhanja, M. M.	Orissa.
124	827	Bhargava, I. D.	Rajasthan.
125	1694	Bhargava, J. P.	Uttar Pradesh.
126	251	Bhargava, K. N.	Rajasthan.
127	1114	Bhargava, M. C.	Uttar Pradesh.
128	1175	Bhargava, M. G.	Uttar Pradesh.
129	1644	Bhargava, N. C.	Uttar Pradesh.
130	783	Bhargava, T. N.	Govt. of India.
131	169	Bharucha, M. D.	Bombay.
132	1402	Bhasin, P. C.	Punjab.
133	1893	Bhatia, K. D.	Govt. of India.
134	1122	Bhatia, H. T.	M. E. S.
135	658	Bhatia, M. S.	Govt. of India.
136	62	Bhatnagar, Jagmohan Lal (L.M.)	Rajasthan.

Serial No.	Roll No.	Name	State/Country
137	860	Bhatnagar, P. S.	Uttar Pradesh.
138	1304	Bhatnagar, S. S. L.	Uttar Pradesh.
139	1661	Bhatnagar, V. R.	Rajasthan.
140	214	Bhatt, U. J.	Saurashtra.
141	245	Bhattacharya, N. G. (L.M.).	Rajasthan.
142	1741	Bhattacharya, P. B.	Vindhya Pradesh.
143	1413	Bhattacharya, S. P.	West Bengal.
144	1508	Bhatti, K. S.	M. E. S.
145	1865	Bhobe, V. M.	Goa.
146	455	Bhonsale, N. K. (L.M.).	Madhya Bharat.
147	1882	Bhosale, B. Y.	Bombay.
148	484	Bhupendra Nath	Govt. of India.
149	1301	Bhuvaragha Moorthy, R.	Madras.
150	1370	Bibhuty, L. N. S.	Bihar.
151	831	Bijawat, M. C. (L.M.).	Uttar Pradesh.
152	462	Bikramjit	Punjab.
153	53	Bishamber Dayal (L.M.).	Delhi.
154	1524	Bishnoi, Anand Singh	Uttar Pradesh.
155	205	Bisht, M. S.	Uttar Pradesh.
156	1383	Biswas, K. K.	West Bengal.
157	1861	Bodhe, J. G.	Bombay.
158	1617	Bolakani, T. P.	Govt. of India.
159	1244	Bora, K. C.	Assam.
160	1395	Borwankar, S. G.	Madhya Pradesh.
161	1628	Bose, A. K.	West Bengal.
162	1777	Bose, D. K.	West Bengal.
163	539	Bose, K. N.	West Bengal.
164	1443	Bose, M. M.	Bihar.
165	1201	Bose, R. C.	West Bengal.
166	1648	Bose, S. K.	Govt. of India.
167	1818	Bose, S. K. (Col.)	M. E. S.

Serial No.	Roll No	Name	State/Country
168	42	Brijimohan Lal (L.M.).	Delhi.
169	616	Brij Narayan	Delhi.
170	1834	Bukhshi, M. M.	Bihar
		"C"	
171	1751	Calla, V. N.	Rajasthan.
172	1132	Cantlay, L. F. (L.M.).	England.
173	1885	Carnac, K. B.	Bombay.
174	1877	Cassad, D. R. P.	Madhya Pradesh.
175	796	Caprihan, S. P.	Madhya Pradesh.
176	1196	Chablani, M. B. (L.M.).	Bombay.
177	519	Chacko, I. C. (L.M.).	Travancore-Cochin.
178	201	Chaddha, Ulfatrai	Delhi.
179	1155	Chakraburty, N. B.	West Bengal.
180	789	Chakravarti, B. M.	Assam.
181	712	Chakravarti, J. C.	Govt. of India.
182	1649	Chakravarti, S. C.	West Bengal.
183	17	Chakravarti, S. N. (L.M.).	West Bengal.
184	1634	Chakravarti, A. C.	Bihar.
185	1797	Chakravarti, S. K,	West Bengal.
186	1888	Chakravarti, H.	Delhi.
187	1947	Chaku, B. L.	J. & K.
188	323	Chambers, J. (L.M.).	West Bengal.
189	1527	Champhekar. M. L.	Orissa.
190	1324	Chanda, R. P.	West Bengal.
191	1680	Chandel, I. S.	Assam.
192	1892	Chandiramani, K. M.	Govt. of India.
193	994	Chandrasekharan, E. C.	Madras.
194	1004	Chandratreya, S. V.	Bombay.
195	1909	Channiah, H.	Mysore.
196	895	Charan, S. K.	Uttar Pradesh.
197	565	Chatterjee, Dinabandhu	Govt. of India.

Serial No.	Roll No.	Name	State/Country
198	1348	Chatterjee, M. K.	West Bengal.
199	1426	Chatterjee, P. C.	West Bengal.
200	913	Chatterjee, P. K.	Govt. of India.
201	934	Chatterjee, P. L.	Govt. of India.
202	1347	Chatterjee, P. N.	West Bengal.
203	529	Chatterjee R.	West Bengal.
204	624	Chatterjee, S. N.	West Bengal.
205	1812	Chattopadhya, B. C.	West Bengal.
206	1496	Chattopadhya, K. P.	West Bengal.
207	1589	Chattopadhya, S. N.	Orissa.
208	1525	Chaturvedi, D. C.	Uttar Pradesh.
209	1749	Chauhan, L. J.	Bombay.
210	691	Chauhan, P. M.	Bihar.
211	906	Chawla, S. S.	M. E. S.
212	263	Chenoy, Faridoon, S. (L.M.)	Hyderabad.
213	893	Chetan Das	M. E. S.
214	281	Chinchankar, K. B.	Bombay.
215	343	Choksi, B. K. (L.M.)	Bombay.
216	145	Chopra, A. N. (L.M.)	Delhi.
217	1455	Chopra, P. C.	Madhya Pradesh.
218	1092	Chopra, Y. P.	Bombay.
219	1715	Choudhury, Achyuta Nanda	Assam.
220	1541	Choudhry, D. C.	Bihar.
221	704	Chougule, Y. K.	Bombay.
222	941	Chowdhury, B.(L.M.)	Assam.
223	1294	Chowdhury, D. P. Roy	West Bengal.
224	346	Chowdhury, Imam-uz-Zaman	Pakistan.
225	963	Chowdhury, P. R.	Assam.
226	321	Chowdhury, Ram Narain	Rajasthan.
227	202	Chowdhury, S. P.	Assam.
228	419	Chowla, P. D.	Govt. of India.

Serial No.	Roll No.	Name	State/Country
229	289	Cochrane, G. A. D. (L.M.)	England.
230	905	Cocksedge, H. G.	Assam.
231	28	Colabawala, J. R. (L.M.)	Pakistan.
232	1623	Collins, A. E. L.	Delhi.
233	1936	Contractor, L. M.	Bombay.
		"D"	
234	261	Daftary, G. D. (L.M.)	Bombay.
235	1336	Daftary, N. D.	Bombay.
236	1477	Dalal, M. N. (L.M.)	Bombay.
237	140	Dam, S. C. (L.M.)	West Bengal.
238	1828	Damodaran, H.	Madras.
239	1487	Daruwala, P. K.	Bombay.
240	552	Daryanani, C. S.	Bombay.
241	1137	Das, A. C.	Orissa.
242	919	Das, A. L.	West Bengal.
243	161	Das, B. C.	Assam.
244	1825	Das, H. H.	Orissa.
245	560	Das, K. C.	Orissa.
246	1823	Das, K. M.	Orissa.
247	1746	Das, N. P.	Orissa.
248	774	Das, P. B. (L.M.)	Madhya Pradesh.
249	285	Das, P. C.	Orissa.
250	1197	Das, S. M. Mohan	Madras.
251	1895	Das, S. R.	Assam.
252	1505	Das, T. M.	West Bengal
253	1556	Das Gupta, A. K.	West Bengal.
254	1202	Das Gupta, B. B.	West Bengal.
255	1815	Das Gupta, B. R.	West Bengal.
256	203	Das Gupta, J. N. (L.M.)	West Bengal.
257	319	Das Gupta, J. N.	West Bengal.
258	1740	Das Gupta, S.	Bihar.

Serial No.	Roll No.	Name	State/Country
259	15	Datta, A. K. (L.M.)	West Bengal.
260	412	Datta, A. K.	Bihar.
261	1786	Datta, A. K.	West Bengal.
262	157	Datta, D. C. (L.M.)	Assam.
263	1349	Datta, D. C.	M. E. S.
264	1156	Datta, P. L.	Govt. of India.
265	1613	Datta, Suram Singh	Rajasthan.
266	158	Datta, S. K.	Assam.
267	71	Dave, D. P.	Madhya Pradesh.
268	1043	Daver, F. K.	Hyderabad.
269	758	D'Costa, A. J.	Govt. of India.
270	1144	De, Anil Chandra	Orissa.
271	1161	DeSousa, P.	Govt. of India.
272	199	Dean, A. W. H. (L.M.)	North Africa.
273	1582	Deo, T. S.	Madhya Bharat.
274	776	Des Raj (L.M.)	Govt. of India.
275	940	Desai C. B.	Rajasthan.
276	1322	Desai C. N.	Bombay.
277	165	Desai, D. S.	West Bengal.
278	1629	Desai G. S.	Bombay.
279	1739	Desai, I. C.	Bombay.
280	1485	Desai, N. M.	Bombay.
281	1466	Desai, N. K.	Bombay.
282	773	Desai, R. V.	Bombay.
283	1497	Deshpande, D. V.	Bombay.
284	1484	Deshpande, K. S.	Bombay.
285	1651	Deuskar, V, R.	Bombay.
286	353	Devarajan, A.	Hyderabad.
287	694	Devarajan, K. S.	Madras.
288	1667	Deviah, N. S.	Madras.
289	737	Dewan, N. G,	Govt. of India.

Serial No.	Roll No.	Name	State/Country
290	1663	Dhamdhere, H. V.	Bombay.
291	1538	Dhar, A. N.	M. E. S.
292	925	Dhar, B. K.	West Bengal.
293	1578	Dhar, Dina Nath	J. & K.
294	617	Dhaul, K. K.	Govt. of India.
295	1338	Dhillon, Arjan Singh	PEPSU.
296	614	Dhingra, A. D.	Bombay.
297	1243	Dhir, H. R.	Punjab.
298	1145	Dhruva, R. C.	Bombay.
299	567	Dhumal, R. J.	Madhya Bharat.
300	1736	Dikey, J. T.	Madhya Pradesh.
301	250	Dildar Hussain.	Hyderabad.
302	1608	Divatia, P. V.	Madhya Bharat.
303	1549	Doctor, P. K.	Pakistan.
304	457	Dogra, R. N.	Punjab.
305	1607	Dogra, N. N.	J. & K.
306	494	Domingo, T. B.	Bihar.
307	210	Doshi, M. M.	Bombay.
308	1546	Dube, S. B.	Madhya Pradesh
309	602	Dubey, B. P.	Bihar.
310	623	Dubey, Jagdish Prasad	Bihar.
311	1883	Dubey, O. P.	J. & K.
312	730	Durairaj, T.	Madras.
313	1412	Durga Prasad	Rajasthan.
314	246	Durrani, N.	Andhra.
315	1393	Dutt, A. C.	West Bengal.
316	1620	Dutta, D. N.	Assam.
317	1140	Dutt, G. N.	Assam.
318	948	Dutt, N. N.	Govt. of India.
319	530	Dutt, Priya Ranjan	West Bengal.
320	688	Dutta, S. C.	Bihar.

Serial No.	Roll No.	Name.	State/Country.
		"E"	
321	801	Eapen, K. E.	Travancore-Cochin.
322	168	Eccleston, W. T. (L.M.)	England.
323	184	Edibam, N. R. (L.M.)	Uttar Pradesh.
324	86	Endlaw, D. N.	Govt. of India.
		"F"	
325	222	Fateh Chand (L. M.)	Uttar Pradesh.
326	1868	Faujdar Thakur	Bihar.
327	594	Fergusson, F. F.	Bombay.
328	231	Fielder, C. J.	West Bengal.
329	1837	Fondekar, P. B.	Delhi.
330	1867	Framoh D. Mehta	Bombay.
331	1864	Frederick, J. M.	Andhra.
		"G"	
332	1480	Gadhoke, S. R.	Rajasthan.
333	829	Gadre, N. B. (L. M.)	Bombay.
334	1543	Gahlowt, R. S.	Uttar Pradesh.
335	1641	Ganapathy, G. S.	Madras.
336	1891	Gandhi, C. H.	Bombay.
337	858	Gandhi, J. H.	Bombay.
338	93	Gandhi, K. J. (L. M.)	Bombay.
339	467	Gandhi, M. M. (L. M.)	Bombay.
340	1457	Gandotra, H. K.	J. & K.
341	179	Gangadhara, K. S.	Mysore.
342	1652	Ganguli, A. C.	West Bengal.
343	1369	Ganguli, D. N.	West Bengal.
344	1503	Ganguli, H. D.	West Bengal.
345	942	Garg, S. K.	Uttar Pradesh.
346	501	Garr, B. L.	Punjab.
347	1923	Gauba, J. C.	Uttar Pradesh.
348	1268	Gauri Nath	Punjab.

Serial No.	Roll No.	Name.	State/Country.
349	1267	Gautam Narayan, Raj-Kumar	West Bengal.
350	63	Ghanekar, Y. K.	Madhya Pradesh.
351	208	Gharpure, A. V.	Bombay.
352	1575	Ghatpande, G. S.	Madhya Bharat.
353	1858	Ghia, R. T.	Saurashtra.
354	1550	Ghosh, M. B.	West Bengal.
355	1030	Ghosh, A. K.	West Bengal.
356	1604	Ghosh, B. N.	West Bengal.
357	1942	Ghosh, D. K.	West Bengal.
358	1462	Ghosh, D. N.	West Bengal.
359	1729	Ghosh, Deba Priya	West Bengal.
360	510	Ghosh, K. P.	M. E. S.
361	1277	Ghosh, Sripada	West Bengal.
362	641	Ghosh, S. B.	Bihar.
363	651	Ghosh, Pasupati	West Bengal.
364	486	Ghosh, Sushil Kumar	Bihar.
365	1286	Ghosh, Taradas	Bihar.
366	808	Ghosh, S. K.	West Bengal.
367	1424	Ghoshal, P. K.	West Bengal.
368	708	Gidwani, M. M.	Bombay.
369	1638	Gill, A. S.	Punjab.
370	1058	Gill, Jagmal Singh	PEPSU.
371	1520	Gill, S. S.	PEPSU.
372	1718	Gnanaprakasam, G. S.	Madras.
373	946	Goel, R. R.	Uttar Pradesh.
374	1091	Goel, Harish Chandra	Govt. of India.
375	1136	Goel, Harbans Lal	PEPSU.
376	1871	Goel, V. S.	C. R. R. I.
377	468	Goghari, N. W.	Bombay.
378	1932	Gogai, S. D.	Assam.
379	1748	Gokal Chand	Madhya Pradesh.

Serial No.	Roll No.	Name.	State/Country.
380	1914	Gokhale, Y. C.	C. R. R. I.
381	1284	Golikere, P. R.	Madras.
382	1625	Gonsalves, G. F. D.	C. R. R. I.
383	1915	Goyal, D. K.	Uttar Pradesh.
384	1187	Goyal, J. P.	Uttar Pradesh.
385	1218	Goyal, S. C.	Uttar Pradesh.
386	1847	Goyal, S. P.	Uttar Pradesh.
387	1192	Goyal, Sohan Lal	Uttar Pradesh.
388	1790	Goyal, V. C.	Uttar Pradesh.
389	47	Gopalacharya, G. (L. M.)	Madras.
390	1044	Gopalan, S.	Hyderabad.
391	1143	Gore, R. R.	Madhya Pradesh.
392	879	Goverdhan Lal	Govt. of India.
393	1686	Govil, C. P.	Govt. of India.
394	1428	Govindarajulu, K.	Andhra.
395	1794	Govindarajulu, P. T.	Madras.
396	1248	Govindarajulu, S. P.	Bombay.
397	1616	Grewal, B. S.	Punjab.
398	1580	Grewal, R. S.	Kashmir.
399	80	Griffiths, W. A.	Bombay.
400	1387	Grover, D. T.	Govt. of India.
401	102	Gue, K. C. (L. M.)	West Bengal.
402	1941	Guha, Asutosh	West Bengal.
403	151	Guha, J. C. (L. M.)	West Bengal.
404	1230	Guha, M. K.	West Bengal.
405	1498	Guha, M. N.	West Bengal.
406	611	Guha, P. R.	Bihar.
407	1810	Guha, R.	West Bengal.
408	1618	Gulabani, B. G.	Punjab.
409	663	Gupchup, N. S.	Bombay.
410	440	Gupta, B. B. (L. M.)	West Bengal.

Serial No.	Roll No.	Name.	State/Country.
411	1707	Gupta, B. N.	Rajasthan.
412	547	Gupta, D. N.	Rajasthan.
413	1624	Gupta, D. N.	J. & K.
414	509	Gupta, Indu Bhushan Das	Bihar.
415	886	Gupta, Govinda	Orissa.
416	1787	Gupta, G. C.	Uttar Pradesh.
417	1028	Gupta, H. K.	Govt. of India.
418	816	Gupta, Hari Dutta	Rajasthan.
419	1643	Gupta, H. R.	Madhya Pradesh.
420	1227	Gupta, Ishwar Chandra	Punjab.
421	1831	Gupta, I. P.	Uttar Pradesh.
422	1239	Gupta, J. P.	Delhi.
423	330	Gupta, Kanchendu	Punjab.
424	597	Gupta, K.	Bihar.
425	1588	Gupta, L. N.	Uttar Pradesh.
426	1051	Gupta, R. L.	Madhya Pradesh.
427	1772	Gupta, R. M.	Bihar.
428	471	Gupta, S.	Bihar.
429	587	Gupta, S. C.	Madhya Bharat.
430	936	Gupta, Sachindra Nath	West Bengal.
431	1233	Gupta, Sudhindra Nath	Govt. of India.
432	1924	Gupte, J. M.	Bombay.
433	1379	Gurbaxani, T. C.	Madhya Pradesh.
434	1242	Gurcharan Singh	Punjab.
435	1695	Gurdip Singh	J. & K.
436	655	Gurjar, N. P.	Bombay.
437	1829	Gurmukh Singh	Rajasthan.
438	1078	Gursahani, R. L.	Govt. of India.
439	1573	Guru Dayal	Uttar Pradesh.
440	652	Guruswamy, S. (L. M.)	Madras.

Serial No.	Roll No.	Name.	State/Country.
		"H"	
441	1252	Hajeley, S. P.	Uttar Pradesh.
442	930	Halder, S. D.	Govt. of India.
443	571	Handa, K. L.	Madhya Bharat.
444	894	Hanly, P. J.	Ireland
445	74	Hardikar, J. C.	Hyderabad.
446	41	Hardit Singh	PEPSU.
447	785	Har Dayal (L. M.)	Govt. of India.
448	1731	Hari Shankar	Madhya Bharat.
449	248	Harris, J. (L. M.)	Uttar Pradesh.
450	38	Haval, Anant Balwant	Bombay.
451	840	Hem Raj	Bhopal.
452	640	Hemnani, M. Rup Chand	Punjab.
453	1935	Hingorani, L. V.	Kutch.
454	1320	Hiremath, S. A.	Madhya Pradesh.
455	1159	Hoda, S. A.	Bihar.
456	104	Hughes, H. (L. M.)	England.
457	1615	Hukam Singh	Punjab.
458	1791	Hussain, S. M.	Bihar.
		"I"	
459	1568	Idiculla, K. I.	Travancore-Cochin.
460	1283	Inamdar, H. M.	Madhya Pradesh.
461	900	Inamadar, S. G.	Madhya Pradesh.
462	563	Inamdar, S. R.	Madhya Pradesh.
463	632	Indramanikar	Orissa.
464	1809	Ittycheria, M. V.	Travancore-Cochin.
465	1057	Iyangar, M. V. Krishnaswamy (L. M.)	Mysore.
466	1129	Iyengar, C. L. N.	Bombay.
467	364	Iyengar, M. A. R.	Mysore.
468	722	Iyengar, N. Narasimham	Govt. of India.

Serial No.	Roll No.	Name.	State/Country.
469	833	Iyengar, R. K. N.	C. R. R. I.
470	1068	Iyer, A. R. Krishna	Travancore-Cochin.
471	292	Iyer, E. V. S.	Orissa.
472	1712	Iyer, M. P. Subramonia	Travancore-Cochin.
473	1041	Iyer, R. Ganapathy	Travancore-Cochin.
474	997	Iyer, T. S. Narayanaswami	Madras.
475	1765	Iyer, A. Rengaswami	Madras.
		"J"	
476	1076	Jabbar, M. A.	Pakistan.
477	1659	Jacob Thomas, A.	Travancore-Cochin.
478	1701	Jacob, T. O.	Madras.
479	1194	Jagdish Bahadur	Uttar Pradesh.
480	1391	Jagdish Kumar	Uttar Pradesh.
481	52	Jagdish Prasad	Uttar Pradesh.
482	287	Jagmohan	Uttar Pradesh.
483	1474	Jagus, P. J.	C. R. R. I.
484	1841	Jain, B. K.	Uttar Pradesh.
485	1536	Jain, C. B.	Govt. of India.
486	1758	Jain, C. S.	Uttar Pradesh.
487	1441	Jain, G. C.	Uttar Pradesh.
488	1425	Jain, K. C.	Govt. of India.
489	1756	Jain, Prem Chand	Himachal Pradesh.
490	1778	Jaiswal, S. N.	Bihar.
491	707	Jali, F. C.	Assam.
492	697	Jambunathan, S.	Madras.
493	670	Janardan Rao, C.	Punjab.
494	1275	Jaswant Singh	Govt. of India.
495	1180	Jategaonkar, V. L.	Bombay.
496	787	Jathal, M. N.	Bombay.
497	1656	Javali, S. C.	Bombay.
498	1563	Jayaraj, A. C.	Madras.

Serial No.	Roll No.	Name.	State/Country.
499	1429	Jayaraman, B.	Madras.
500	271	Jayaswal, U. S. (L. M.)	Bihar.
501	1070	Jaywant, L. K.	Madhya Bharat.
502	1418	Jaya Singh, H.	Madras.
503	1691	Jha, B.	Bihar.
504	1142	Jha, B. D.	Madhya Bharat.
505	1587	Jha, C. N.	Bihar.
506	596	Joglekar, G. D.	Bombay.
507	1450	Joglekar, K. V.	Bombay.
508	1169	Joglekar, M. V.	Bombay.
509	1910	John A. Green	West Bengal.
510	1101	John, K. P.	Travancore-Cochin.
511	761	John Mukand	Govt. of India.
512	1398	Johorey, M. C.	Uttar Pradesh.
513	1036	Jones, Glyn	Pakistan.
514	134	Jones, R. Trever (L. M.)	England.
515	304	Jootla, Baboo Singh	Orissa.
516	1235	Joshi, J. S. (L. M.)	Bombay.
517	1282	Joshi, N. P.	Bombay.
518	122	Joshi, N. S. (L. M.)	Bombay.
519	1724	Joshi, N. V.	Hyderabad.
520	1430	Joshi, R. N.	Bombay.
521	315	Joshi, S. B. (L. M.)	Bombay.
522	31	Jussawalla, J. R. (L. M.)	Hyderabad.
523	1226	Jyoti Prakash	Uttar Pradesh.
		"K"	
524	1408	Kabiraj Lakshmi Narayan	Bihar.
525	1228	Kakar, J. N.	Punjab.
526	1926	Kala, B.	Uttar Pradesh.
527	1670	Kale, L. W.	Bombay.
528	1657	Kale, M. D.	Bombay.

Serial No.	Roll No.	Name.	State/Country.
529	1704	Kale, V. V.	Bombay.
530	1097	Kamath, M. N.	Madras.
531	852	Kandaswamy, V.	Govt. of India.
532	874	Kanga, F. J. (L. M.)	Bombay.
533	107	Kanhere, V. P. (L. M.)	Bombay.
534	1504	Kankanwadi, D. B.	Bombay.
535	1016	Kantawala, K. M.	Bombay.
536	1887	Kanugo, K. S.	Govt. of India.
537	1374	Kanwar Sain (L. M.)	Govt. of India.
538	1577	Kapadia, R. I.	Hyderabad.
539	695	Kapur, C. D.	Govt. of India.
540	1193	Kar, S. M.	Uttar Pradesh.
541	1453	Karandikar, S. K.	Bombay.
542	1493	Karkare, M. P.	Bombay.
543	1102	Karra, J. R.	Hyderabad.
544	1654	Kartha, K. K.	Travancore-Cochin.
545	750	Kartik Pershad	Uttar Pradesh.
546	1115	Kashyap, M. G.	Orissa.
547	1880	Kathuria S. L.	Govt. of India.
548	249	Katrak, M. M.	Hyderabad.
549	1930	Katti, B. S.	Bombay.
550	1874	Kaul, Som Nath	J & K
551	1928	Kaul, Som Nath	J & K
552	1574	Kaushika, K. R.	Bombay.
553	729	Kewal Krishan.	Punjab.
554	297	Khan, Abdul Jabbar	Uttar Pradesh.
555	337	Khan, G. H.	J. & K.
556	306	Khan, M. I.	Pakistan.
557	255	Khan, Mohammed Abdul Kayyum	Hyderabad.
558	345	Khan, M. A. Subhan	Hyderabad.

Serial No.	Roll No.	Name.	State/Country.
559	1015	Khan, Mohammed Azam (L. M.)	Pakistan.
560	446	Khanna, G. C.	Punjab.
561	72	Khanna, Indra Narain	Govt. of India.
562	698	Khanna, N. N.	Govt. of India.
563	1134	Khanna, P. N.	PEPSU.
564	1857	Khanna, T. S.	C. R. R. I.
565	1539	Khathuria, B. L. (L. M.)	Rajasthan.
566	78	Khatri, K. C.	Govt. of India.
567	1403	Khosla, B. R.	M. E. S.
568	591	Khot, N. A. (L. M.)	Madhya Bharat.
569	1561	Khurana, D. N.	Madhya Pradesh.
570	187	Kikkeri, S. A.	Punjab.
571	1182	Kochhar, R. K.	Uttar Pradesh.
572	1439	Koenigsberger, O. H.	England.
573	1270	Kohli, J. S.	M. E. S.
574	979	Kothari, V. C.	Saurashtra.
575	1437	Koya, K. V. Ahmad	Madras.
576	1152	Krishna Moorthy, T.	Andhra.
577	681	Krishnamurti, B.	Andhra.
578	1726	Krishna Murti, M.	Madras.
579	1545	Krishnamurti, P.	Andhra.
580	1448	Krishnan, E.	Madras.
581	605	Krishnan, K. S.	Madras.
582	1298	Krishnan, N.	Govt. of India.
583	1771	Krishnappa, S.	M. E. S.
584	1356	Krishnaswamy, C. R. Mudaliar.	Mysore.
585	448	Krishnaswamy, P. A. (L. M.)	Madras.
586	1330	Kujur, L. K.	Bihar.
587	782	Kumar, G. L.	Madhya Pradesh.
588	1845	Kumar, P. R.	M. E. S.
589	1669	Kumaran, M.	Madras.

Serial No.	Roll No.	Name.	State/Country.
590	947	Kumar, Y. D. (L. M.)	Delhi.
591	845	Kumawat, B. P.	Rajasthan.
592	1936	Kurian, N.	Travancore-Cochin.
593	1048	Kurup, P. K.	Travancore-Cochin.
594	1062	Kuruvile, P. K.	Travancore-Cochin.
595	1529	Kuttalanathan, L.	Madras.
596	18	Kynnersley, T. R. S. (L. M.)	England.
		"L"	
597	778	Laha, Kashi Pati	West Bengal.
598	1566	Laha, S. K.	West Bengal.
599	1696	Laharwal, Gulam Rasool	J. & K.
600	726	Lahiri, M. C.	Government of India.
601	1632	Lahkar, K. D.	Assam.
602	374	Lakadawala, Rustum, M.	Hyderabad.
603	1934	Lakshman Das, A.	Vindhya Pradesh.
604	284	Lakshman Swarup	Uttar Pradesh.
605	932	Lakshmi Chand (L. M.)	Uttar Pradesh.
606	1361	Lakshmi Narayan	Bihar.
607	26	Lakshminarayana Rao, A. (L. M.)	Andhra.
608	1364	Lal, A. K.	Bihar.
609	747	Lal, M. B.	Government of India.
610	1920	Lal, M. M.	Madhya Pradesh.
611	627	Lall, B.	Bihar.
612	1259	Lall, Y. K.	Bihar.
613	1513	Lalvani, M. N.	Government of India.
614	1900	Lamba, T. S.	Punjab.
615	1199	Laroia, D. K.	Uttar Pradesh.
616	1687	Latuckar, S. K.	Bombay.
617	678	Lawrence, M. S.	Madras.

Serial No.	Roll No.	Name.	State/Country.
618	1246	Logavinayagam, K. S.	Madras.
619	1431	Lokagariwar, P. L.	M. E. S.
620	921	Lokanathan, P.	Madras.
		"M"	
621	636	Macha, T. K.	Bombay.
622	1603	Madbhavi, S. M.	Bombay.
623	869	Maddimsetty, R. S.	Andhra.
624	449	Madhav, T. K.	Punjab.
625	646	Madhava, K. B. (L. M.)	Madras.
626	181	Madhava Rao, Ch.	Andhra.
627	148	Mahabir Prasad (L. M.)	Uttar Pradesh.
628	1176	Mahabir Prasad	Uttar Pradesh.
629	1375	Mahadevan, C. R.	Madras.
630	1717	Mahadevan, S. H.	Madras.
631	1380	Mahal, P. S.	Punjab.
632	639	Mahalanobis, P. C. (L. M.)	West Bengal.
633	303	Mahapatara, M.	Orissa.
634	714	Mahboob Ilahi, Kazi	Pakistan.
635	1843	Mahendroo, Y. R.	Punjab.
636	553	Mahida, U. N.	Bombay.
637	1633	Mainthia, D. P.	Kutch.
638	1653	Maitra, M. S.	West Bengal.
639	1650	Majumdar, B. N.	West Bengal.
640	1309	Majumdar, S. N.	West Bengal.
641	952	Makhanwahla, R. B.	Bombay.
642	1870	Malhotra, A. C.	PEPSU.
643	36	Malhotra, B. R. (L. M.)	Government of India.
644	972	Malhotra, C. L.	Madhya Pradesh.
645	974	Malhotra, D. P.	J. & K.
646	1764	Malhotra, Jagmohan	Rajasthan.
647	1678	Malhotra, O. P.	Punjab.

Serial No.	Roll No.	Name.	State/Country.
648	1849	Malhotra, H. C.	Punjab.
649	67	Malik, Teja Singh (L. M.)	Delhi.
650	620	Malik, C. P.	Govt. of India.
651	1901	Malya, M. R.	Madras.
652	1769	Mamtassi, H. H.	Govt. of India.
653	1668	Manchigiah, M. H.	Mysore.
654	1401	Mane, P. M.	Bombay.
655	568	Mane, Y. G. (L. M.)	Madhya Bharat.
656	1601	Manerikar, V. B.	Bombay.
657	423	Mani, M. W. G.	Madras.
658	1551	Mansoor Ali	Bihar.
659	1948	Marya, R. K. S.	PEPSU.
660	1053	Marya, Jugdev Singh	PEPSU.
661	1946	Mascarenhas, W. X.	Bombay.
662	1590	Massarik, P.	West Bengal.
663	1473	Masarwala, V. J.	Bombay.
664	1472	Mastoor, A. R.	Bombay.
665	984	Mathew, K. M.	Travancore-Cochin.
666	1288	Mathrani, H. P.	Govt. of India.
667	1204	Mathur, A. C.	Uttar Pradesh.
668	834	Mathur, B. D.	Rajasthan.
669	992	Mathur, B. G. (L. M.)	Rajasthan.
670	1518	Mathur, B. S.	Punjab.
671	864	Mathur, C. B. L.	Rajasthan.
672	842	Mathur, J. L.	Rajasthan.
673	1853	Mathur, K. B.	Rajasthan.
674	1222	Mathur, K. C.	Uttar Pradesh.
675	331	Mathur, Kishori Lal	Rajasthan.
676	1203	Mathur, G. D.	Uttar Pradesh.
677	828	Mathur, M. M.	Rajasthan.
678	418	Mathur M. S. (L. M.)	Delhi.

Serial No.	Roll No.	Name.	State/Country.
679	759	Mathur, S. B.	Uttar Pradesh.
680	117	Matthew, P. G. (L. M.)	Travancore-Cochin.
681	613	Mawani, K. H.	Saurashtra.
682	1907	Mazamdar, B. C.	C. R. R. I.
683	1802	Mazumdar, K. L.	Assam.
684	54	McKelvie, G. M. (L. M.)	Scotland.
685	671	Meeran, M.	Madras.
686	506	Mehar Singh	Govt. of India
687	1302	Mehndiratta, M. R.	Punjab.
688	277	Mehra, S. R.	C. R. R. I.
689	810	Mehta, D. J.	Bombay.
690	370	Mehta, Des Raj	Bihar.
691	34	Mehta, J. T.	Saurashtra.
692	1392	Mehta, J. V.	Madhya Pradesh.
693	1002	Mehta, M. A.	Bombay.
694	1688	Mehta, M. C.	Bhopal.
695	237	Mehta, N. N.	Govt. of India.
696	1621	Mehta, Y. K.	Bombay.
697	1734	Melkote, R. S.	Hyderabad.
698	1830	Menon, A. A.	Madhya Pradesh.
699	1146	Menon, M. D.	Govt. of India.
700	988	Menon, T. Balakrishna	Travancore-Cochin.
701	1716	Menon, T. M.	Bombay.
702	1464	Mewada, M. N.	Bombay.
703	1813	Mirchandani, H. P.	Madhya Pradesh.
704	1636	Mirchandani, I. E.	Punjab.
705	705	Mirchandani, N. D. (L. M.)	Govt. of India.
706	444	Mirza, Fahim Beg	Bhopal.
707	302	Mirza, M. A.	Uttar Pradesh,
708	1111	Mirza, R. E.	Pakistan.
709	1762	Mishra, D. N.	Bihar.

Serial No.	Roll No.	Name.	State/Country.
710	1272	Mishra, U. N.	Orissa.
711	728	Misra, B.	Orissa.
712	1278	Misra, B.	Orissa.
713	434	Misra, Chandi Prasad (L. M.)	Bihar.
714	1306	Misra, D. S.	Orissa.
715	999	Misra, K. N.	Uttar Pradesh.
716	837	Misra, Lakshmi Pati (L. M.)	West Bengal.
717	1217	Misra, P. N.	Uttar Pradesh.
718	901	Mistry, C. Mani Lal	Bombay.
719	1409	Mital, G. L.	Uttar Pradesh.
720	1714	Mital, K. C.	Rajasthan.
721	1811	Mitra, A. P.	West Bengal.
722	1925	Mitra, J. N.	Vindhya Pradesh.
723	1943	Mitra, Jagannath	West Bengal.
724	1310	Mitra, N. B.	Govt. of India.
725	1459	Mitra, S. K.	West Bengal.
726	316	Mitra, T.	West Bengal.
727	1158	Mital, O. P.	Uttar Pradesh.
728	915	Mittal, Om Prakash	Govt. of India.
729	10	Modak, N. V. (L. M.)	Bombay.
730	1482	Modi, I. K.	Bombay.
731	520	Mody, M. T.	Bombay.
732	580	Moghe, L. V.	Madhya Bharat.
733	1131	Mohammad	Bihar.
734	1548	Mohd. Abdul Khadir	Hyderabad.
735	256	Mohammed Asadullah	Hyderabad.
736	403	Mohammed Farhatullah	Hyderabad.
737	259	Mohammed Ibrahim	Hyderabad.
738	394	Mohammed Ibrahim (L. M.)	Hyderabad.
739	673	Mohammed Share Ali	Madras.
740	326	Mohammed Usman	Hyderabad.

Serial No.	Roll No.	Name.	State/Country.
741	625	Mohanty, A. B.	Orissa.
742	696	Mohile, N. H.	Madras.
743	1009	Mohindra, O. P.	Govt. of India.
744	739	Mohindra, S. K.	Punjab.
745	891	Mohury, B. D.	West Bengal.
746	1933	Majumder, D.	West Bengal.
747	1237	Momin, G. C.	Tripura.
748	983	Mone, V. T.	Bombay.
749	1737	Morarji, N. G.	Bombay.
750	177	Morgan, I. (L. M.)	West Bengal.
751	1709	Moorthi, S. L. N.	Madras.
752	664	Mudaliar, T. S. K.	Madras.
753	693	Mudaliar, K. M. Rajaratnam	Madras.
754	1702	Mukerjee, A.	West Bengal.
755	46	Mukerjee, A. C.	Uttar Pradesh.
756	1410	Mukherjee, Asim	U. S. A.
757	1917	Mukherjee, A. M.	West Bengal.
758	608	Mukherjee, P. R.	West Bengal.
759	1722	Mumtaz Ali, S.	Orissa.
760	139	Murari Lal	Punjab.
761	755	Murty, N. G. K.	Bombay.
762	762	Muthukumara Swamy, A.	Madras.
		"N"	
763	1012	Nadgauda, P. M.	Bombay.
764	23	Nadirshah, E. A.	Bombay.
765	1377	Nadkarni, D. S.	Bombay.
766	1100	Naegamvala, J. P.	Bombay.
767	1014	Naga Bushanam, P. R.	Madras.
768	1796	Nagarajan, R.	Govt. of India.
769	1697	Nagarajan, S.	Madras.
770	488	Nagarkar, D. B.	West Bengal.

Serial No.	Roll No.	Name.	State/Country.
771	1609	Nagarkar, G. P.	Bombay.
772	950	Nagarsheth, M. P.	Govt. of India.
773	1594	Naidu, A. N. Damodaram	Madras.
774	820	Naidu, P. Ethirajulu	Andhra.
775	654	Naidu, S. R.	Madras.
776	581	Naik, B. G.	Madhya Bharat.
777	949	Naik, Ishwar Lal Kasanji	Bombay.
778	1420	Naik, K. Sundar	Madras.
779	1037	Nair, K. R. Madhavan	Travancore-Cochin.
780	1814	Nalawade, A. T.	Madhya Bharat.
781	1732	Namasivayam, K.	Madras.
782	268	Nambiar, K. K.	Madras.
783	1792	Nambiar, P. G.	Madras.
784	1296	Nanawatty, B. K.	Bombay.
785	1826	Nand, A. P.	Orissa.
786	60	Nanda, B. D. (L. M.)	J. & K.
787	661	Nanda, G.	Orissa.
788	1640	Nanda, Gopal, G.	Madras.
789	1445	Nanda, J. B.	J. & K.
790	1699	Nanda, K. L.	Punjab.
791	883	Nanda, M. L.	Govt. of India.
792	1151	Nandi, S. C.	Bihar.
793	338	Nangea, G. R.	Himachal Pradesh.
794	29	Narasimham, J. S.	Hyderabad.
795	1760	Narasimhan, M. T.	Madras.
796	1460	Narasimha Rao, K.	Andhra.
797	1274	Narasimhamurthi, B. S.	Govt. of India.
798	916	Narasu, P. Lakshmi	Andhra.
799	1744	Narayana, M. L.	Andhra.
800	1355	Narayanaswamy, S.	Mysore.
801	657	Narayanan, P.	Andhra.

Serial No.	Roll No.	Name.	State/Country.
802	1552	Narboo, S.	J. & K.
803	1479	Narke, S. P.	Bombay.
804	1645	Natarajan, M.	Madras.
805	679	Natesan, L. N.	Madras.
806	1711	Natu, M. R.	Madras.
807	1723	Natu, S. V.	Bombay.
808	1878	Navaney, M. K.	Govt. of India.
809	183	Nawab, Ahsan Yar Jung Bahadur (L. M.)	Pakistan.
810	660	Nayak, S. C.	Madras.
811	154	Nayar, D. P.	Punjab.
812	1517	Nayar, K. Krishnan	Madras.
813	1024	Nayar, K. Madhavan	Travancore-Cochin.
814	1211	Nayaz Ahmed	Bhopal.
815	683	Nayudu, Dharma Rao, N.	Andhra.
816	427	Nayyar, Sohan Lal	Punjab.
817	1753	Nayar, K. Madhavan	Travancore-Cochin.
818	1183	Nazareth, C. V.	Delhi.
819	390	Nehra, V.	M. E. S.
820	1565	Nerukar, M. S.	Bombay.
821	342	Nicolaides, E. P.	Bombay.
822	1433	Nigam, S. P.	Uttar Pradesh.
823	1630	Niranjan Paul	West Bengal.
824	550	Nivas, H. K.	Bihar.
		"O"	
825	1690	Ojha, B.	Bihar.
826	1245	Ormerod, H. E. (L. M.)	England.
827	795	Otia, J. C.	Bombay.
828	790	Oza, M. G.	Govt. of India.
829	767	Oza, N. M.	Bombay.

Serial No.	Roll No.	Name.	State/Country.
		"P"	
830	1838	Padam, Harbans Singh	Punjab.
831	1759	Padhi, A. C.	Govt. of India.
832	690	Padhi, R. N.	Orissa.
833	564	Padhi, Sita Ram	Orissa.
834	1125	Padamanabhan, C. V.	Madras.
835	1698	Padamanabhan, P. S.	Orissa.
836	1082	Padamanabham, Y.	Andhra.
837	1869	Padwal, M. J.	Bombay.
838	1512	Pagay, R. M. (L. M.)	Uttar Pradesh.
839	959	Pai, M. V.	Bombay.
840	945	Pal, S. C.	Assam.
841	912	Panchanathan, S.	Madras.
842	333	Pancholy, H. M.	Bombay.
843	1897	Panda, D. C.	Orissa.
844	1442	Pandya, K. C.	Bombay.
845	1224	Panjwani, S. N.	Uttar Pradesh.
846	1761	Pant, G. C.	Uttar Pradesh.
847	417	Parang, Hari Ram (L. M.)	Pakistan.
848	513	Parija, K. C.	Orissa.
849	128	Parikh, H. B. (L. M.)	Bombay.
850	1519	Parikh, R. M.	Bombay.
851	1840	Parikh, V. N.	Bombay.
852	264	Parmara, D. S.	Uttar Pradesh.
853	1532	Parmanand T. Sehra	Govt. of India.
854	1631	Parmar, P. K.	Saurashtra.
855	743	Partap Singh	Uttar Pradesh.
856	1721	Parthasarathy, C. S.	Govt. of India.
857	859	Patel, A. T.	Uttar Pradesh.
858	188	Patel, B. D. (L. M.)	Bombay.
859	890	Patel, B. P.	Govt. of India.

Serial No.	Roll No.	Name.	State/Country.
860	717	Patel, C. B.	Govt. of India.
861	1685	Patel, C. M.	Bombay.
862	968	Patel, D. C.	Bombay.
863	967	Patel, J. C.	Bombay.
864	1415	Patel, M. D.	Bombay.
865	735	Patel, M. M.	Govt. of India.
866	1206	Patel, M. M.	Bombay.
867	1492	Patel, Manibhai, M.	Bombay.
868	44	Patel, M. R. (L. M.)	Bombay.
869	653	Patel, N.B.	Bombay.
870	1313	Patel, N. C.	Saurashtra.
871	1011	Patel, N. K.	Bombay.
872	1491	Patel, O. H.	Bombay.
873	793	Patel, Y. G.	Bombay.
874	1949	Pathak, K. C.	Assam.
875	577	Patil, B. D.	Madhya Bharat.
876	359	Patil, G. K.	Bombay.
877	584	Patil, Y. K.	Madhya Bharat.
878	1528	Patkar, B.B. (L. M.)	Bombay.
879	1805	Patnaik, G.	Orissa.
880	1793	Patnaik, P. R. M.	Orissa.
881	1606	Patro, R. C.	Orissa.
882	672	Patrulu, P. S.	Andhra.
883	1822	Pattanayak, B. B.	Orissa.
884	648	Perry, R. G.	West Bengal.
885	477	Pershad, B.	Bihar.
886	339	Pessumal, N. Dhamani (L. M.)	Delhi.
887	392	Phadke, P. G.	Madhya Bharat.
888	1596	Phansalkar, R. L.	Bombay.
889	1021	Philipose E. U.	Travancore-Cochin.
890	1658	Pillai, A. Sivarama	Travancore-Cochin.

Serial No.	Roll No.	Name.	State/Country.
891	1581	Pillai, V. Govindaswami	Madras.
892	1061	Pillai, K. Gopala	Travancore-Cochin.
893	1780	Pimpal, J. S.	Bombay.
894	885	Poonen, P. C.	Govt. of India.
895	813	Prabhala, R.	Andhra.
896	1766	Prabhu, M. K.	Madras.
897	1384	Prakash, Anand	Uttar Pradesh.
898	733	Prasad, B.	Bihar.
899	1863	Prasad, Bhawanath	Bihar.
900	1200	Prasad, D. N.	Bihar.
901	1635	Prasad, G.	Bihar.
902	1124	Prasad, G. S.	Bihar.
903	1679	Prasad, K.	Uttar Pradesh.
904	1360	Prasad, Krishto	Bihar.
905	1642	Prasad, M.	Bihar.
906	1250	Prasad, Nandkishore	Bihar.
907	1343	Prasad, Nilkanth	Bihar.
908	898	Prasad, Ram Swarup	M. E. S.
909	436	Prasad, Rashdhari	Bihar.
910	1368	Prasad, Sarju	Bihar.
911	1889	Prasad, Satish	Delhi.
912	1626	Prasad, Sheo Nandan	Bihar.
913	1185	Pratap, B.	Govt. of India.
914	907	Prem Chand	Uttar Pradesh.
915	1416	Prem Manohar	Uttar Pradesh.
916	1157	Prem Mohan	Uttar Pradesh.
917	1537	Prem Sagar, T.	Madras.
918	1776	Prinja, K. C.	Delhi.
919	402	Pujari, Achyutanand	Orissa.
920	1126	Punniah, P. B.	Andhra.
921	482	Puranik, R. G.	Bombay.

Serial No.	Roll No.	Name.	State/Country.
922	310	Puri, B. S.	Delhi.
923	1108	Puri, P. R.	Govt. of India.
		"Q"	
924	1906	Qazi Gulam Rasool	J. & K.
925	1672	Qazi Mohd. Afzal	J. & K.
926	384	Qureshi, A. H.	Pakistan.
927	882	Qureshi, A. H.	Pakistan.
928	884	Qureshi, A. R.	Pakistan.
		"R"	
929	1511	Radhey Shiam	M. E. S.
930	1107	Rafi Ahmed, S. M.	Pakistan.
931	87	Raghavachary, K. S. (L. M.)	Madras.
932	849	Raghavan, N. C. S.	Orissa.
933	1008	Raghavan, P.	Bombay.
934	771	Raghaviah, M.	Andhra.
935	1677	Raghbir Singh, S. (L. M.)	PEPSU.
936	1172	Raheja, M. L.	M. E. S.
937	628	Raj, P. V.	Andhra.
938	965	Rajagopalan, K. G.	Govt. of India.
939	1486	Rajagopalan, K.	Travancore-Cochin.
940	724	Rajagopalan, S. K.	Govt. of India.
941	190	Rajam, M. K. (L. M.)	Mysore.
942	1824	Rajanna, B. V.	Andhra.
943	1750	Rajaram, T. N.	Madras.
944	756	Rajaraman, S.	Travancore-Cochin.
945	1757	Rajendran, S.	Madras.
946	868	Raju, D. Narayana	Andhra.
947	162	Raju, P. V.	Madras.
948	746	Raju, R. L.	Mysore.
949	751	Raju, S. P. (L. M.)	Hyderabad.

Serial No.	Roll No.	Name.	State/Country.
950	1944	Raju, V.	Bombay.
951	1803	Rajwade, M. V.	Madhya Pradesh.
952	1121	Ram Bilas.	Punjab.
953	1534	Rama Brahmam, M.	Kutch.
954	1846	Ram Krishna	Uttar Pradesh.
955	1249	Rama Rao, N.	Govt. of India.
956	496	Rama Rao, T. (L. M.)	Mysore.
957	1268	Rama Rao, V.	Orissa.
958	230	Ramamurty, K.	Andhra.
959	1916	Ramanna, K.	Madras.
960	407	Ramaswamy, K.	Hyderabad.
961	752	Ramaswamy, N. S.	Govt. of India.
962	1269	Ramaswamy, S.	Mysore.
963	421	Ramchandani, N. R.	Assam.
964	1754	Ramachandran, N.	Madras.
965	1470	Ramiah, V.	Mysore.
966	1533	Ranade, J. Y.	Bombay.
967	1767	Rana, N. I.	Saurashtra.
968	438	Rangarajan, P.	Madras.
969	152	Rangaswami, M. A.	Bihar.
970	1605	Rangaswami, R. S.	Madras.
971	669	Rangaswami, T. V.	Madras.
972	82	Rangaswami, V. N.	Madras.
973	108	Rangaswami, V. S. (L. M.)	Madras.
974	1673	Rao, K. Amritha	Madras.
975	1221	Rao, A. Lakshmikant	Govt. of India.
976	1327	Rao, A. Rajeswara	Orissa.
977	1610	Rao, A. R. Satyanarayana	Andhra.
978	1013	Rao, B. K. V.	Andhra.
979	589	Rao, B. M.	Kutch.
980	1639	Rao, D. V.	Hyderabad.

Serial No.	Roll No.	Name.	State/Country.
981	1848	Rao, D. V.	Madhya Pradesh.
982	1768	Rao, G. Chalapati	Andhra.
983	389	Rao, H. Sunder (L. M.)	Govt. of India.
984	1799	Rao, G. Papa	Orissa.
985	1564	Rao, K. Bapa	Andhra.
986	800	Rao, K. Gopinatha	Rajasthan.
987	1763	Rao, K. R. Nagaraja	Vindhya Pradesh.
988	1554	Rao, K. Narayana	Andhra.
989	1788	Rao, K. S. Narayana	Madras.
990	1894	Rao, U. H. Parameshwar	Madras.
991	1265	Rao, K. Ramamohan	Andhra.
992	1913	Rao, N. Mohan	C. R. R. I.
993	1801	Rao, G. S.	Govt. of India.
994	1713	Rao, K. Krishna Mohan	Andhra.
995	1881	Rao, K. Sreenivasa	Madras.
996	649	Rao, K. Subba	Kutch.
997	1465	Rao, K. Subba	Mysore.
998	1890	Rao, K. Subba	Andhra.
999	1540	Rao, K. V.	M. E. S.
1000	1945	Rao, K. Venkateswara	Andhra.
1001	835	Rao, M. A.	Madhya Pradesh.
1002	1647	Rao, M. Subba	Andhra.
1003	1077	Rao, M. Seshumadhava	Andhra.
1004	103	Rao, N. Subba (L. M.)	Mysore
1005	1683	Rao, M. S. Venkoba	Govt. of India.
1006	1095	Rao, P. V. S. Prasada	Andhra.
1007	933	Rao, N. Venkata	Govt. of India.
1008	1745	Rao, P. Rama	Madras.
1009	757	Rao, R. Rama Mohan	Andhra.
1010	873	Rao, R. R. Thimmaji	Andhra.
1011	1562	Rao, S. Subba	West Bengal.

Serial No.	Roll No.	Name.	State/Country.
1012	1405	Rao, S. Subba	Govt. of India.
1013	1526	Rao, T. Satchidananda	Andhra.
1014	1444	Rao, U. B. Sreepada	Madras.
1015	643	Rastogi, D. P.	Rajasthan.
1016	451	Rath Nilkanth	Orissa.
1017	498	Rathod, M. P.	Bombay.
1018	973	Rathod, N. G.	Saurashtra.
1019	73	Ratnagar, R. D. (L. M.)	West Bengal.
1020	909	Ray, K. B. (L. M.)	West Bengal.
1021	944	Ray, K. C.	West Bengal.
1022	987	Ray, K. C.	Madhya Pradesh.
1023	1876	Ray, Mrigendranath	Assam.
1024	1544	Ray, S. N.	West Bengal.
1025	1419	Reddy, B. V.	Andhra.
1026	876	Reddy, C. Krishna	Andhra.
1027	1555	Reddy, C. N.	Hyderabad.
1028	1738	Reddy, K. Pattabhi Rama	Madras.
1029	347	Reddy, K. Ramaswamy	Madras.
1030	1052	Reddy, L. C. Muniswami	Mysore
1031	1937	Reddy, P. T.	Hyderabad.
1032	1112	Reddy, P. R. G.	Andhra.
1033	1908	Reddy, S. K. Hanumantha	Mysore.
1034	1113	Reddy, T. A. Ramanatha	Madras.
1035	163	Rege, D. Y.	Bombay.
1036	559	Rijhwani, J. M.	Govt. of India.
1037	1706	Rohatgi, N. N.	Bihar.
1038	156	Romesh Chandra	Uttar Pradesh.
1039	1299	Roy, B. N.	Bihar.
1640	112	Roy, G. P. (L. M.)	Orissa.
1041	1447	Roy, J. K. (L. M.)	West Bengal.
1042	1271	Roy, K. P.	West Bengal.

Serial No.	Roll No.	Name.	State/Country.
1043	1911	Roy, P. C.	West Bengal.
1044	1266	Roy, P. K.	Bihar.
1045	766	Roy, R. C.	West Bengal.
1046	435	Roy, T. K.	Pakistan.
1047	1743	Row, A. M. V. Prasada	Madras.
1048	1689	Ruthnaswamy, V. V.	M. E. S.
1049	1899	Rynjah, U. N.	Assam.
		"S"	
1050	1904	Sachdev, Avtar Singh	PEPSU.
1051	365	Saberi Yousaf, M. L.	Hyderabad.
1052	1836	Sabherwal, M. L.	Rajasthan.
1053	1912	Sabhlok, Om Parkash	PEPSU.
1054	1280	Sadarangani, T.	Govt. of India.
1055	969	Sadasivaswami, P. S.	Madras.
1056	1417	Saha, N.	West Bengal.
1057	1099	Saha, R. K.	Govt. of India.
1058	335	Saha, S. L.	Govt. of India.
1059	536	Sahu, B. N.	Orissa.
1060	1855	Sahay, B. N.	Bihar.
1061	1708	Sahay, S. N.	Bihar.
1062	1321	Sahay, T. K.	Bihar.
1063	1789	Sahgal, D. K.	Punjab.
1064	1255	Sahni, K. S.	Uttar Pradesh.
1065	439	Saigal, Balbir Singh	Govt. of India.
1066	1163	Sajjan Basettappa	Govt. of India.
1067	120	Saksena, C. P.	Vindhya Pradesh.
1068	1919	Salvi, K. G.	C. R. R. I.
1069	1232	Samad, M. A.	Andhra.
1070	1553	Samaddar, S. K.	West Bengal.
1071	1816	Samajdar, S.	West Bengal.

Serial No.	Roll No.	Name.	State/Country.
891	1581	Pillai, V. Govindaswami	Madras.
892	1061	Pillai, K. Gopala	Travancore-Cochin.
893	1780	Pimpal, J. S.	Bombay.
894	885	Poonen, P. C.	Govt. of India.
895	813	Prabhala, R.	Andhra.
896	1766	Prabhu, M. K.	Madras.
897	1384	Prakash, Anand	Uttar Pradesh.
898	733	Prasad, B.	Bihar.
899	1863	Prasad, Bhawanath	Bihar.
900	1200	Prasad, D. N.	Bihar.
901	1635	Prasad, G.	Bihar.
902	1124	Prasad, G. S.	Bihar.
903	1679	Prasad, K.	Uttar Pradesh.
904	1360	Prasad, Krishto	Bihar.
905	1642	Prasad, M.	Bihar.
906	1250	Prasad, Nandkishore	Bihar.
907	1343	Prasad, Nilkanth	Bihar.
908	898	Prasad, Ram Swarup	M. E. S.
909	436	Prasad, Rashdhari	Bihar.
910	1368	Prasad, Sarju	Bihar.
911	1889	Prasad, Satish	Delhi.
912	1626	Prasad, Sheo Nandan	Bihar.
913	1185	Pratap, B.	Govt. of India.
914	907	Prem Chand	Uttar Pradesh.
915	1416	Prem Manohar	Uttar Pradesh.
916	1157	Prem Mohan	Uttar Pradesh.
917	1537	Prem Sagar, T.	Madras.
918	1776	Prinja, K. C.	Delhi.
919	402	Pujari, Achyutanand	Orissa.
920	1126	Punniah, P. B.	Andhra.
921	482	Puranik, R. G.	Bombay.

Serial No.	Roll No.	Name.	State/Country.
1102	1775	Selvam, T. T.	Madras.
1103	307	Sen, A. K.	Tripura.
1104	1735	Sen, A. K.	West Bengal.
1105	727	Sen, B. R.	West Bengal.
1106	1032	Sen, D. M.	West Bengal.
1107	1727	Sen, Deba Prasad	West Bengal.
1108	1010	Sen Gupta, K. C.	West Bengal.
1109	1804	Senapathy, G. N.	Orissa.
1110	1515	Sen, N.	Govt. of India.
1111	863	Sen Gupta P. N.	West Bengal.
1112	1500	Sen, R. B.	West Bengal.
1113	1331	Sen, S. K.	Bihar.
1114	1557	Seshappa, A.	Mysore.
1115	472	Seshagiri Rao, N.	Andhra.
1116	1896	Seshavataram, C.	Andhra.
1117	1781	Sheth, B. P.	Saurashtra.
1118	1570	Sethana, H. K.	West Bengal
1119	1090	Sethi, G. R.	Govt. of India.
1120	1329	Sethi, V. P.	Madhya Pradesh.
1121	1684	Shah, B. G.	Bombay.
1122	551	Shah, M. J.	PEPSU.
1123	1752	Shah, K. G.	Rajasthan.
1124	1506	Shah, S. G.	Bombay.
1125	1585	Shah, S. R.	J. & K.
1126	35	Shah, V. J.	Bombay.
1127	1785	Shah, Z. S.	Madras.
1128	175	Shahani, C. M.	West Bengal.
1129	1507	Shalikh, A. A. K.	Pakistan.
1130	1850	Shankar, V. V. R.	Andhra.
1131	83	Shannon, I. A. T.	Bombay.
1132	1059	Sharangpani, P. S. (L. M.)	Bombay.

Serial No.	Roll No.	Name.	State/Country.
1133	96	Shareef, S. A.	Ceylon.
1134	504	Sharma, D. C.	Punjab.
1135	1950	Sharma, Hansraj	J & K.
1136	115	Sharma, Hari Shankar	Uttar Pradesh.
1137	1118	Sharma, K. N.	Rajasthan.
1138	870	Sharma, M. R.	Punjab.
1139	516	Sharma, Purnanand	Bihar.
1140	1452	Sharma, P.	Assam.
1141	1467	Sharma, S. A.	Madhya Pradesh.
1142	164	Sharma, S. S.	Uttar Pradesh.
1143	1084	Shastri, M. Balagangadhara	Andhra.
1144	1091	Shaukat Rai	Delhi.
1145	720	Shaw, M. (L. M.)	Govt. of India.
1146	1821	Sheikh, Abdul Salam	J. & K.
1147	39	Shenoy, B. N.	Madras.
1148	786	Sheo Dip Narayan	Bihar.
1149	489	Sheth, K. L.	Bombay.
1150	1807	Shevade, S. V.	Rajasthan.
1151	382	Shinde, P. K. (L. M.)	Bombay.
1152	1595	Shinde, Y. A. (L. M.)	Bombay.
1153	388	Shiva Raj, A.	Hyderabad.
1154	1148	Shivdasani, P. D.	Bombay.
1155	490	Shobha Ram	Uttar Pradesh.
1156	953	Shri Krishna	Vindhya Pradesh.
1157	152	Shukla, C. N.	Uttar Pradesh.
1158	792	Shukla, G. D.	Bombay.
1159	1819	Shukla, M. L.	Uttar Pradesh.
1160	1560	Siddabasaviah, K. V.	Mysore.
1161	1860	Sidhwa, T. M.	Uttar Pradesh.
1162	1700	Sikka, D. R.	Madhya Bharat.
1163	1287	Sil, Krishna Shankar	West Bengal.

Serial No.	Roll No.	Name.	State/Country.
1164	1352	Singh, J. N.	Bihar.
1165	1449	Singh, J. P.	PEPSU.
1166	1135	Singh, R. C.	Punjab.
1167	1351	Singh, R. P.	Bihar.
1168	1372	Singh, S. M. P.	Bihar.
1169	1614	Singhal, Mangat Rai	Bombay.
1170	340	Sinha, B.	Bihar.
1171	971	Sinha, B. P.	Bihar.
1172	734	Sinha, B. P.	Bihar.
1173	191	Sinha, H. P.	Govt. of India.
1174	1774	Sinha, H. P.	Bihar.
1175	960	Sinha, K.	Uttar Pradesh.
1176	1342	Sinha, L. U. C.	Bihar.
1177	425	Sinha, M. K. P.	Bihar.
1178	1257	Sinha, N. K.	Bihar.
1179	1291	Sinha, Nilkanth	Bihar.
1180	706	Sinha, P. P.	Bihar.
1181	1273	Sinha, P. S.	Uttar Pradesh.
1182	1319	Sinha, R. P.	Bihar.
1183	754	Sinha, S. K.	Bihar.
1184	1260	Sinha, Shyam Lal	Bihar.
1185	871	Sinha, S. N.	Bihar.
1186	1103	Sinha, Shyam Narain	Bihar.
1187	1127	Sinha, S. N.	Orissa.
1188	1902	Sinha, S. P.	Bihar.
1189	219	Sirajuddin, P.	Madras.
1190	856	Sircar, S. K.	Bihar.
1191	680	Sivaprakasam, P. S.	Madras.
1192	626	Sivasankaran, O.	Madras.
1193	715	Sivasubramanian, M. K.	Govt. of India.
1194	692	Sivaswamy, A. R.	Govt. of India.

Serial No.	Roll No.	Name.	State/Country.
1195	20	Smith, H. C. (L. M.)	Bombay.
1196	283	Sohan Lal	Bihar.
1197	1488	Sompura, G. B.	Saurashtra.
1198	12	Sowani, D. G. (L. M.)	Bombay.
1199	1584	Spencer, S. S.	Bombay.
1200	682	Sreekaniah, C. K.	Madras.
1201	240	Srinivasan, K.	Madras.
1202	1098	Srinivasam, K. S.	Madras.
1203	1423	Srivastava, A. K.	Uttar Pradesh.
1204	1918	Srivastava, C. P.	Vindhya Pradesh.
1205	1354	Srivastava, G. N.	Bihar.
1206	1205	Srinivasan, T. K.	Madhya Pradesh.
1207	618	Srirangachary, G.	Andhra.
1208	45	Srivastava, Madho Prasad	Uttar Pradesh.
1209	958	Srivastava, P. N.	Uttar Pradesh.
1210	514	Srouty, M. S.	Madras.
1211	1210	Subbiah, C. P.	Govt. of India.
1212	1681	Subbiah, G.	Madras.
1213	1795	Subbaya, K. B.	Madras.
1214	1311	Subbaraju, Bh.	Madras.
1215	723	Subrahmanyam, J.	Govt. of India.
1216	866	Subrahmanyam, P. L.	Andhra.
1217	1312	Subramaniam, P. S.	Madras.
1218	1451	Subramaniam, S. K.	Madras.
1219	1674	Subramaniam, V.	Madras.
1220	1105	Sud, A. N.	Punjab.
1221	1231	Sudhamoy Pal	West Bengal.
1222	65	Sujan, S. B.	Uttar Pradesh.
1223	1432	Sujan Singh	Delhi.
1224	1171	Sukhrani, R. R.	Govt. of India.
1225	1940	Sumair Chand	Uttar Pradesh.

Serial No.	Roll No.	Name.	State/Country.
1226	1406	Sundaram, Shunmuga R.	Madras.
1227	791	Sundaram, S.	Madras.
1228	141	Sundaresan, T. V.	Madras.
1229	1385	Sur, A. K.	Uttar Pradesh.
1230	926	Sur, S. K.	West Bengal.
1231	25	Surati, H. M.	Hyderabad.
1232	637	Surya, N. S. (L. M.)	Govt. of India.
1233	1345	Swaminathan, C. G.	C. R. R. I.
1234	1440	Swaminathan, S. S.	Madhya Pradesh.
1235	1671	Syed Abdul Latheef	Madras.
1236	1499	Syed, A. B. Inamul Hoque	Assam.
		"T"	
1237	1728	Talapatra, S. K.	West Bengal.
1238	825	Talat Baig	Madras.
1239	1886	Talukdar, B. H.	Assam.
1240	1434	Tamizuddin, A. G.	Madras.
1241	1400	Tandon, G. S.	Punjab.
1242	1168	Tandon, S. N.	M. E. S.
1243	794	Tank, D. M.	Bombay.
1244	1150	Taraporevala, J. A.	Bombay.
1245	1323	Tawadey, V. B.	M. E. S.
1246	1516	Tayal, K. C.	Uttar Pradesh.
1247	1501	Taylor, Norman Henry	Bombay.
1248	1898	Teckchandani, D. H.	Sikkim.
1249	630	Thadaney, K. V.	Madras.
1250	1586	Thaker, H. J.	Madhya Pradesh.
1251	1096	Thapliyal, K. N.	Uttar Pradesh.
1252	1572	Thillainayagam, R.	Madras.
1253	1730	Thirunavukarasu, M. A.	Madras.
1254	1386	Thusu, A. N.	J. & K.
1255	130	Todd, J. M.	Scotland.

Serial No.	Roll No.	Name.	State/Country.
1256	1666	Toki, G. S.	Punjab.
1257	1903	Toshakhani, S. N.	J. & K.
1258	918	Trehan, J. M. (L. M.)	Govt. of India.
1259	1190	Tripathy, J.	Orissa.
1260	1921	Tripathy, S. N.	Madhya Pradesh.
1261	1705	Tufani Rai	Bihar.
1262	1770	Turkhia, M. C.	Arabia.
		"U"	
1263	961	Udham Singh	Himachal Pradesh.
1264	1166	Uma Kant.	Uttar Pradesh.
1265	847	Uppal, H. L.	C. R. R. I.
1266	1612	Uppal, M. G.	PEPSU.
1267	1475	Unwalla, B. T.	Bombay.
1268	1089	Uttam Singh (L. M.)	Uttar Pradesh.
		"V"	
1269	84	Vagh, B. V. (L. M.)	Bombay.
1270	416	Vahidy, Zahir Ahmed.	Pakistan.
1271	1733	Vaida, G. H.	J. & K.
1272	574	Vaidya, Anant Ganesh	Madhya Bharat.
1273	351	Vaidya, G. D.	Ceylon.
1274	738	Vaish, Vidya Ram	Govt. of India.
1275	176	Vakil, N. H.	Bihar.
1276	1862	Varghese, P. C.	West Bengal.
1277	631	Varma, D. C.	Madhya Pradesh.
1278	1300	Varma, D. N.	Bihar.
1279	1373	Varma, D. N.	Bihar.
1280	1832	Varma, Des Raj	Punjab.
1281	505	Varma, Hari Gopal	Uttar Pradesh.
1282	881	Varma, J. N.	Bihar.
1283	635	Varman, K. R.	Govt. of India.

Serial No.	Roll No.	Name.	State/Country.
1284	491	Varma, P. L.	Punjab.
1285	362	Vartak, G. R.	Bombay.
1286	400	Vasay, K. M.	Hyderabad.
1287	466	Vaze, D. L.	Bombay.
1288	1820	Vedagiri, T. S.	Govt. of India.
1289	1178	Veeraraghavan, T. M.	Madras.
1290	1835	Veerappan. N.	Madras.
1291	1523	Venkatachalam, B.	Andhra.
1292	1147	Venkataraman, P.	Madras.
1293	772	Venkataramanan, T. S.	Madras.
1294	1879	Venkatesulu, G.	Govt. of India.
1295	1173	Venugopal, C.	Madras.
1296	1827	Verma, R. P.	Bihar.
1297	1784	Verma, Umeshwar Prasad	Bihar.
1298	126	Vesugar, J. B. (L. M.)	U. S. A.
1299	1600	Vibhakar, P. K.	Saurashtra.
1300	1833	Vichare, S. G.	Saurashtra.
1301	1576	Vidyarthi, S. D.	Uttar Pradesh.
1302	1622	Vijh, G. C.	Punjab.
1303	1866	Virginkar, M. V.	Bombay.
1304	1808	Vishrampuri	Rajasthan.
1305	1471	Vora, P. K.	Kutch.
1306	1954	Vyas, I. D.	Bombay.
1307	1305	Vyavaharkar, D. A.	Bombay.
		"W"	
1308	1085	Wadhwani, G. B.	Uttar Pradesh.
1309	235	Wale, N. D.	Bombay.
1310	75	Walker, W. F. (L. M.)	Scotland.
1311	1583	Wanchoo, P. N.	J. & K.
1312	822	Williams, L. C.	Ceylon.

Serial No.	Roll No.	Name.	State/Country.
		"Y"	
1313	1289	Yadav, Brij Lal	Bhopal.
1314	578	Yadav, H. J.	Madhya Bharat.
1315	1567	Yadva, S. G.	Bombay.
1316	1530	Yegna Narayana, K.	Andhra.
1317	1006	Yogi, M. V.	M. E. S.
1318	541	Younus, S. M.	Hyderabad.
		"Z"	
1319	1303	Zaki, A.	Bihar.
1320	1535	Zipkes, E.	Iran.
1321	954	Zutshi, Y. N.	Uttar Pradesh.

Associate Members

Serial No.	Roll No.	Name.	State/Country.
1	31	Antia, F. P.	Bombay.
2	52	Armstrong Smith Ltd.	Bombay.
3	39	Basil Gray	Delhi.
4	51	British Insulated Callenders' Cables Limited	Bombay.
5	54	Burn & Co., Ltd.	West Bengal.
6	35	Caltex (India) Ltd.	Bombay.
7	50	Central Road Research Institute	Govt. of India.
8	43	Central Standard Office for Railways	Govt. of India.
9	45	Chatterjee, D.	West Bengal.
10	41	De, K. C.	West Bengal.
11	57	Desai, A. P.	West Bengal.
12	22	Dunlop Rubber Co. (Ind.) Ltd.	West Bengal.
13	30	Engineer, M. H.	Bombay.
14	16	Engineer-in-Chief's Branch	Govt. of India.
15	15	Heatly Gresham Ltd.	West Bengal.
16	58	Indian Standards Institution	Delhi.
17	56	Kaura, Mool Raj	Delhi.
18	31	Khanna, K. N.	Delhi.
19	38	Kraty, F. C.	West Bengal.
20	44	Laurie, F. J. K.	West Bengal.
21	6	Madden, W. J.	West Bengal.
22	45	Patel, K. R.	West Bengal.
23	21	Patel, L. R.	West Bengal.
24	14	Patell, J. K.	Bombay.
25	34	Ramsay, A. R. P.	West Bengal.
26	40	Shahani, T. C.	Delhi.
27	29	Society of Motor Manufacturers & Traders Ltd.	Delhi.
28	55	The Burmah Oil Co., (India Trading) Ltd.	Assam.
29	42	Weatherall, H. M.	Bihar.
30	23	Willcox, E. W.	Delhi.

Paper No. 180

"STABILIZED SOIL CONSTRUCTION IN THE FORMATION OF TUTICORIN-TIRUCHENDUR ROAD"

By

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AND

T. S. CHANDRASEKHAR, B.E.

CONTENTS

SYNOPSIS

This Paper describes the design and construction of granular soil stabilization in the formation of a road from Tuticorin to Tiruchendur

via Mukkani in Madras State. A sand-clay base course and moorum-sand berms were provided for the road.

A comparison is made between the gradation and consistency characteristics of the design mixes used for the base course in the road and those in the recommended practices in U. K. and U. S. A. It is observed that with a decrease in the maximum particle size in ranges less than 1.2 mm, consistency characteristics are of critical importance while gradation considerations are of little significance.

The need for a scientific basis for arriving at the maximum permissible value or the optimum value of the plasticity index in granular soil mixtures for roads is indicated and a modification of current methods in the experimental determination of the plasticity index of soils on the minus 200 fractions instead of the minus 40 fractions is suggested. The theoretical conversion of this value for the whole soil taking into consideration the complete granulometry is given.

The influence of common salt (chlorides) on the consistency properties of the clay and on its susceptibility to pulverization and workability is discussed and the practical significance of this in taking up stabilization works in highly plastic soil areas as black cotton clays is brought out.

The role of machinery in soil stabilization is briefly discussed and the usefulness of relatively common types as grader, roller, lorries etc., in combination with suitable manual operations is indicated.

The degrees of pulverization of the clay binder specified for satisfactory stabilization in current practices in Madras State, U. K., and U. S. A. are discussed and the results of certain field experiments conducted on the road are reported.

Actual costs for the various items of the stabilization work are furnished with details of data for important cases.

1. SITE AND CLIMATIC FACTORS

1.1. Introduction

The road from Tuticorin to Tiruchendur via Srivaikuntam is circuitous and is 46 miles long. Tuticorin is an important seaport near the southern tip of the Indian Union and Tiruchendur is a famous pilgrimage centre. A direct route between the two places is 22 miles long and will be shorter than the existing road by 24 miles. In addition, the new route would connect a number of important villages with a total population of about 50,000, which are centres for manufacture of palmyrah jaggery and common salt. The river Tambaraparni at mile 13/3 of the direct route near Mukkani is unbridged and, as a first phase, the construction work was taken up from Tuticorin to Mukkani, Fig. 1.

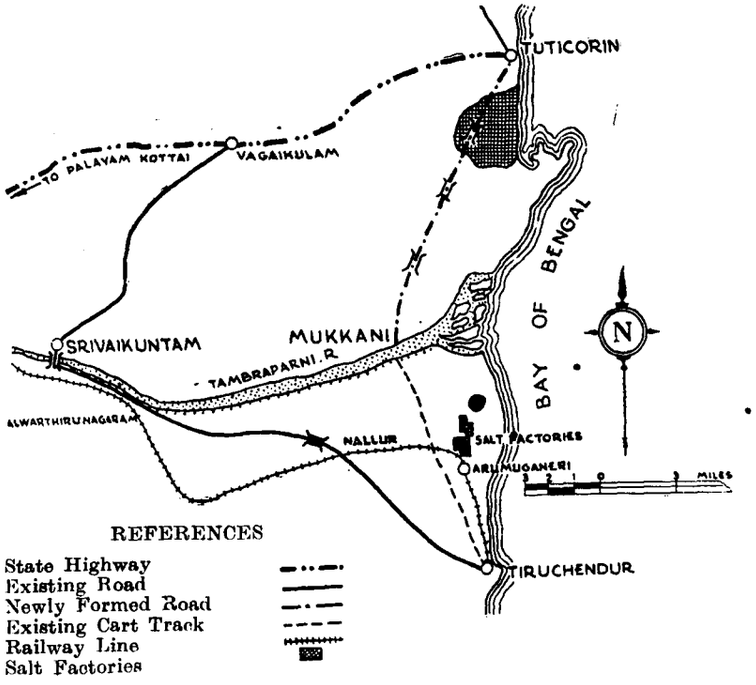


Fig. 1.

1.2. Nature of Country

The country is flat and the road is very near the sea coast. The route is crossed by a number of streams and drainage crossings. The subgrade soil varies from sand and silty sand to clays of medium and high plasticity. Important types of the subgrade soils met with on the selected route are shown in Fig. 2.

1.3. Climate and Moisture Conditions

Annual rainfall in the area is about 23 to 32 inches*, most of which occurs during the period October to December. The summers are hot and arid. In the low lying areas near Tuticorin, the subgrade soil gets saturated with water for about 3 months in the year. The subgrade is well drained in the sandy sections of the road and poorly drained in the clayey sections.

The first half of the road from Tuticorin is subject to heavy gales carrying abrasive soil particles with an estimated velocity

* Figures obtained from the Meteorological Department, Government of India.

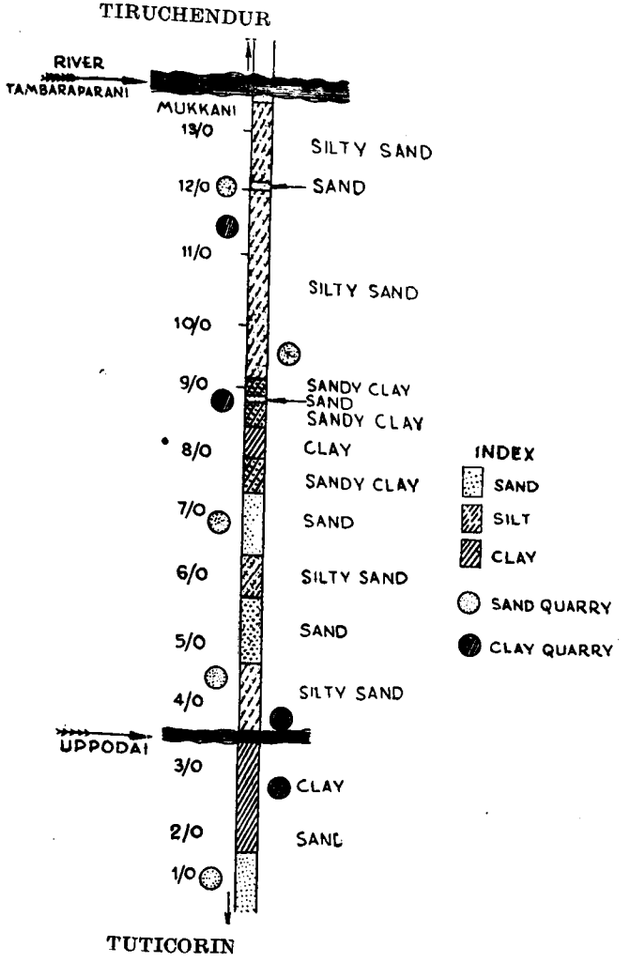


Fig. 2. **Types of subgrade soils and location of quarries**

of about 30 to 40 miles per hour, and this gives rise to soil erosion at the surface and other problems in the construction and maintenance of roads in the area.

2. ORGANIZATION

2.1. A special sub-division with one Assistant Engineer and one Junior Engineer was formed for this work. Since soil stabili

zation is relatively new to the contracting profession in Madras State, a major portion of the work was done departmentally. Only the collection of metal and moorum was entrusted to contractors.

2.2. Equipment

The plant used for the job were the following :

	No. used
Bull-Dozer 100 H. P.	1
Grader 100 H. P.	1
Transport Lorries	3 to 5
Water Lorry	1
Smooth-wheeled Power Roller 6 to 8 Tons	1 to 2
Water Pump	1 to 2
Field Laboratory	1 (vide Appendix I for equipment)

2.3. Base Camp

In order to accommodate the field soils laboratory, the plant, and tents for the crew, a base camp was established. As the work progressed, the base camp was shifted to more convenient places.

3. FORMATION OF THE ROAD

3.1. A typical view of the area traversed by the road is shown in Photo 1.

Jungle clearance and earth work for the formation were done mostly by means of the bull-dozers except in marshy locations and near water crossings, where manual labour was employed. In a certain reach of the road where a surface layer (about 6 in. thick) of a conglomerate of shingles, coral stones and sand was met with, use of the bull-dozer was not economical since the blade of the bull-dozer could not cut deep into the soil.

The formation of the road was made 2 to 4½ ft high and 24 ft wide on top with a side slope of 2 to 1, Figs. 3 and 4. Use of the bull-dozer facilitated simultaneous compaction of the fill during the formation work. The average out-turn of earthwork with a bull-dozer for an 8-hour day was about 25,000 cubic feet in clay and about 32,000 cubic feet in sandy and silty soils.

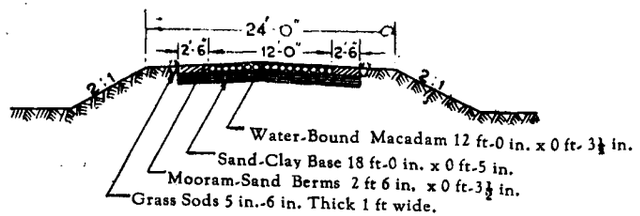


Fig. 3. **Cross section in sandy sub-grade**

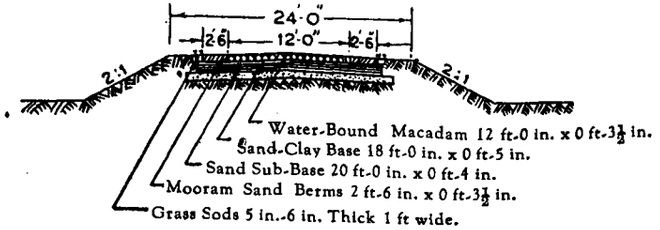


Fig. 4. **Cross section in clay sub-grade**

4. STRENGTHENING THE SUBGRADE

4.1. The new formation was strengthened before the foundations were laid. The nature of this strengthening treatment depended upon the type of the subgrade soil.

4.2. Sand Reach

In sandy subgrade the difficulties were :

(i) negotiating the route by the construction traffic,

(ii) obtaining an adequate support for a successful laying of the base course.

Clay powder, passing through A. S. T. M. (or B. S.) ½ in. sieve, was spread on the prepared subgrade to a height of about one inch to two inches, depending upon the plasticity of the clay. The clay was mixed with 3 to 4 in. of sand below so as to obtain a plasticity index of 2.5 to 3.0* for the resultant mix. Earlier experience in stabilization works in Madras State had shown that a satisfactory riding surface could be obtained of a material with values of plasticity index in this range. Mixing consisted of

* Obtained as per calculation by Hogentogler's formula, Table 2, Reference 10 in Bibliography.

repeated scarifying and blading two or three times with a grader. The subgrade was levelled and watered by means of a sprayer in calculated amounts. The materials were mixed and the surface was brought to camber and compacted with the pneumatic-tyred wheels of a grader. At this stage the surface did not show adequate strength to take up smooth-wheeled power rolling primarily because the mix obtained showed poor compactibility. It was then allowed to cure overnight to permit the water to work into the clay particles and was compacted with the power roller the next day. Unevenness of the surface, if any, was rectified by means of a level drag and the surface was watered and re-rolled with pneumatic-tyred wheels. A cone bearing power (with a North Dakota Cone Penetrometer) of not less than 180 pounds per sq. in. was obtained for the subgrade immediately after compaction.

4.3. Silty or Clayey Reach

The silt or clay subgrade was sectioned to 1 in 36 camber. A suitable quantity of water was sprinkled and the surface was rolled with a power roller (6 to 8 tons). Where the soil was highly plastic, the surface was covered with a thin layer of dry sand before rolling. This prevented the clay from sticking to the surface of the roller wheels.

5. SUB-BASE

5.1. Where the subgrade soil was clay, the foundation courses consisted of a sub-base of sand and a base of sand-clay mix ; in the sandy reaches, the sub-base was dispensed with.

5.2. Sub-base

To eliminate the possibility of the very soft plastic subgrade material penetrating into the base course [1], a sub-base of sand was provided for the total length of about 2½ miles where the soil was clay. To facilitate compaction of the sand with the available equipment, 5 to 10 per cent clay binder was added in one or two furlongs. For a major portion of the reach, however, a silty sand having 5 to 8 per cent of its weight passing A.S.T.M. (or B.S.) 200 sieve and susceptible to compaction with the available equipment was obtained from nearby quarries and used.

5.3. Width and Thickness

The width of the sub-base was 20 ft and the thickness varied from 2 to 5 in., depending upon the consistency characteristics and moisture conditions of the subgrade soil [1].

5.4. Method of Construction

Requisite quantities of silty sand, or where this was not available, sand and clay, were collected over the prepared subgrade, (dry mixed where necessary) and stacked in the form of windrows on the roadside. The windrows were divided into a convenient number of bays and an optimum quantity of water was added. The windrows were wet mixed by manual labour and the material was spread to proper camber (1 in 36) and grade. The surface was compacted initially with pneumatic-tyred wheels of a grader and finished with a smooth-wheeled power roller (6 to 8 tons). The sub-base was allowed to set or dry cure in the sun for about two or three days.

Field tests showed a dry density of about 105 lb per cu.ft. and a North Dakota Cone Bearing Power of 270 lb per sq. in. soon after compaction. These values were taken more as guides than as specification values for exercising rigid field control on the work. The primary purpose was that the surface should be made stable enough to permit further construction.

5.5. Maintenance

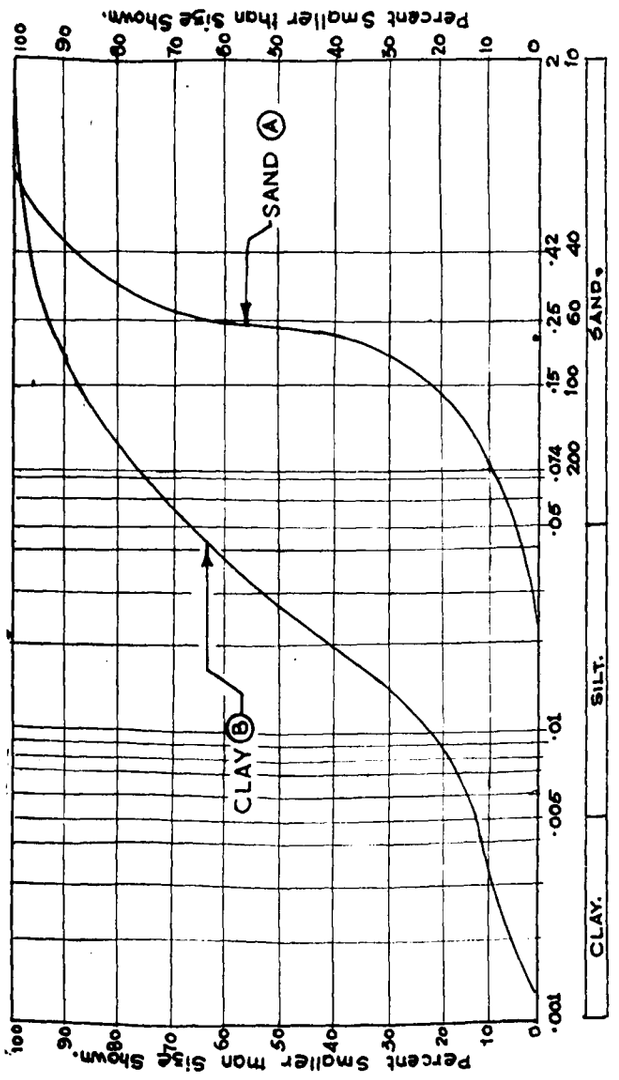
Pneumatic-tyred construction traffic was permitted to use the sub-base for collection of materials for the base course. Any ruts that formed were rectified and the surface brought to proper camber (1 in 36) and grade by means of a grader.

6. BASE COURSE

6.1. Good granite metal was not available from leads less than 20 miles. Limestone soling, 13 ft by 6 in., with a lead of 13 miles would cost about Rs 15,000 per mile. Sand and clay were available in close proximity, Fig. 2. The estimated cost of sand-clay base course, 18 ft by 5 in., was about Rs 7,500 per mile. So stabilized soil foundation was adopted.

6.2. Soil Materials Used and Their Characteristics

The subgrade soils were not used for the base course since there was considerable variation in their physical and other characteristics within short intervals warranting frequent changes in the design of the mix as well as the method of construction[2]. The results of tests on soil samples are shown in Table 1 and Fig. 5. Most of the clay samples contained soluble salts mostly chlorides to the extent of 2 to 10 per cent.



	Location	Clay per cent	Silt per cent	Sand per cent	Textural Classification
A	6/5 to 7/0 of Tuticorin–Tiruchendur Road	—	4	96	Sand
B	8/6 of Tuticorin–Tiruchendur Road	11	58	31	Clay

Fig. 5. Mechanical analysis of typical soils used for base course

TABLE 1

Characteristics of the Soil used for the Sand-clay Base Course

No. and Laboratory Nomenclature	Description of soil sample	Location of quarry Mile/Furlong	Sieve Analysis. A.S.T.M. Sieve No. passing 10	40	60	100	200	Liquid limit Per cent	Plastic limit Per cent	Plasticity index	Soluble salts Per cent	pH value	PRA classification	Casagrande's classification	Remarks
A_2	Sand	6/5	100	87	56	18	6	—	—	—	—	—	A-3	SP	Typical sand used Saline soil
B	Clay	2/6	100	99	97	89	76	59	25	34	8.1	7 to 8	A7-6	CH or CL	-do-
B_1	Clay	3/4	100	99	99	98	93	67	26	41	10.1	7 to 8	A7-6	CH or CL	-do-
B_2	Clay	8/6	100	89	82	67	40	32	16	16	4.2	7 to 8	A6	CH or CL	-do-
B_3	Clay	11/3	100	99	99	95	77	30	14	16	2.3	7 to 8	A6	CH or CL	-do-

6.3. Characteristics of Soil Mixtures

Suitable combinations of the sand and clay were made and the mixes were subjected to Proctor density tests and bearing power tests with a North Dakota Cone Penetrometer on test blocks compacted to the same density. Typical test results obtained for the soils and the trial mixes for the reach 6/0 to 8/0 are given in Table 2 and Fig. 6.

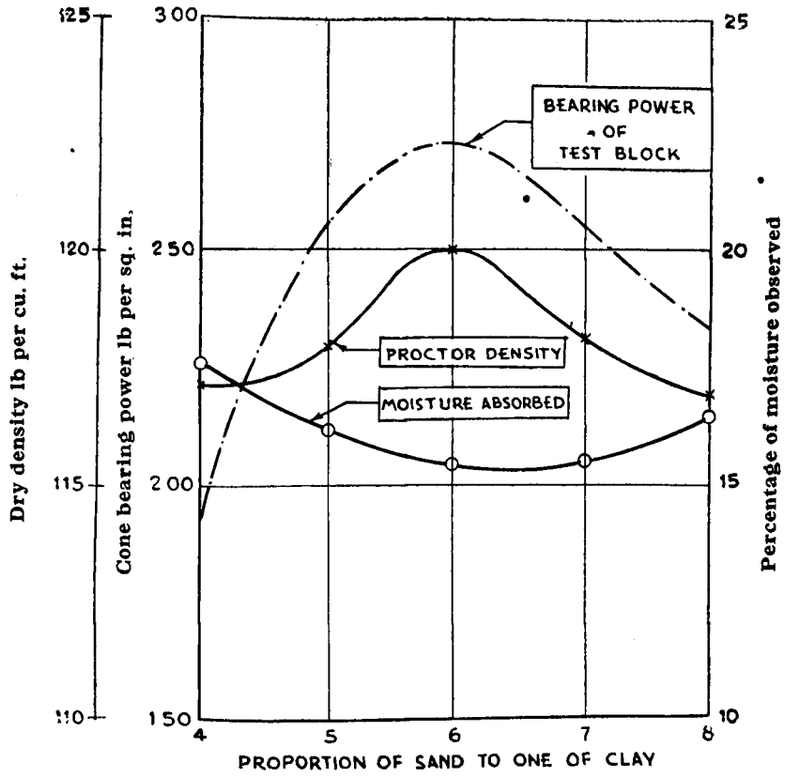


Fig. 6. Test results for design of mix for base course

6.4. Design of Mixes

The design of a dense graded base course involves the selection of suitable materials in coarse and fine fractions, obtaining a desired affinity between them, grading of fractions to

TABLE 2

Design of Mix for Base Course
Reach 6/0 to 8/0

Proportions are all by dry weight

Sl. No.	Particulars of test etc.	Sand A	Clay B	Trial mixes of sand and clay				
				4A+B	5A+B	6A+B	7A+B	8A+B
1.	Plasticity index*	—	41	9.08	7.46	6.43	5.65	5.0
2.	Percentage passing *ASTM* No. 10 sieve	100	100	100	100	100	100	100
3.	-do- 40 ,,	87	99	89	89	89	88	88
4.	-do- 60 ,,	56	99	64	63	62	61	61
5.	-do- 100 ,,	18	97	34	32	29	28	27
6.	-do- 200 ,,	6	76	23	20	18	17	16
7.	Proctor density lb per cu.ft.	—	—	116.5	117.5	120	188	116.5
8.	Optimum moisture per cent	—	—	9	9	9	9	9
9.	Field density lb per cu.ft.	—	—	119.0	120.9	122.78	120.2	118.2
10.	North Dakota Cone bearing power soon after compaction lb per sq.in.	—	—	1000	625	440	420	—
11.	North Dakota Cone bearing power of a test block after soaking in water for 3 days lb per sq. in.	—	—	189	252	270	252	232
12.	Moisture absorbed after soaking for 3 days per cent	—	—	17.1	16.25	15.37	15.44	16.50

A. Sand from quarry 6/5–7/0 of Tuticorin–Tiruchendur Road

B. Clay from quarry 3/4 of Tuticorin–Tiruchendur Road

*The values of plasticity index for mixtures are calculated from the formula given by Hogentogler, which is as follows:

Plasticity Index of a mix composed of A and $B = \frac{X S_1 P_1 + Y S_2 P_2}{X S_1 + Y S_2}$

where X = Per cent of A in the mix,
Y = Per cent of B in the mix,
S_1 = Per cent of Soil fines (passing No. 40 *ASTM* sieve) in A,
S_2 = Per cent of soil fines (passing No. 40 *ASTM* sieve) in B,
P_1 = Plasticity index of soil fines (passing No. 40 *ASTM* sieve) in A,
P_2 = Plasticity index of soil fines (passing No. 40 *ASTM* sieve) in B,

give sufficient density, control of the swelling of the fines to a volume not greater than the volume available to accommodate it and obtaining a desired affinity between the base course and the surface course[1].

Recommended practices for the design of granular soil mixes in U.S.A. and U.K. specify gradation and consistency requirements for base and surface courses for different maximum particle sizes of the soils [1,3,4]. The maximum particle sizes vary from 3 in. (7.6 mm.) to 2 mm. in the U.S. practice and 3 in. (7.6 mm.) to about 2.4 mm. in the U.K. practice. For base courses the liquid limits and the plasticity index values should not exceed 25 and 6 per cent respectively. These recommendations are to serve more as guides than as rigid specifications. While the recommended practices may hold good for the average soil and climatic conditions of countries in the temperate regions, they may not be true for the tropical conditions in India[5,6]. In a sub-tropical region as Texas in the United States, a plasticity index value up to 15 and a liquid limit up to 45 are permitted[1].

The results of tests on soil mixes for the Tuticorin-Tiruchendur Road show that the maximum particle sizes varied from 0.43 mm. to about 2 mm. In order to obtain a mix with a gradation between the limits that are recommended in the U.K. and U.S. practice, a third soil would have to be added. This would result in a considerable increase in the cost of the work. Further, past experience and observations in the design and construction of stabilized soil roads in Madras State have shown, that soil mixes that had a gradation outside the recommended limits and that satisfied the consistency requirements, gave satisfactory performance as base courses for secondary roads, when compacted to have a cone bearing power of 200 pounds per sq. in. after soaking for three days. In the light of these findings a combination of the two locally available soils viz., medium to fine sand and clay, was used and the design mixes were fixed from considerations of maximum density and bearing power, which is in conformity with recent practice in soil stabilization in other countries[7,8].

6.5. Comparison of the Design Mixes with the Recommended Specifications in U.K. and U.S.A.

Gradation. Table 3 shows the results of tests on the design mixes adopted for the various reaches in the Tuticorin-Tiruchendur Road.

The grading curves of the design mixes with a maximum particle size of 2 mm. are shown in Fig. 7. These fall outside the

TABLE 3

Sand Clay Mixes Adopted for the Base Course

Sl. No.	Particulars of tests etc.	Reach	1/5 to 2/2	2/2 to 3/2	3/2 to 6/0	6/0 to 8/0	8/0 to 11/0	11/0 to 13/0
		Soil Mix	$5A+B$	$6A+B_1$	$7A_1+B_1$	$6A_2+B_1$	$5A_3+B_2$	$4A_4+B_3$
1.	Plasticity index* ...		6.58	5.9	6.1	6.43	6.9	4.87
2.	Passing ASTM Sieve No. 10		100	100	100	100	99	99
	-do- 40		77	98	82	89	87	85
	-do- 60		44	66	56	62	73	72
	-do- 100		17	25	27	29	48	42
	-do- 200		11	15	16	18	18	21
3.	Proctor density lb per cu. ft.		115.5	117.0	124.1	120.0	116	120
4.	Optimum moisture per cent		8.0	10.0	8.8	9.0	13.9	10.0
5.	Field density lb per cu. ft.		118.4	118.0	123.9	122.8	116	120.8
6.	North Dakota Cone Bearing power soon after compaction lb per sq. in.		600	400	480	440	360	360
7.	North Dakota Cone Bearing power after soaking in water for 3 days lb per sq. in.		225	198	216	270	320	252
8.	Moisture absorbed after soaking for 3 days per cent		11.51	12.50	10.50	15.37	16.9	14.64

* Calculated from Hogentogler's formula (see footnote of Table 2).

A = Sand from quarry at 1/5 of the road.

B = Clay from quarry at 2/6 of the road.

A_1 = Sand from quarry at 4/4 of the road.

B_1 = Clay from quarry at 3/4 of the road.

A_2 = Sand from quarry at 6/5 to 7/0 of the road.

B_2 = Clay from quarry at 8/6 of the road.

A_3 = Sand from quarry at 9/2 of the road.

B_3 = Clay from quarry at 11/3 of the road.

A_4 = Sand from quarry at 11/8 of the road.

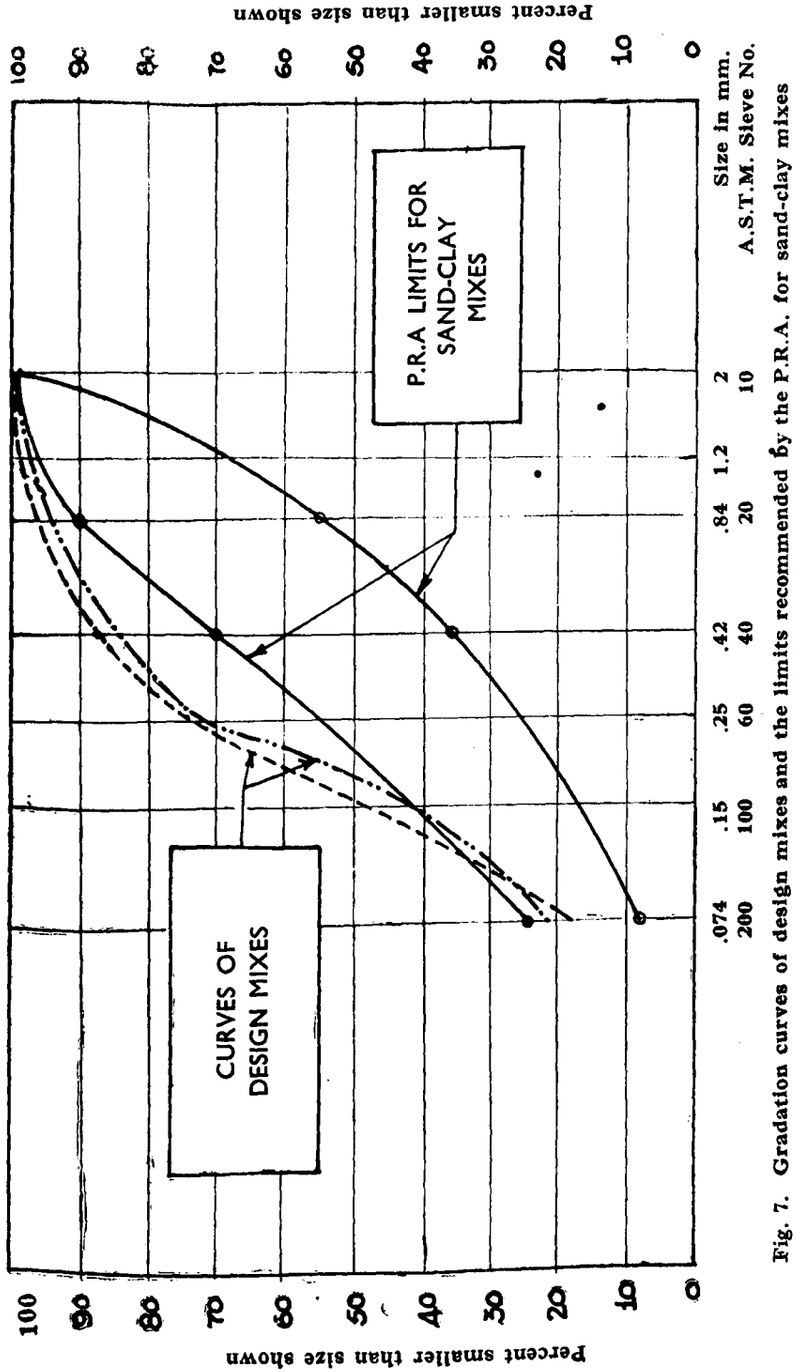


Fig. 7. Gradation curves of design mixes and the limits recommended by the P.R.A. for sand-clay mixes (Maximum particle size 2 mm.)

limits recommended by P.R.A. except in the range of the fraction passing through A.S.T.M. No. 200 sieve. This is in accordance with the principle that where the grading requirement is not fully satisfied for all the particle sizes, it is best to satisfy the requirements of the finer sizes and to neglect those of coarser fractions[9].

In Fig. 8 are shown the range of the grading curves for the design mixes with maximum particle sizes less than 2 mm. and the P.R.A. grading curves for sand-clay mixtures with a slight modification. The upper limiting curve for mixtures of maximum particle size of 2 mm. is normally given by 'a b d'[9] which indicates that no recommended limits are available for soils with a maximum particle size less than 2 mm. For purposes of the present discussion, the upper limiting curve is drawn as 'a b c' which is similar to the grading curves given for other maximum particle sizes. Point 'c' then corresponds to a maximum particle size of 1.2 mm. which shows that the maximum particle size for the sand-clay mixtures for which recommended limits are available, may be taken to vary from 2 to 1.2 mm.

The three design curves in Fig. 8 show the extreme grading limits in both the coarser and finer sizes for the soil mixes with a maximum particle size less than 1.2 mm. In comparing these design curves with the recommended limits available for particles of higher maximum sizes, the following observations are relevant.

The recommended grading limits for soils with different maximum particle sizes mostly follow the pattern of Fuller's curves for maximum density, but how far the size distribution can deviate from Fuller's curve without affecting mechanical stability is not known[1,4]. It has, however, been accepted that a wide range of limits may be suitable. Experience also shows that in order to obtain sufficient cohesion a greater proportion of material passing No. A.S.T.M. (or B.S.) No. 200 sieve is required than that given by the Fuller's curve. Drawing the Fuller's curves for the extreme values of the maximum particle sizes, viz., 1.1 and 0.43 mm. the amounts passing through A.S.T.M. or B.S. No. 200 sieve are 24 and 40 per cent respectively. Actually for the design mixes adopted, the maximum density and stability values are obtained with less amounts, viz., 11 to 18 and 15 per cent respectively. While the optimum amount of fines for maximum strength is also a function of the quality of the binder [8], the design mixes adopted for the sand-clay base course showed that with decrease in the maximum particle size in a range less than 1.2 mm., the Fuller's curves show progressively higher values for soil fines passing A.S.T.M.

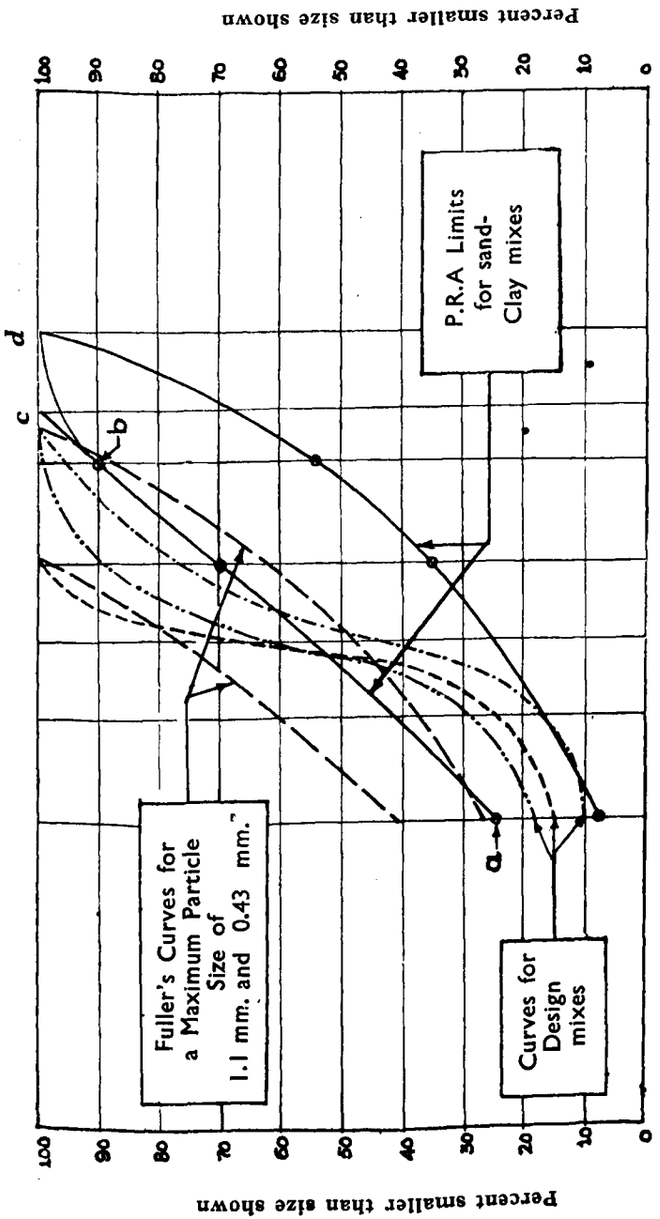


Fig. 8. (1) P.R.A. limits for sand-clay mixtures (2) The range of particle size distribution of design mixes with a maximum particle size less than 1.1 mm., and (3) Fuller's curves for maximum particle sizes of 1.1 mm. and 0.43 mm.

or B.S. No. 200 sieve than what is required for maximum density and stability. In other words, in such ranges considerations of gradation are of little significance and consistency requirements assume a critical importance. An examination of Fig. 8 also shows that with a decrease in the maximum particle size, the soil fraction passing A.S.T.M. or B.S.No. 200 sieve according to Fuller's curve, increases progressively while the increase in actual requirement of this fraction in the recommended practice for stabilized soil mixtures is comparatively less.

Actual tests on the minus* 40 (A.S.T.M. sieve) fraction of the design mixes showed little or no plastic characteristics. The poor significance of grading for such non-plastic soil mortars (minus 10 fractions) and in this case soil fines (minus 40 fractions) is also pointed out by Wooltorton on the strength of research results [1].

6.6. Consistency

Wooltorton [1] has worked out a scientific basis for obtaining the maximum permissible plasticity index for well graded soil mixtures. The principle is that the swelling, if any, must not exceed the volume available within the interlocked structure to accommodate such swelling. The maximum value of this can only be the volume of the contained air. For graded materials (minus $\frac{3}{4}$ in. size) compacted by standard methods, the air void content is taken as about 4.5 per cent. When the minus 40 fraction is about 30 per cent, the usually recommended limit of plasticity index of 6 is obtained.

The design mixes adopted in the Tuticorin-Tiruchendur Road were not susceptible to an experimental determination of the consistency limits and were to be considered from the test results alone as 'Not Plastic'. But the soil mixtures showed good workability and compaction characteristics. The values of plasticity indices for the mixes were then determined by theoretical methods due to Hogentogler [10], and to Pereira [11], of which the former takes into consideration only the effect of minus 40 fraction in the change of the value of the plasticity index due to the admixture, while the latter combines the complete granulometry of the soils in a form similar to Abraham's fineness modulus. For the design mixes adopted, the plasticity index values according to Hogentogler's formula varied from 4.8 to 6.9, Table 3. A comparative study made on these two methods indicates that Pereira's formula gives generally higher values for mixtures containing large amounts of fines and lower values for coarser soils as compared with Hogentogler's, Table 4. In a

* Material passing through.

Photo 1. Typical view of the route prior to formation

Photo 2. Collection of clay powder over windrowed sand. Note separate gauges are used for sand and clay collection.

Photo 3. **Dry mixing of sand and clay**

Photo 4. **Forming bays for watering**

Photo 5. **Addition of water**

Photo 6. **Wet mixing**

Photo 7. **Spreading and levelling to camber**

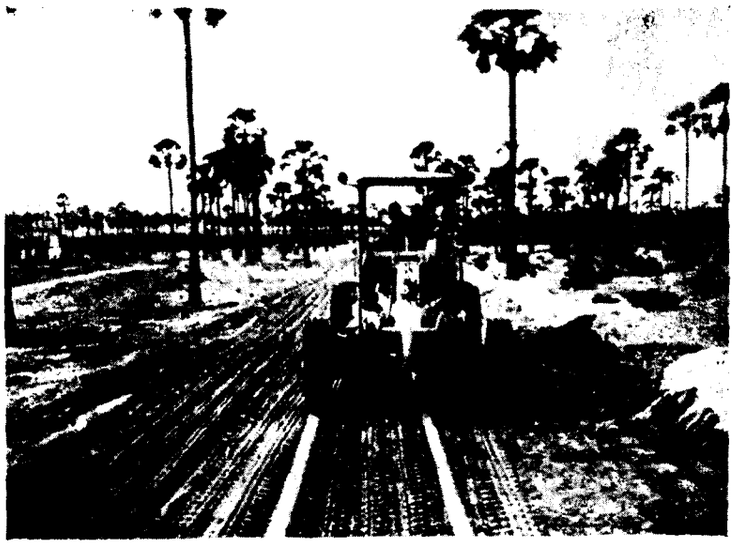


Photo 8. Initial rolling with pneumatic tyres

Photo 9. Final compaction with smooth-wheeled power roller

TABLE 4

Plasticity Indices of Soils and Soil Admixtures

Sl. No.	Particulars of Test etc.		Sand*	Clay	1 sand + 1 clay	2 sand + 1 clay	3 sand + 1 clay	4 sand + 1 clay	5 sand + 1 clay
1.	Sieve Analysis Per cent passing *ASTM* Sieve No.	10	100	100	100	100	100	100	100
		40	75	99	87	83	81	80	79
		60	36	97	67	56	51	48	46
		100	7	89	48	34	28	23	21
		200	0.4	75	37.7	25	19	15	13
2.	Plasticity index on minus 40 by test			31.6	21.8	10.8	4.3	*N.P.***	*N.P.***
3.	Plasticity index of minus 40 as per Hogentogler's formula				17.9	12.5	9.7	7.9	6.6
4.	Plasticity index of the soil mixture as per Pereira's formula***				19.5	14.3	11.2	9.2	7.7
5.	Plasticity index on minus 40 by test			44.6	44.6	44.6	44.6	44.6	44.6
6.	Equivalent plasticity index for † minus 40 fraction as calculated from the test value for minus 200				17.5	11	7.6	5.3	4.1
7.	Plasticity index for whole soil as per Pereira's formula but taking the value of Plasticity Index for minus 200 instead of minus 40 fraction.				30.2	22.8	18.4	15.2	13.1

A : Sand from 1/5 B : Clay from 2/6

* *A* : Sand has a slightly different gradation than that taken for design in Table 3.

** N. P. Not Plastic.

*** Formula due to Pereira : $PI = \frac{A_1 a_1 I_1 + A^2 a_2 I_2}{A_1 a_1 + A_2 a_2}$, in which

PI = Plasticity index of the mixture.

I_1 & I_2 = Plasticity indices of the soils to be mixed.

A_1 & A_2 = Weight percentage of each soil.

a_1 & a_2 = Two values of granulometry of the soils which are defined as $a = \frac{\Sigma y}{n}$, in which

y = the ordinates (the percentage which pass) of the granulometric curve corresponding to B. S. sieves 200, 100, 50, 25, 14 and 7,

n = the number of ordinates considered.

† Calculated from empirical formula given in Para. 6.6.

Item No. 5 indicates that the same type of binder is present for the different mixes.

Item No. 7 does not take into consideration any surface area factor referred to in Para. 6.6.

number of tests conducted on soil mixtures, Pereira claims to have obtained values of plasticity index very close to the experimental values. The design mixes adopted for the stabilized base course in Tuticorin-Tiruchendur Road contained considerable amount of non-plastic fines (minus 40 fractions) and the conventional method of conducting the consistency tests on such fractions did not show the plasticity characteristics of the soil mixtures. This is because of the presence of sand and silt in the minus 40 fractions, which act as diluants and lower the plasticity. In order to obtain consistent and unambiguous results it appears more appropriate to conduct the consistency tests on still finer fractions, viz., minus 200 material and base all design calculations on these values. Since the minus 200 fraction may be taken as contributing fully towards the plasticity characteristics of the soil, for any given variety of clay these properties will mostly depend upon the amount of such material present.

The plasticity index of the minus 40 fractions in a soil may be correlated with that of the minus 200 fractions by means of the empirical formula given by R.W. Miller[5]:

$$\frac{\text{P.I. of minus 40 fraction} + 4}{\text{P.I. of minus 200 fraction} + 4} = \frac{\text{Per cent of minus 200 fraction in minus 40 fraction}}{100}$$

Or,

[Plasticity index of minus 40 fraction+4] × Per cent of minus 40 fraction = [Plasticity index of minus 200 fraction + 4] × percent of minus 200 fraction.

The value of an 'equivalent' plasticity index for the minus 40 fraction of soil mixtures can thus be obtained from the plasticity index values determined by test for the minus 200 fraction, Table 4.

This equivalent plasticity index for minus 40 fractions or the plasticity index of the minus 200 fraction, as determined by actual test, may then be introduced in an equation of the type suggested by Pereira, the surface area for the different size fractions being considered, if possible, and the equivalent plasticity index for the 'Whole' soil or soil mixture obtained.

A rational method of approach for the determination of the plasticity requirements therefore appears to consist in an understanding of:

(i) the plasticity index as determined by actual tests on the minus 200 fractions for purposes of assessing more consistently the plasticity characteristics of the binder material in a soil or soil mixture;

(ii) the 'equivalent' plasticity index of the 'whole' soil as obtained by an appropriate method similar to Pereira's.

The maximum permissible or the optimum value of plasticity index for minus 200 fractions in a given soil or the equivalent plasticity index for the whole soil may be arrived at on lines either similar to or suitably modified from that arrived at by Wooltorton [1]. The method may also be extended to poorly graded soils. Observations of the behaviour of a large number of stabilized soil mixtures used in different soil and climatic conditions and analysis of the results with special reference to the factors mentioned would furnish data for drawing out suitable specifications. However, the importance of chemical and surface chemical factors, the influence of which may not be directly reflected in these test characteristics, must not be overlooked.

6.7. Thickness

From observations on the performance of sand-clay base courses laid in the State, a compacted base thickness of 5 inches was considered quite satisfactory for the proposed road.

6.8. Width

The stabilized soil foundations were extended 3 ft beyond the edge of the pavement in order to afford lateral stability to the base at the edges of the pavement and a firm support for the berms.

6.9. Manufacture of Clay Powder

To facilitate uniform mixing of the soil materials by manual labour, the binder soil (clay) was collected in the form of a powder passing $\frac{1}{8}$ in. mesh screen. In sand-clay stabilization works taken up earlier in the State and in the initial stages of this work, the method adopted in pulverizing the clay at the quarry was as follows:

Clay was dug in clods in the field, spread on a prepared hard ground, sun dried to a suitable moisture content, and crushed by passing a smooth-wheeled power roller. The crushed material was sieved through a $\frac{1}{8}$ in. mesh screen and the material passing alone was used in the stabilization.

The above method hampered progress, was laborious and proved costly since only about 30 to 40 per cent of the crushed material would pass through the $\frac{1}{8}$ in. sieve. A different method attempted in the present work proved simpler and cheaper. Clay quarries of minimum dimensions of about 200 ft by 200 ft were selected and the surface clay was scraped by means of a grader with its blade adjusted to a depth of not more than $\frac{1}{4}$ to $\frac{1}{2}$ inch. The scraped material was sieved through a $\frac{1}{8}$ in. mesh screen and the material passing was collected. On an average about 60 to 70 per cent of the scraped material passed through the said sieve.

6.10. Stacking and Preserving Clay Powder

The pulverized clay was to be protected from rains to prevent caking. To cover the clay stacks with sheds, even thatched ones, was not a practical proposition because of the large area involved. Clay powder at the quarry site was therefore stacked in a prismoidal form with its base located at an elevated place not likely to be inundated by rains. Observations made after heavy rains showed that the top crust was rendered wet for a depth of only three inches and that the material inside was dry and fit for use on the job. The effect of rain water on the soil containing sodium chloride may be considered to cause a limited translocation of the solution from the flocculated surface material followed by dispersion in this area of chemical recession. The sodium clay fraction in the upper layer swells and seals the capillaries to prevent further percolation. The texture of the interior portion was thus preserved [1]. In this way, on an average, about 80 to 85 per cent of the stacked material could be used for the sand-clay mix without any difficulty. Even the balance could be suitably dried and reclaimed for use.

6.11. Construction

Sand was collected and stacked on the roadside in two windrows to specified dimensions on the prepared subgrade or subbase, and clay powder was collected over it in proper proportions, Photo 2. The sand and the clay powders were immediately mixed by means of mummutties until a uniform mix was obtained, Photo 3. Dry mixing immediately after collection of the materials prevented possible caking of the clay powder due to rains. The mixed material was re-stacked roughly in the form of windrows, which were divided into bays, each 10 ft long, Photo 4. An optimum quantity of water, making due allowance for evaporation and construction losses, was added to each bay, Photo 5. The water was allowed to soak through the dry soil mix overnight. Next day the windrows were wet mixed by manual labour, Photo 6, and a further quantity of water was added or the material was allowed to dry out, as was found necessary to bring it to the optimum moisture content. The soil was then spread and compacted in two equal layers making a total thickness of 5 inches. Each layer was sectioned to proper level and camber (1 in 36) by means of a camber board, Photo 7 and compacted initially with pneumatic-tyred wheels of a grader, Photo 8, and then finished with a 6 to 8 ton power roller, Photo 9. Rolling with the power roller was continued until the specified density was obtained of the compacted soil. The surface of the first layer was scored with a nail drag before the second layer was laid so that a good bond was obtained between the two layers.

6.12. The moisture content of the soil mix was determined before and after wet mixing. The compacted base was tested at least in four places in a furlong for dry density and for cone bearing power, both soon after compaction and after soaking under water for 3 days. The moisture absorbed due to soaking was also determined.

The laboratory test values obtained for the design mixes adopted in the different reaches of the road served as guides in controlling the work in the field. Tentatively, a density of 97 per cent Proctor's was taken as a desired minimum. In Table 5, the range and average for the middle 90 per cent of field test values are given for the reach 6/0 to 8/0. It is seen that the test values obtained in the field compare very favourably with the values specified by the laboratory.

TABLE 5

Results of Field Control Tests on the Sand- Clay Base in the Reach 6/0—8/0

Sl. No.	Name of field control test		Values obtained in the laboratory	Middle 90 per cent of the values obtained in the field.	
				Range	Average
1.	Dry density	lb per cu. ft.	Proctor's 120 Test Block 122.8	121.4—125.7	123.8
2.	North Dakota cone bearing power after soaking for 3 days	lb per sq. in.	270	270—300	300
3.	Moisture absorbed after soaking for 3 days	per cent	15.3	10.75—12.5	11.6

6.13. Maintenance

No traffic was allowed to use the stabilized soil base except pneumatic-tyred construction vehicles. The surface was dry cured in the sun for at least 5 days before the wearing course was laid.

If laying of the wearing course was delayed by more than about a fortnight, use by the construction traffic and exposure to wind and weather resulted in the binder material getting dislodged from position and the surface presented a loose appearance. The surface was maintained in a fair condition by sprinkling water by means of sprayers at least once in a week. Once the base course was laid properly, it remained unaffected by rains except for the formation of stray gullies at the edges, which were suitably rectified.

During the initial stages of the work in the reach from 2/0 to 3/2, delay in laying the wearing surface and exposure of the stabilized base to hot weather and heavy gale resulted in a bad erosion at the surface of the base course, giving it an uneven and pitted appearance. This was later rectified by providing an additional layer of stabilized soil.

In certain locations iron-tyred traffic had to be permitted to cross the base course from one side to the other. This was made possible by covering the base course with two successive layers of hay and side soil, each 6 in. thick, for a suitable width. The covering was removed prior to the construction of the wearing course.

7. USE OF SPECIAL MACHINERY IN SOIL STABILIZATION

7.1. In a granular soil stabilization the main items of work in the field are :

(i) pulverizing the soils,

(ii) intimate mixing, and

(iii) compacting at optimum moisture to required density.

For this purpose, a few relatively common types of machinery were employed with a considerable amount of manual labour, especially for mixing and spreading. Experience in similar works undertaken in the State has shown that while the use of specialized machinery has definite advantages, successful stabilization is possible by employing a judicious combination of manual labour and simple mechanical equipment, as lorries and rollers.

8. EXPERIMENTS

8.1. Recommended practices in U.S.A. specify [3] that after pulverizing and mixing, 100 per cent of the binder soil should pass through 1 in. sieve and at least 80 per cent should pass through A.S.T.M. No. 4 sieve (apperture size 0.187 inch). The U.K. practice specifies [4] that at least 80 per cent of the pulverized soil should pass through a 3/16 in. B.S. sieve. The tentative specifications adopted in the sand-clay stabilization work in the State require that 100 per cent of the binder materials should pass through 1/8 in. screen, which is rather conservative compared with the current practices in the U.S.A. and the U.K. In order to determine the feasibility of using bigger size binder aggregates, experimental stretches were laid.

8.2. In the reach from 10/8 to 11/4, the clay binder, as obtained by scraping with a grader (without being sieved through the $\frac{1}{8}$ in. screen), was used. The maximum aggregate size was $\frac{1}{2}$ inch. For purposes of comparison, the results of the field control tests for the experimental reach from 11/1 to 11/4 and an adjoining reach from 11/5 to 11/8 with the normal specifications are given in Table 6. The field density values range from 120 to 125 pounds per cubic foot for the first case and from 120 to 126 pounds per cubic foot for the latter. The bearing power of the compacted surface and the moisture absorbed due to soaking are virtually the same. The service behaviour of the experimental reach has been quite satisfactory indicating that for the soils used in the work larger size binder aggregate have not been detrimental.

9. INFLUENCE OF THE PRESENCE OF SALTS IN THE CLAY BINDER

9.1. A severe limitation in the use of clay in stabilization is the difficulty in pulverizing, which is essential in obtaining a uniform mix. The clay binder used for the stabilization work varied from a medium to a highly plastic variety, which, judging from the plasticity characteristics alone, might not be susceptible to easy pulverisation and intimate mixing. The method adopted, Para. 8.2, was found very successful. The easy susceptibility to pulverization and mixing, is to be attributed

TABLE 6

Results of Field Experiments using Clay Powder of sizes minus 1/4 inch and minus 1/8 inch for the Sand-Clay Base Courses

Sl. No.	Name of tests	Results of tests: using clay powder minus 1/4 in. size				using clay powder minus 1/8 in. size			
		11/1	11/2	11/3	11/4	11/5	11/6	11/7	11/8
1.	**Field Density in Lb per cu. ft.**								
	165 ft (right)*	122.1	121.4	122.5	125.2	120.7	126.0	126.2	124.7
	330 ft (left)	121.4	124.4	120.3	123.8	120.3	123.8	124.3	125.2
	495 ft (right)	125.0	124.5	122.1	125.0	121.4	121.4	123.2	124.1
	660 ft (left)	122.8	121.3	122.1	120.1	125.0	125.6	125.1	121.7
	Average	122.8	122.9	121.75	123.50	121.9	125.6	124.7	123.9
2.	**North Dakota Cone Bearing Power after Soaking in Water for 3 days Lb per sq. in.**								
	165 ft (right)	270	270	260	280	265	290	270	270
	330 ft (left)	270	270	290	265	290	290	270	290
	495 ft (right)	290	270	280	270	300	290	280	290
	660 ft (left)	280	270	270	265	270	270	200	295
	Average	277.5	270	275	270	281.5	285	277.5	278.7
3.	**Percentage of Moisture Absorbed after Soaking in Water for 3 days, per cent**								
	165 ft (right)	11.80	11.30	11.8	11.1	11.8	11.5	11.5	11.9
	330 ft (left)	11.20	11.30	11.1	11.2	11.1	12.3	11.2	17.3
	495 ft (right)	11.70	11.10	11.7	12.3	12.3	11.7	11.70	11.1
	660 ft (left)	11.90	11.80	11.8	11.7	11.2	11.0	11.60	12.7
	Average	11.55	11.78	11.73	11.83	11.3	11.675	11.55	11.75

* Four test points were located at equal intervals in each furlong at 6 ft distances alternatively to the right and left of the centre line of the road.

to the presence of large amounts of common salt (chlorides of sodium, magnesium and iron, about 2 to 10 per cent). The change from a plastic to a friable soil due to presence of salts as sodium chloride is defined by Baver as follows [11]:

> "The properties of different alkali soils vary, dependant upon flocculation effects that are produced by the presence of excess salts. Even though an abundance of sodium ions is characteristic of all alkali soils, the influence of sodium on the physical properties depends upon the nature of the sodium compounds that are present. For example, white alkali soils contain sodium on the exchange complex and an excess of sodium salts (*Nacl*, Na_2SO_4) in solution. These soils are fairly friable and are not highly dispersed. The reason for this friability is found in the flocculating effects of the excess salts. The presence of sodium salts causes a repression of the 'ionization' (thickness of electrical double layer) of the absorbed sodium ions. This causes a decrease in potential, hydration, swelling and dispersity. The colloidal material is flocculated."

9.2. The result of laboratory study on the influence of salt on the consistency properties and pulverization characteristics of the clay soils are given in Tables 7, 8 and Fig. 9. The procedure for laboratory study is given below.

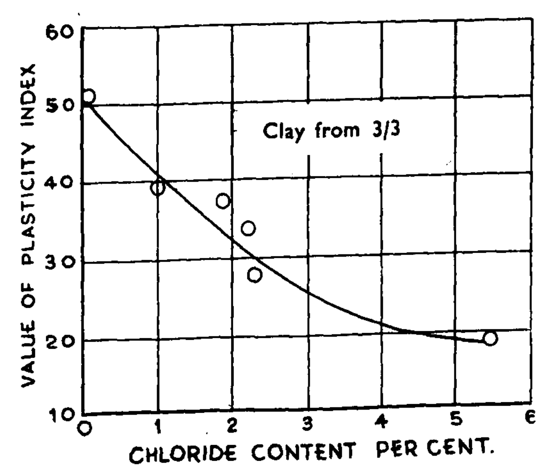


Fig. 9. Variation in Plasticity Index of clay soil with change in chloride content

TABLE 7

The Influence of the Presence of Common Salt on the Plasticity and Pulverization Characteristics of Clay Soils

Sl. No.	Description and location of clay sample	Soluble salts mostly (chlorides) Per cent	Sodium chloride Per cent	Plasticity index		Base exchange (salt free soil) milli equivalents/100 gm. of soil			Pulverization index	
				with salt	without salt	Total	*Ca*	*Na* + *K*	with salt Per cent	without salt Per cent
1.	Grey clay from 2/6	8.1	4.3	31.6	43.2	20.6	10	4.6		
2.	Dark grey clay from 3/3	10.1	2	45.2	52.0	18.0	10	3.2	38	9
3.	Light grey clay from 8/7	4.2	3	15.9	20.6	16.7	12.5	3.9		
4.	Light brown clay from 11/4	2.3	1.6	15.7	18.1	17.9	15	1.8		

TABLE 8

The Variations in the consistency Properties of a very Salty Binder Soil obtained and not used

Sl. No.	Description of samples and nature of treatment	Soluble chloride content Per cent	Liquid limit Per cent	Plastic limit Per cent	Plasticity index Per cent
1.	Natural clay	5.47	39.7	22.4	17.3
2.	After 3 washings with distilled water	2.28	53.5	27.1	26.4
3.	After 4 washings with distilled water	2.23	59.8	27.2	32.6
4.	,, 5 ,,	1.90	63.5	27.8	35.7
5.	,, 6 ,,	1.008	67.8	29.8	38.0
6.	After a large number of washings with distilled water	0.142	74.1	23.4	50.7

A sample of clay soil containing salt was mixed with water up to the liquid limit consistency and dried to constant weights at 110 deg. C. One pound of the dry clay aggregates passing ¾ in. and retained on ½ in. sieve was taken in a Proctor mould and subjected to 10 blows by Proctor rammer at each of the top and bottom surfaces and sieved through a ⅛ in. sieve. The material passing is expressed as a percentage of the total taken for test and may be termed the 'Pulverization Index' of the soil. The test was repeated on the same soil freed from salts. The soil with salt content showed higher values of pulverization index or say a higher susceptibility to pulverization than the same soil free from the salts. The presence of common salt (chlorides) results in a high reduction in the plasticity index values [14]. In one case, Fig. 9, the value decreased from 50.7 to 17.3 due to presence of the salts. Leaching washes away the salt and hydrolyses the clay, which results in the formation of a plastic jelly mass [12].

9.3. Besides improving the susceptibility to pulverization and mixing, the presence of common salt facilitates the retention of mixing water, retards evaporation and enables a better moisture control during the construction operations [1, 3]. Being a soluble binder, it acts as a cementing medium owing to an

interlacing of salt crystals formed in dry weather [1,10]. This was specially advantageous in maintaining the base course in a fairly good condition until the wearing surface was laid.

This study has led to two important observations of vital practical significance, viz.:

(a) Addition of common salt to a clay soil may reduce its plasticity characteristics and thus improve its susceptibility to pulverization and mixing.

(b) The mechanical stability of a soil that contains common salt and that is liable to leaching during its service may be adversely affected with the reduction in the salt content.

10. PROGRESS OF STABILIZATION WORK

10.1. The average outturn per day for the base course with 110 to 130 men mazdoors and mechanical equipment of 1 grader, 1 smooth-wheeled power roller, 1 water lorry and 1 water pump was half a furlong and the maximum that could be done was about 440 feet. The machinery could not be utilised for the full 8 working hours of the day. Attempts to increase the outturn to about one furlong per day by reducing the idling time have shown that, by the time the mix is spread and brought to camber and grade at the end of a section, the soil at the starting end gets dried up resulting in a moisture content less than the optimum. Overcoming this difficulty entails employment of additional manual labour, which becomes rather unwieldy and more expensive per unit.

10.2. A second alternative is to undertake work simultaneously at two places within a maximum distance of say, one mile. Two sets of manual labour can be employed so that the machanical equipment can be used in both the places for the full time. This is possible, provided the collection of materials is already complete and adequate supervisory staff is available. On the other hand, if the collection is to proceed simultaneously with the processing work, a fleet of not less than 10 transport lorries would be required to attend to the collection of about 90 to 100 lorry loads of materials per furlong per day.

11. WEARING COURSE

11.1. Because of the existence of iron-tyred traffic, the sand-clay surface would not withstand abrasion and could serve

only as a foundation course. The central twelve feet of the base course was covered with a water-bound macadam surface, 3½ in. thick (compacted). The shoulders were provided with a stabilized moorum-sand mix, 2 ft 6 in. by 3½ in. thick.

11.2. Design of Stabilized Moorum-Sand Mix for Berms

While stabilized soil has serious limitations in its usefulness as a wearing course due to the existence of iron-tyred traffic in this State, a combination of moorum and sand appears to hold out some promise that is yet to be fully determined. Field experiments conducted earlier elsewhere in the composite Madras State had shown encouraging results. In the recommended practices in the U.K. and U.S.A., grading limits are specified for granular surface courses [3,4]. The plasticity indices are to be between 4 and 9 and the liquid limit of the binder soil is not to exceed 35. Because of the comparatively drier and warmer climate in Madras State, higher values of plasticity index appear necessary.

A combination of moorum and sand showing a high density and bearing power was selected for the design mix. The value of plasticity index as determined from Hogentogler's formula was 9.04. The results of tests on the moorum, sand and their combinations are given in Table 9. The curve for the design mix adopted is shown in Fig. 10, with the recommended limits for corresponding maximum particle size in the U.K. practice. The grading curve is mostly outside the recommended limits but satisfies the requirements of the finer sizes [9].

11.3. Construction of Wearing Surface

The base course of sand-clay was dry cured for about 5 days, and moorum ¼ in. thick was spread for a central width of 12 feet. Broken metal, 2 in. I.R.C. size, was spread to a loose thickness of 4 in. and the surface was brought to proper camber. Simultaneously, moorum and sand required for the berms were collected in proper proportions, windrowed, "dry mixed" and "wet mixed" in the manner described for the base course. The wet mix was spread on the berms on either side of the metal edge and compacted with a power roller. The metalled portion at the centre was "dry rolled", profusely watered and "wet rolled". The surface was brought to proper camber by filling in depressions, if any. Moorum, ¾ in. thick, was spread uniformly on the top of the rolled surface and edge bunds were formed on the moorum-sand mix in the berms. The metalled surface was profusely watered and rolled until a cream of the moorum was formed over the entire surface.

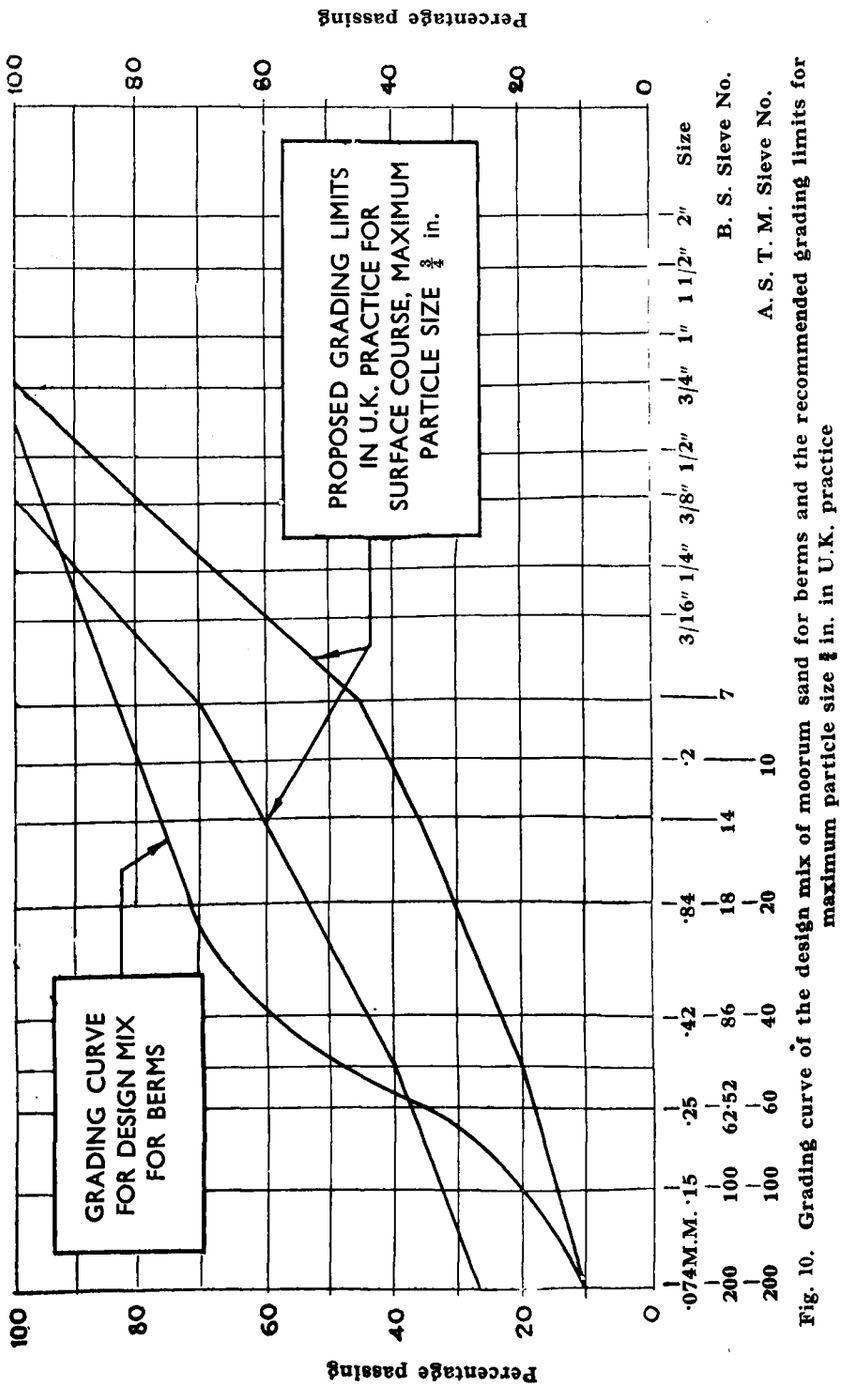


Fig. 10. Grading curve of the design mix of moorum sand for berms and the recommended grading limits for maximum particle size ¾ in. in U.K. practice

TABLE 9

Design of Moorum—Sand mix for the Berms—Mile 1/5—13/2

Sl. No.	Particulars of test etc.	Sand A	Moorum B	Combinations of sand and moorum		
				A+B	1½A+B	2A+B
1.	Plasticity index*		23.1	9.04	6.9	5.5
2.	Percentage passing					
	ASTM sieve ¾ in. size	100	100	100	100	100
	½ in. size	100	96.8	98.4	98.72	98.93
	¼ in. size	100	87.4	93.7	94.96	95.80
	3/16 in. size	100	79.6	89.8	91.84	93.20
	ASTM sieve No. 10	100	61.7	80.9	84.7	87.3
	40	74.6	48.0	61.3	64.2	66.0
	60	35.9	38.4	37.2	37.0	36.80
	100	6.8	30.2	18.5	16.2	14.3
	200	0.4	19.2	9.8	7.9	6.7
3.	Proctor density lb per cu. ft.	109.1	127.0	128.8	128.4	118.3
4.	Optimum moisture per cent	6.0	7.8	9.5	10.2	8.5
5.	Field density lb per cu. ft.	—	127.4	127.0	127.0	118.4
6.	North Dakota Cone bearing power soon after compaction lb per sq. in.	—	1440	520	520	360
7.	North Dakota Cone bearing power after soaking for 3 days lb per sq. in.	—	360	380	243	243
8.	Moisture absorbed after 3 days soaking per cent		22.6	13.1	14.1	13.9

* Calculated from Hogentogler's formula; see foot note under Table 2.

Sand was blinded to a thickness of $\frac{1}{4}$ in. over the rolled surface. The berms were resectioned and trimmed to proper camber and level. The moorum-sand mix was allowed to dry and moisture content was at its optimum. The full width of the road from end to end of the berms was rolled and opened to traffic. The macadam surface was kept moist by watering for fifteen days continuously.

12. PRESENT CONDITION

12.1 Traffic

The census taken in May 1954 shows a traffic intensity of 900 tons per day, both pneumatic and iron-tyred.

12.2. Foundation and Wearing Surface

The foundations are standing extremely well. Due to heavy traffic in the reach from 1/5 to 2/0, the water-bound macadam wearing surface had worn out and a renewal of 2 in. was provided in the year 1953–54. (In 1954–55, pre-coated chipping carpet was provided for the reach 1/5 to 6/0). No improvements were effected in the other reaches of the road since its construction in December 1952. The moorum-sand mix used for the berms has become loose due to use by traffic. For the moisture and climatic conditions obtaining in the road, it is essential to maintain the stabilized berms by periodical watering and compaction. Also a greater quantity of binder material than what was actually used appears necessary.

13. COST

13.1. The total expenditure incurred on the project was Rs 502,000, of which stabilized foundations and berms cost Rs 127,480. This amount includes the hire charges of about Rs 48,468 credited to the machinery used on the job. Appendix 2 gives the expenditure and cost analyses for various items of work and hire charges for the machinery. The actual expenditure incurred for the sand-clay base course, 18 ft by 5 in., was Rs 7,823 per mile and that for the stabilized moorum-sand berms, 2 ft by 6 in. by $3\frac{1}{2}$ in., was Rs 2,762 per mile.

13.2. A comparison of the expenditure incurred for the stabilized soil base course, 18 ft by 5 in., and the estimated cost for conventional stone soling using limestone, 13 ft by 6 in., is given in Appendix 3. Provision of stabilized soil foundations resulted in a savings of about Rs 7,291 per mile.

14. CONCLUSIONS

14.1. The laboratory-cum-field experience and observations made in the stabilized soil work in the formation of Tuticorin-Tiruchendur Road permit the following conclusions:

(a) In areas where conventional stone soling is costly and where suitable soil materials are available locally, stabilized soil can be used for foundations of roads as an economical alternative.

(b) Granular soils with a maximum particle size as small as 0.43 mm. can be mechanically stabilized. For such soils, while consistency requirements assume critical importance, particle size gradation considerations are of little significance.

(c) Presence of common salt (chlorides) in a clay soil reduces the plasticity index and improves its susceptibility to pulverization and mixing. Because of a wide occurrence of sand and saltish clay in close proximities in the southern and south-eastern coastal regions of the State, a successful extension of the sand-clay stabilization in the areas holds out excellent possibilities.

(d) The improvement in the workability of clay soils by the addition of common salt (chlorides) is of immense practical significance especially in evolving methods of stabilizing highly plastic soils as black cotton clays. However, the limitations arising out of possible leaching of the salts, especially when used in surface courses, and the interaction of the salts on the stability of the systems should be adequately realized.

(e) The degree of pulverization specified for adoption in the Madras State, viz., to reduce 100 per cent of the clay binder to pass a $\frac{1}{8}$ in. sieve, is rather conservative. The successful behaviour of the

experimental reaches in the five furlongs with a maximum particle size of ½ in. shows that the present specification in respect of pulverization may be modified.

(f) A rational and scientific basis for the design of stabilized soil mixes appears to consist in studying the swelling characteristics of the mixtures as indicated by Wooltorton and evaluating the values of the plasticity index on a suitable modification of the methods indicated by Pereira but taking in either case the minus 200 fraction, which does not change appreciably in its test constants due to artificial mixing of coarse and fine soils or due to presence of non-plastic 40/200* fractions.

(g) The limited data on the usefulness of moorum-sand mix for wearing surface indicate that a higher amount of binder soil than what is recommended in western practice may be necessary and that constant maintenance by grading, watering, and compacting is indispensable.

(h) There exists a dire need for a close systematization of the manual and mechanical labour so that the machinery used on the job is utilized with a minimum idling time.

(i) Co-ordinated control of the work by both the field and laboratory staff is indispensable for a successful undertaking of a stabilization project from a practical as well as a research point of view.

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* Passing ASTM sieve No. 40 and retained on ASTM sieve No. 200.

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APPENDIX 1

LIST OF EQUIPMENT FOR FIELD SOILS LABORATORY WITH APPROXIMATE COSTS

S. No.	Name of equipment	No. required	Approximate cost Rs
1.	Standard A. S. T. M. sieves No. 10, 40, 60, 100 and 200	1 set	300
2.	Liquid limit apparatus	1	200
3.	Proctor density mould with rammer	1	450
4.	Cone Penetrometer (North Dakota Type) with weights 10, 20 and 40 lb	1 set	450
5.	Sand density bottle	1	150
6.	Balance 500 gm. capacity	1	300
7.	Balance 200 lb capacity	1	450
8.	Stove or burner	1	40
9.	Miscellaneous items as furniture, trays, measuring jars, sample containers, cans and plates for moisture determination, standard forms, etc.	Lump sum	160
		Total Rs	2,500

APPENDIX

COSTS

TABLE 1

Abstract of Expenditure

	Items of work	Expenditure Rupees
1.	Road formation (inclusive of earthwork for the earthen shoulders)	45,000
2.	Soil stabilization (for foundation courses and berms)	127,480
3.	Water-bound macadam wearing surface	122,815
4.	Grass edging	5,000
5.	Culverts and causeways	134,850
6.	Temporary bridges (to facilitate work while execution)	10,000
7.	Mile and furlong stones	655
8.	Major supervision charges	20,000
9.	Petty supervision charges and contingencies	22,000
10.	Conveyance as jeep etc.,	5,000
11.	Camp arrangements and laboratory charges	5,668
12.	One per cent centage charges on item other than lump sum	3,532
	Total	502,000

Appendix 2 (*Contd.*)

TABLE 2

Cost Analysis of Materials for the Stabilization Works

Reach in miles	COST IN RUPEES: Strengthening the subgrade			Sand-blanket course			Sand-clay base course			Moorum-sand berms		
	Mate-rials	Process-ing	Total	Mate-rials	Process-ing	Total	Mate-rials	Process-ing	Total	Mate-rials	Process-ing	Total
1/5—3/2 ...	198	110	308	4,270	893	5,163	12,678	7,688	20,366	2,892	1,313	4,205
3/3—6/0 ...	175	165	340	—	—	—	10,297	7,963	18,260	4,332	1,991	6,323
6/0—8/0 ...	—	—	—	—	—	—	7,868	5,813	13,681	4,002	1,453	5,455
8/0—11/0 ...	—	—	—	435	198	633	12,285	9,000	21,285	6,961	2,250	9,211
11/0—13/3 ...	—	—	—	435	198	633	8,520	6,874	15,394	4,504	1,719	6,223
Total 1/5-13/2	373	275	648*	5,140	1,289	6,429**	51,648	37,338	88,986†	22,691	8,725	3,317@
Rate for Labour	at 0.6.9 per100 sq. ft.			at 0.7.9 per 100 sq. ft. Vide Table 3, Appendix 2			at 3.2.6 per 100 sq. ft. for 5 in com-pacted thickness. Vide Table 3, Appendix 2			at 2.13.6 per 100 sq. ft. for 3 in compacted thickness. Vide Table 3, Appendix 2		
Cost per mile in rupees	864			3,673			7,823			2,762		

* for nearly 6 furlongs ** for 14 furlongs † for nearly 11 miles & 3 furlongs @ for 11 miles and 3 furlongs

TABLE 3 Appendix 2 (*Contd.*)

Observed Rates for Labour for Various Items of Soil Stabilization

Quantity	Description of work	Rate	Per	Amount
	(A) PREPARING AND STRENGTHENING SANDY SUBGRADE WITH CLAY POWDER SIZE MINUS ½ IN. EXCLUDING COST OF MATERIALS 660 ft × 20 ft × 2 in. to 4 in. thick			
16 No.	Man mazdoors for spreading clay powder (minus ½ in.) for 1 in. to 2 in. thickness i.e. 1100 to 2200 cu. ft. ...	1-4-0	each	20 0 0
1 No. for 1½ hours	Grader ...	91	for 8 hour day	17 1 0
1 No. for 1 hour	Smooth-wheeled power roller ...	60	do.	7 8 0
	Watering charges ...	L.S.		10 0 0
	Sundries ...	L.S.		0 7 0
	Total per furlong ...			55 0 0
	Total cost per mile ...			440 0 0
	Cost per 100 sq. ft. ...			0 6 9
	(B) (i) LAYING BLANKET COURSE OF SAND EXCLUDING COST OF MATERIALS 660 ft × 20 ft × 4 in. to 6 in. thick			
30 No.	Man mazdoors for spreading and cambering the surface ...	1-4-0	each	37 8 0
1 No. for 1 hour	Grader ...	91	8 hour day	11 6 0
1 No. for ½ hour	Smooth-wheeled power roller ...	60	do.	3 12 0
	Watering charges ...	L.S.		10 0 0
	Sundries and unforeseen charges	L.S.		1 2 0
	Total per furlong ...			63 12 0
	Total cost per mile ...			510 0 0
	Cost per 100 sq. ft. ...			0 7 9

TABLE 3 (*Contd.*) Appendix 2 (*Contd.*)

Quantity	Description of work	Rate	Per	Amount
	(ii) LAYING BLANKET COURSE OF SAND EXCLUDING COST OF MATERIALS 660 ft × 20 ft × 2 in. to 4 in. thick			
20 No.	Man mazdoors for spreading sand and cambering the surface ...	1-4-0	each	25 0 0
1 No. for 1 hour	Grader ...	91	8-hour day	11 6 0
1 No. for ½ hour	Roller	60	do.	3 12 0
	Sundries and unforeseen charges	L.S.		0 6 0
	Total per furlong ...			49 8 0
	Total cost per mile ...			396 0 0
	Cost per 100 sq. ft. ...			0 6 0
	(C) (i) LAYING SAND CLAY BASE COURSE IN TWO LAYERS EXCLUDING COST OF MATERIALS 660 ft × 18 ft × 5 in.			
	Labour for windrowing sand and clay in proper proportions, dry and wet mixing, and spreading as per C (ii) below...	220		220 0 0
	Grader ...	91	Day	45 8 0
1 No. for ½ day	Smooth-wheeled power roller ...	60	,,	60 0 0
1 No. for 1 day	Watering charges ...	L.S.		30 0 0
	Laboratory charges ...	L.S.		18 12 0
	Sundries ...	L.S.		0 12 0
	Total ...			375 0 0
	Total cost per mile ...			3,000 0 0
	Total cost per 100 sq. ft. ...			3 2 6
	Cost per 100 sq. ft. for 2½ in. to 3 in. thick, i.e. one layer ...			1 9 3

TABLE 3 (*Contd.*) Appendix 2 (*Contd.*)

Quantity	Description of work	Rate	Per	Amount
	(ii) LABOUR TOWARDS FIRST ITEM IN (C) (i)			
8 No.	Man mazdoors for windrowing ... Windrowing clay powder over windrowed sand	1- 4-0	each	10 0 0
8 No.	Man mazdoors ...	1- 4-0	each	10 0 0
16 No.	Boy mazdoors ...	0-10-0	,,	10 0 0
40 No.	Man mazdoors for dry mixing the sand and clay ...	1- 4-0	,,	50 0 0
50 No.	Man mazdoors for wet mixing ...	1- 4-0		62 8 0
60 No.	Man mazdoors for spreading the wet mixing ...	1- 4-0	,,	75 0 0
	Sundries ...	L.S.		2 8 0
				220 0 0
	D (i) LAYING MOORUM-SAND BERMS EXCLUDING COST OF MATERIALS 2 × 660 ft × 2 ft 6 in. × 3½ in. thick			
	Labour charges towards windrowing moorum and sand in proper proportions dry and wet mixing spreading as per D (ii) below.			68 0 0
1 No. for 2 hours	Smooth-wheeled power roller ...	60	8-hour day	15 0 0
	Watering charges ...	L.S.		10 0 0
	Sundries ...	L.S.		0 12 0
	Total ...			93 12 0
	Cost per mile ...			750 0 0
	Cost per 100 sq. ft.			2 13 6

TABLE 3 (*Contd.*) Appendix 2 (*Contd.*)

Quantity	Description of work	Rate	Per	Amount
	D (ii) LABOUR TOWARDS WINDROWING MOORUM AND SAND IN PROPER PROPORTIONS DRY AND WET MIXING AND SPREADING AGAINST FIRST ITEM IN D (i)			
1 No.	Man mazdoors for windrowing 7 units of sand and 7 units of moorum	1- 4-0	each	1 4 0
3 No.	Man mazdoors	1- 4-0	,,	3 12 0
10 No.	Boy mazdoors	0-10-0	,,	6 4 0
8 No.	Man mazdoors for dry mixing moorum and sand	1- 4-0	,,	10 0 0
13 No.	Man mazdoors for wet mixing moorum and sand spreading the wet mix and cambering	1- 4-0	,,	16 4 0
6 No.	Man mazdoors	1- 4-0	,,	7 8 0
20 No.	Boy mazdoors	0-10-0	,,	12 8 0
2 No.	Man mazdoors for edge bunding	1- 4-0	,,	2 8 0
6 No.	Man mazdoors for sectioning the berms after laying wearing course	1- 4-0	,,	7 8 0
	Sundries			0 8 0
		Total		68 0 0

Appendix 2 (*Contd.*)

TABLE 4
HIRE CHARGES FOR PLANT

Sl. No.	Name of the plant	Charges for less than 8 hours per day			Charges for 8-hour day			Total Amount			Total for each plant			Remarks
		No. of days	No. of hours	Amount	No. of days	No. of hours	Amount							
1	Bull Dozer	3	15	185 0 0	94	752	9,519 0	9,704	0		9,704	0		For each work for formation.
2	Grader	256	649	7,415 0 0	40	320	3,640 0	11,055	0		11,055	0		Rs 3,000 for formation and Rs 8,055 for foundation work including strengthening of subgrade.
3	Lorries No. 8703	183	732	4,314 0	11	88	281 8	4,595	8		36,520	2		For foundation work including strengthening of the subgrade and for berms.
	2621	111	444	2,658 0	52	416	1,543 0	4,201	0					
	8694	260	1040	5,851 0	7	56	203 0	6,054	0					
	1874	151	604	3,499 0	57	456	1,513 2	5,012	2					
	8859	154	616	3,611 0	46	368	1,361 8	3,972	8					
	8921	124	496	3,415 0	67	536	2,348 0	5,763	0					
	8643	62	248	1,106 0	119	952	3,445 0	4,551	0					
	8587	34	136	670 0	25	200	701 0	1,371	0					
4	Rollers No. 273	231	347½	2,625 4	3	25	187 8	2,812	12		2,812	12		For macadam consolidation.
		232	145	461¼ 3,465 12	7	57	427 8	3,893	4		3,893	4		Used for foundation work including strengthening of the subgrade and for berms.
											Total hire charges for the work		Rs 63,985	2
											Total hire charges for foundation work alone		Rs 48,468	6

Appendix 3

COMPARISON OF THE COSTS OF CONVENTIONAL STONE SOLING 13 ft × 6 in. AND STABILIZED SOIL FOUNDATIONS 18 ft × 5 in.

Reach	Details	Rate per 100 cu. ft.	Cost per mile Rs
	Base of Stone Soling 13 ft × 6 in.		
1/5–6/0	$8 \times 660 \times 13 \times \frac{1}{2} \times 4\frac{1}{2} = 154{,}440$ cu. ft. 40/14/- Lime stone soling		63,127
6/0–13/2	$8 \times 660 \times 13 \times \frac{1}{2} \times 7\frac{1}{4} = 248{,}820$ cu. ft. 46/0/0		114,457
		Total	177,584
	Average cost per mile		15,114
	Base of Stabilized Sand-Clay 18 ft × 5 in.		
1/5–13/2	Average cost per mile vide Table 2, Appendix 2		7,823
	Savings per mile		7,291

DATA FOR LIMESTONE SOLING 100 cu. ft. (6 in. thick).

Quantity cu. ft.	Size	Description of work	Rate per 100 cu. ft.	Amount
		Reach 1/5–6/0.		
100	6 in. thickness	Limestone soling	7 13 0	7 13 0
110	–do–	Lead 3 miles cart track	12 0 0	12 0 0
110	–do–	Lead 9½ miles by lorry at Rs 2 per mile	19 0 0	20 13 0
		Total		40 14 0
		Reach 6/0–13/2.		
100	–do–	Limestone soling	7 13 0	7 13 0
110	–do–	Lead 4 miles cart track	15 12 0	17 5 0
110	–do–	Lead of 9½ miles by lorry at Rs 2 per mile	19 0 0	20 14 0
		Total		46 0 0

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New Features for the Merton Overloader

After two years of success in Britain and in the 22 countries to which it has been exported the British made Merton Overloader now has several important new features. As a result of this success Merton Overloaders are now being exported to the United States of America, Canada and parts of South America. The sole concessionaires in the United Kingdom and in the Americas are Mackay Industrial Equipment Ltd., of Faggs Road, Feltham, Middlesex, who tell us that this is the only British construction equipment now being exported to the U. S. A.

The improved Merton Overloader—the only British construction plant being exported to the U.S.A.

The bucket of the new Merton Overloader, Mark V, has a capacity of ¾ cu. yd. and covers the full width of the front wheels of the tractor. This eliminates any tendency for the front wheels to ride up on the material being loaded and also greatly increases the efficiency of the machine when excavating.

The digging depth of the bucket can be adjusted, simply by the removal and replacement of two bolts, to any position between 2 in. above ground level and 4 in. below ground level. The adjustment to 2 in. above the horizontal will simplify the operation of the machine when it is loading a stockpile on uneven ground when it is important that water or foreign matter from the base should not be mixed with the material being loaded.

The discharge height of the Merton Overloader is now variable. A small hand winch, operated by one man, raises and lowers the overhead structure of the machine by extending and retracting the telescopic rear upright members so that the bucket can be discharged at any height from a minimum of 6 ft. 11 in. to a maximum of 11 ft. 2 in. To change from minimum to maximum discharge heights takes only three minutes and entails the removal and replacement of only four bolts. The reach of the bucket, that is the distance from the inside edge of the bucket when in the discharge position to the rearmost part of the tractor (the tyres), is 3 ft. 6 in. when in the minimum discharge position and 2 ft. when in the maximum discharge position.

From the minimum discharge position the overhead structure can be lowered still further to the travelling position giving the machine an overall height of 8 ft. 5 in.

An enclosed cab is now a standard fitment on the Merton Overloader. It is constructed of heavy gauge sheet steel and fitted with toughened safety glass windows, which give the operator excellent all round vision. The turning radius of the Mark V Merton Overloader is the same as that of the Mark IV—17 ft. 6 in.

A light materials bucket of 1 cu. yd. capacity is available as an optional extra. Other optional equipments are a 6 ft. 9 in. bulldozer blade and a one ton capacity crane hook attachment.

The Merton Overloader of course, does not turn or slew, it shuttles backwards and forwards in a straight line between stockpile and lorry. The power unit is the Fordson Major diesel engine.

The complete cycle from loading the bucket to discharging and back to loading takes 15-20 sec., and during this time the machine can also travel backwards and forwards a distance of twelve yards. It is claimed that it can load blasted rock at the quarry face at the rate of one ton per minute or sand from a stockpile at the rate of 5 cu. yd. in 2¼ minutes.