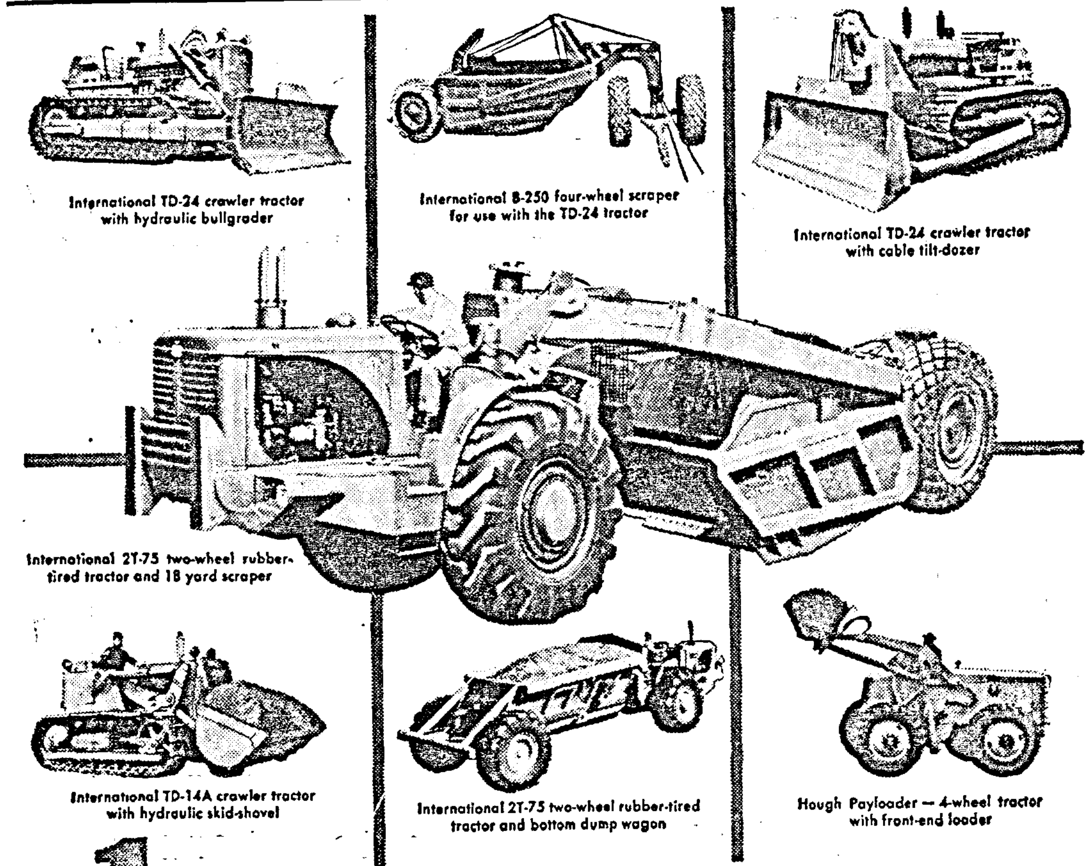
TRANSPORT-COMMUNICATIONS

MONTHLY REVIEW

FEBRUARY 1955—No. 94

INDIAN ROADS CONGRESS
TRANSPORT IS CIVILIZATION

INDIAN ROADS CONGRESS, NEW DELHI.



1 source of supply for ALL your EARTHMOVING equipment

Now — grouped under the world-famous IH symbol — International offers a complete line of heavy-duty machines for every phase of earthmoving. This means that now, more than ever, your International Industrial Power distributor is your "Earthmoving Headquarters"— a single source of supply for machines, service and parts.

You'll find the right equipment to power your job faster, better and more profitably — backed up by unsurpassed service facilities and parts supplies to keep your equipment operating. You cut downtime, pile up profit-time *every time* with International.

A demonstration will prove that it's International "Power That Pays"—see your IH distributor today. International Harvester Export Company, Chicago 1, U.S.A.

- Seven powerful crawler tractors headed by the giant TD-24
- Twenty-two matching hydraulic and cable controlled bulldozers, bullgraders and tilt-dozers
- Four 4-wheel scrapers matched for use with the TD-24 and TD-18A tractors
- Two high-speed, 2-wheel rubber-tired tractors with 18 and 13 yard scrapers
- High-speed bottom dump wagon with 20 yard capacity matched to the 2T-75 tractor
- Eighteen 6 and 4 cylinder diesel and carbureted power units
- A complete line of auxiliary equipment including cable control units, generators, pumps, pipebooms, skid and dozer shovels

VOLTAS

VOLTAS LIMITED

Successors to the Engineering and Import Divisions of Volkart Brothers

BOMBAY - CALCUTTA - MADRAS - COCHIN
NEW DELHI - LUCKNOW - AHMEDABAD - SECUNDERABAD

INTERNATIONAL HARVESTER

BUILDING AND MAINTAINING ROADS with "CATERPILLAR" Diesel Motor Graders

There are thousands of miles of unpaved roads in India, the maintenance of which constitutes a major problem to Government and Municipal bodies. Construction, too, is a part of this problem. Widening, realignment, grade improvement and resurfacing must be carried out if roads are to keep pace with changing needs.

"CATERPILLAR" Diesel Motor Graders are becoming increasingly recognised in India for road building, ditching, bunding and other construction work. They are built not only to perform a wide variety of work but to continue to do that work over extended periods.

"CATERPILLAR" Motor Graders do better work, in less time, at a substantial saving in cost.

Caterpillar

MODEL No. 12	No. 112	No. 212
100 H.P.	75 H.P.	50 H.P.

Caterpillar REGISTERED TRADEMARK

DIESEL ENGINES - TRACTORS MOTOR GRADERS EARTHMOVING EQUIPMENT

Caterpillar Distributors in India

CALCUTTA	BOMBAY	NEW DELHI
TRACTORS (INDIA) LIMITED	LARSEN & TOUBRO LIMITED	WILLCOX (BUCKWELL-INDIA) LIMITED.
P. O. BOX 323	P. O. BOX 278	P. O. BOX 289

Sales and Service

TRANSPORT-COMMUNICATIONS

MONTHLY REVIEW

FEBRUARY 1955—No. 94

TABLE OF CONTENTS

Transport - Communications Monthly Review is published on the 25th of each month by the **Indian Roads Congress, New Delhi.**

This Review is sponsored by the Roads Wing of the Ministry of Transport, but the Government of India accept no responsibility for any views or opinions expressed.

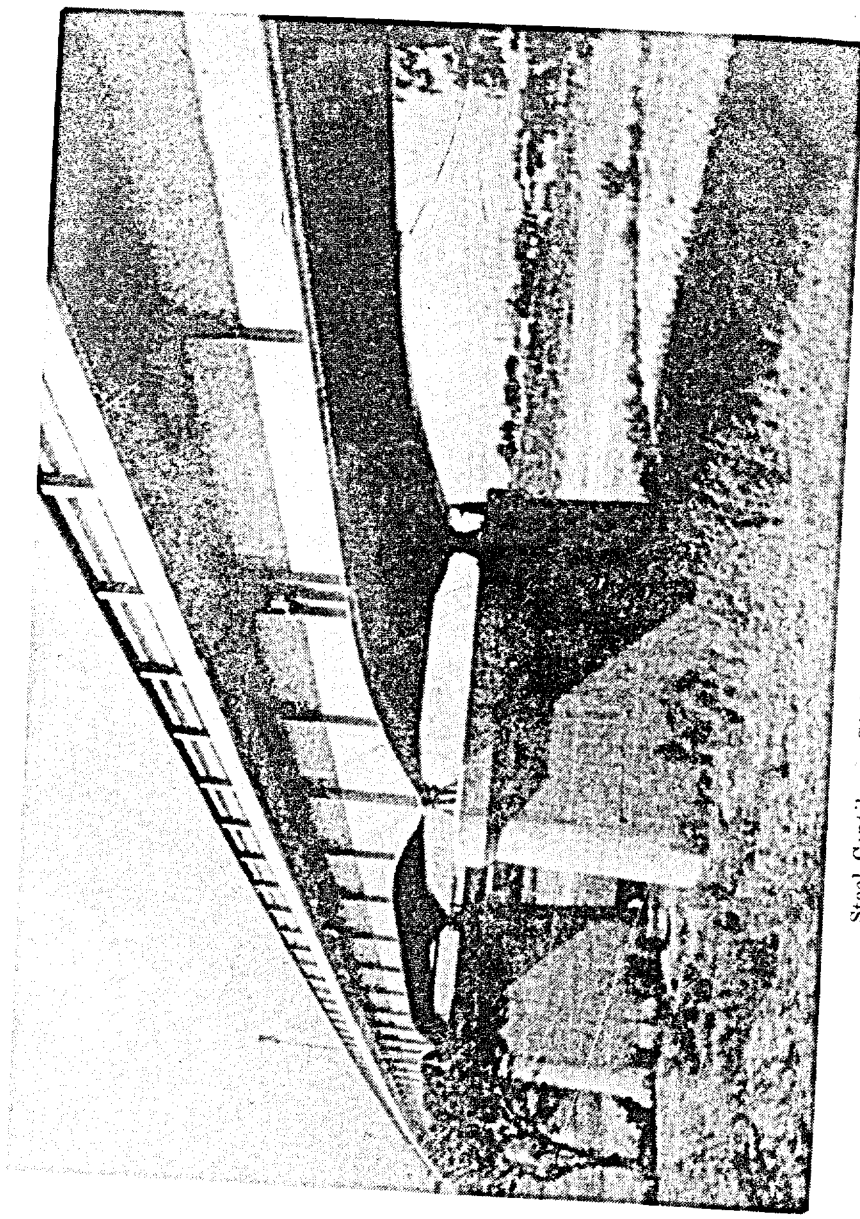
Subscriptions. Annual subscription including postage is Rs Fourteen. Single copy including postage is Rs one and annas four.

To Members of the Indian Roads Congress, Engineering personnel below the rank of an S. D. O. and Engineering students a special reduced subscription rate of Rs 8 per annum is offered. Students are required to apply through the Principal of their College.

Advertisements. Advertising rates per insertion

	Full Page	Half Page
Inside front cover	Rs 100/-	—
Inside back cover	100/-	—
Outside back cover	120/-	—
Ordinary position	75/-	45/-

Detailed rate card can be had on application to the Secretary, Indian Roads Congress, Jamnagar House, Shahjahan Road, New Delhi-2.



Steel Cantilever Girder (all welded) 196.7 m. or 645 ft.
KOYA BRIDGE (Ohashi)—JAPAN—Osaka—Tondabayashi Road.

TRANSPORT-COMMUNICATIONS MONTHLY REVIEW

A REVIEW OF
ROAD ENGINEERING, DEVELOPMENT & TRANSPORT

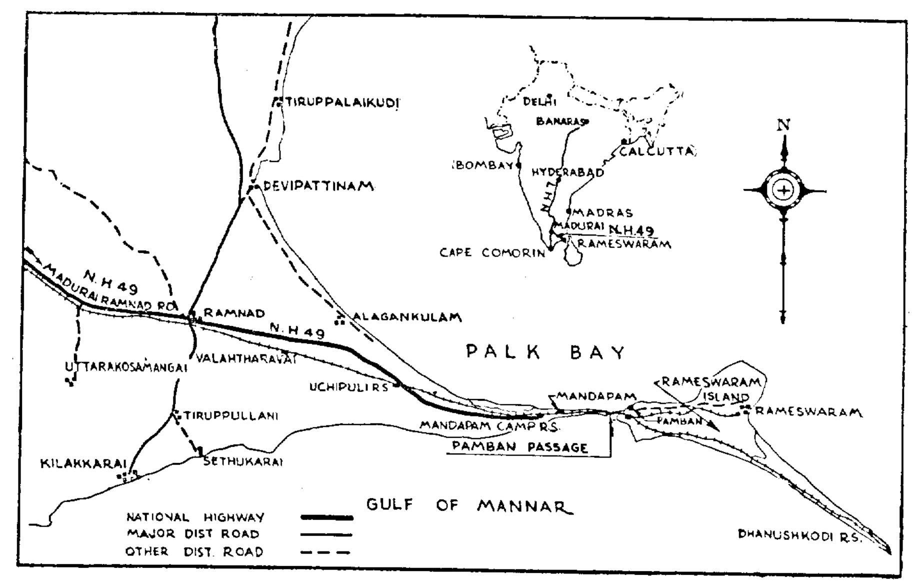
FEBRUARY 1955

THE FORMATION OF RAMNAD-MANDAPAM ROAD USE OF STABILIZED SOIL FOR FOUNDATIONS

(Contributed)

INTRODUCTION

MATHURAI-DHANUSHKODI road, N. H. No. 49, is planned to connect Mathurai with the extreme end of the Indian Union at Dhanushkodi, a Railway terminus and get-off to Ceylon. Dhanushkodi is at the farther end of the Rameswaram island, which is separated from the mainland by the Pamban passage. The Pamban passage is wide and a road bridge across it will be very costly, so the formation of the road has been sanctioned as a first phase upto Mandapam, an important place on the seashore of the mainland. A railway workshop, the Emigration Department of the Ceylon Government, the Central Marine Fisheries Research Station, and a dry dock are located at Mandapam.



LOCATION OF THE ROAD

A road known as Mangamma Salai and classified as Raja Pathai equivalent to present day National Highway was in existence some centuries back between Ramnad and Mandapam but this had deteriorated into a cart track. The present National Highway alignment follows this old road throughout except in some portions where deviations have been effected in order to obtain curves of not less than 1,000 feet radius.

NATURE OF SOIL AND SUB-GRADE MOISTURE CONDITIONS

The surface soil for a major portion of the route from 0/0-16/0 is a medium sand of fairly good grading and the subsoil is a sandy clay occurring at depths of 3 to 6 feet below ground level. In the reach, from 16/0-21/4 the soil varies from sand to lime soil and clay The route is very near the sea coast and is subject to moisture saturation for about two to three months in the year.

STRUCTURAL PROVISIONS

Foundations

In this area there are no metal quarries within economical leads. Good lime stone is available in the Rameswaram island and granite metal is available in Tirupparangundram in Mathurai District. But these have to be transported over long stretches by rail and are very costly. The average costs are Rs 60/- per 100 cu. ft of $1\frac{1}{2}$ to 3 in. lime stone metal and about Rs 90/- per 100 cu. ft of $1\frac{1}{2}$ in. granite metal. If lime stone metal is provided for soling, assuming a width of 14 ft and depth of 6 in. for a 12 ft wide carriagway, the cost of soling per mile will be as under:—

Soling stones at Rs 60/- per 100 cu. ft.

$$\frac{8 \times 660 \times \frac{1}{2} \times 60 \times 14}{100} = \text{Rs } 22{,}176$$

Spreading charges at Rs 3-8-0 per 100 sq. ft.

$$\frac{8 \times 660 \times 14 \times (3\text{-}8\text{-}0)}{100} = \text{Rs } 2{,}587$$

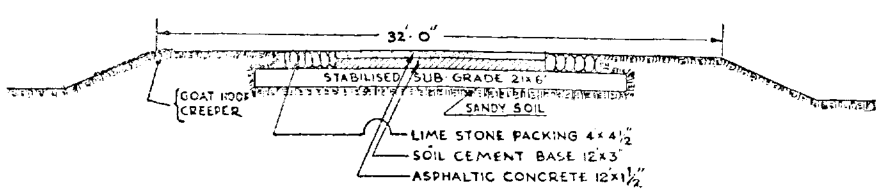
Sundries	= Rs 237
Total cost per mile	= Rs 25,000

Because of the availability of sand and pulverizable sandy clay in close proximities, use of stabilized soil with or without additives such as cement etc. was an alternative. The cost per mile of stabilized soil foundations of sand-clay sub-base (21 ft × 6 in.) and soil-cement base (12 ft × 3 in.) with 8 percent cement by volume is only Rs 11,400/- (3,400 + 8,000). So the latter was adopted.

Wearing Surface

Since stabilized soil would not withstand the direct action of iron-tyred traffic, it has been used only for foundation courses. The wearing surface is asphaltic concrete 12 ft × $1\frac{1}{2}$ in.

A typical cross-section of the road is shown below.



TYPICAL CROSS SECTION

DESIGN AND CONSTRUCTION OF THE ROAD

Because of the relatively new type of work proposed for the foundations, the work was taken up departmentally, except for collection of stone materials which was let on contract.

Formation of the Road

The width of land acquired was 100 ft and the formation was made 32 feet wide

with side slopes of 1 : 2. Bulldozers were used for a major part of the formation work and graders for sectioning. While the cost of formation with machinery was cheaper, manual labour was resorted to in portions where no working space was available for using the machinery and on occasions when the plants were under repair. See Appendix II.

STABILIZED SOIL FOUNDATIONS

Principle: The main object of stabilizing a soil, whatever be the method adopted, is to improve the engineering properties of locally available soils and minimize the detrimental effects due to climatic variations. In general, this is achieved by:

(a) combining the local soils in suitable proportions in order to obtain a well graded material,

(b) adding a stabilizing agent as Portland cement etc. to the natural soils, and

(c) compacting the soils and soil admixtures to high densities at controlled moisture conditions.

Sub-base of Sand-clay, 2 ft × 6 in.

Laboratory Tests Tests were conducted on typical soil samples obtained from each furlong or longer intervals and the combinations of sand and clay that give maximum Proctor density and cone bearing power arrived at.

Construction. The sand subgrade is brought to proper shape and camber by means of a grader. The binder soil (clay) is obtained from borrow pits at the sides and spread to required thickness by manual labour. It is pulverized by first passing disc harrows towed by a tractor with spiked wheels and then by a Seaman Pulvi-Mixer. The pulverized binder soil is then mixed with a suitable depth of sand below. Calculated quantity of water is added either from outside or through the nozzles provided in the spray bar in the mixing chamber of the pulvimixer and wet mixing is done. On completion of wet mixing, the mix is spread and got sectioned to required camber, and subjected to compaction by a sheepsfoot roller towed by a tractor till the sheepsfoot roller rides on the surface with about $\frac{1}{2}$ to 1 in. mulch on the surface. The surface is graded to proper camber, compacted by penumatic tyred roller and then finished with a smooth wheeled power roller 6-8 tons. See Appendix II.

Base Course of Soil-Cement (12 ft × 3 in.)

Tests conducted in the laboratory showed that a combination of one sand plus one clay with 8 per cent cement by volume was quite satisfactory for the reach 0/0-16/0 in respect of both durability and compressive strength (not less than 250 on Proctor samples after moist curing for one week.) The nature of soils in 16/0-21/4 were varying. So mixes were so designed that strength and durability requirements were satisfied. Eight per-cent cement by volume was found to meet the requirements for this reach also.

Processing. Mild Steel channel forms are fixed on either side on the sand-clay sub-base with spikes at 6 ft distance. Requisite quantity of clay is collected and spread to about 8 ft width and is pulverized by a Seamen Pulvimixer. 5 to 6 passes of the Pulvimixer pulverized the clay to a size of less than 1/4 in. It is then collected and stacked in the form of a windrow. Over this, sand soil is spread in proper proportion, the whole conforming to a finished gauge of section $\frac{(5\frac{1}{2}' + 4') \times 1}{2}$. This is lightly spread out and the Seamen mixer is passed over again to obtain an intimate mix of the soils and the mixed materials is formed into a windrow of the size mentioned.

Cement bags are then spotted at 5 ft intervals (for calculations vide Appendix I) on the windrow and emptied. The cement is spread and dry mixed. The soil-cement mixture is formed into a windrow, divided into 5 feet compartments and calculated amount of water, allowing about 2 per cent for construction and evaportion losses, is added. The materials are wet mixed and the wet soil-cement is evenly spread on the road to proper camber.

Compaction is commenced by tyre rolling. As multi-tyred roller is not available, compaction is done with a six wheeled loaded lorry, starting from the edge and working towards the centre. At conclusion of pneumatic tyre rolling, the surface is bladed to proper camber by a grader and finished with a smooth wheeled 6-ton Tandem Roller. On completion of compaction, a core is taken out for testing for density and moisture content and the results are checked with those specified by the laboratory.

The finished surface is covered with sand 2 in. thick, and kept damp for 7 days. A water lorry with a sprinkler is used to keep the sand moist. After completion of moist curing, the sand is removed and the slab is examined for weak spots.

Progress:—The daily out-turn is about 500 feet or 600 sq. ft.

WEARING SURFACE OF ASPHALTIC CONCRETE

The soil-cement base is brushed clean and made free from dust. A priming coat (shell primer No. 2) is applied uniformly at the rate of 15 lb per 100 sq. ft and evenly spread with rubber squeezers. The priming coat is allowed to soak for 24 hours.

The specification for aggregate for wearing surface provides for 12 cu. ft of granite chips (8 cu. ft of ¾ in. I.R.C. size plus 4 cu. ft of 1/2 in. I. R. C. size) and 7 cu. ft of sand per 100 square feet. Asphalt 30/40 is used at 3½ lb per cu. ft of chips and 7 lb per cu. ft of sand with 6¼%. Socosol is added as solvent. The granite metal chips are obtained from Thirumayam Quarry in Thiruchirapalli District and also from Thirupparangundram quarry in Mathurai District.

Mixing:—The mixing is done in a special paddle mixer in batches of 4½ cu. ft each in the specified proportion. The asphalt is heated in a boiler to 350° F the optimum mixing temperature, and the required quantity of socosol is added. The asphalt and the coarse aggregate are then mixed in the paddle mixer.

Laying, Rolling And Finishing:—The asphaltic concrete mix thus prepared is uniformly spread to proper thickness and camber over the soil-cement base and rolled with a flat 8 ton roller till adequate consolidation is obtained. During the initial stages, local undulations, if any, are made up with the asphaltic mix. At the conclusion of final rolling the surface is covered with sand mastic 1/4 in. thick and rerolled to a smooth finish.

In the earlier stages the asphaltic concrete was laid in 2 layers without sand flushing. Laying in two layers was not found to be conducive to economy or facility of construction and asphaltic concrete laid without sand flushing did not produce a desirable smooth finish.

Progress:—The out-turn per day is about 400 running feet or 4,800 sq. ft.

OTHER WORKS LIKE CEMENT CONCRETE EDGING, METAL SHOULDERS, GOAT HOOF CREEPER EDGING ETC.

In order to prevent the ends of the wearing surface from fraying at junctions of cross-roads, cement concrete edging of precast 1 : 2 : 4 cement concrete blocks 3 in. × 4½ in. is done. Lime stone shoulders of 4½ in. compacted thickness are provided on either side of the wearing surface for a width of 3 ft.

As the soil is sandy, grass verges can be maintained in this dry area only by regular watering and this will be costly. In sandy areas goat hoof creeper planting is successful and requires attention only for 3 months. Hence goat hoof creeper edging is provided on the shoulders and the side slopes of the road to minimise formation of gullies due to rains.

EXPERIMENTAL WORKS

Since this is the first work of its kind in India, where stabilized soil is used in such magnitude in road construction, it was considered necessary to make comparative study of the relative efficiency and economy of different specifications for the surface and foundation courses. Experimental stretches of the following specifications were laid in two reaches.

1. 1 in. Premix asphaltic concrete carpet over

(i) 4 in. thick soil-cement base having a cement content of (a) 8 per cent
(b) 6 ,,

(ii) 6 in. thick soil-cement base having a cement content of (a) 6 per cent
(b) 4 ,,
(c) 2½ ,,

2. Carpet 2½ in. thick over (i) and (ii) shown against (1)

3. Sand carpet 3 in. thick over the stabilized soil sub-base.

4. One in. premix asphaltic concrete carpet on 2 in. sand-carpet over stabilized soil sub-base.

5. Two coats of surface dressing on soil-cement base using

(a) 35 lb per 100 sq. ft of binder for the first coat where primer is used and 45 lb per 100 sq. ft where primer is not used.

(b) 25 lb per 100 sq. ft of binder for the 2nd coat or suitable variations in accordance with the nature of binder used.

Progress:—The work was commenced in April '50 and completed in March 1954.

Costs:—The approximate cost of formation is Rs 2510/- per mile by using machinery and Rs 2930/- by manual labour. The cost of providing stabilized soil sub-base 21 ft × 6 in. is Rs 3400/- per mile.

The average cost for soil-cement base, 12 ft × 3 in. thick is Rs 5/- per 100 sq. ft including hire charges for plants but excluding cost of materials. The average cost of asphaltic concrete wearing surface 12 ft × 1½ in. is Rs 6/12/0 per 100 sq. ft including hire charges of plants but excluding cost of materials.

The estimated cost of forming the road and providing stabilized soil sub-base is about Rs 4.6 lakhs and that for soil cement base and asphaltic concrete wearing surface is Rs 10.93 lakhs.

CONCLUSION

The soil stabilization work done in the Ramnad-Mandapam Road is a good example of the use of locally available soils. The work has been done employing a judicious combination of manual labour and machinery. The Pulvimixer employed is the first of its kind in India. A number of field experimental lengths have been constructed and it is hoped that the results obtained would help evolution of economical designs and specifications for soil stabilised roads in India.

APPENDIX I

Calculations for spacing of Cement Bags

The cement requirements as per design is 8 per cent by volume of the compacted base. The quantity of cement required per running foot of roadway = 1 × 12 × 1/4 × 8/100 = 0.24 cu. ft.

Quantity of the soil mix (sand clay : 1 : 1) required for a compacted thickness of 3 in. per running foot of roadway = 1 × 12 × 3/12 : 3.00 cu. ft.

Assuming the dry density of the compacted soil mixes 120 lb per cu. ft weight of dry soil required = 3.00 × 120 = 360 lb.

Assuming that one cu. ft of loose sand or clay clods weighs on an average 80 lb. loose volume of soils required $= \frac{360}{80} = 4.5$ cu. ft.

Add for waste during construction about 15 per cent = 0.25 cu. ft Total = 4.75 cu. ft.

To obtain 4.75 cu. ft the soil materials are stacked in a windrow of dimensions $\frac{(4' + 5\frac{1}{2}') \times 1}{2}$

For 0.24 cu. ft of cement, the quantity of soil required is 4.75 cu. ft.

For one bag or 1.2 cu. ft of cement, the quantity of loose soil required

$$= \frac{4.75 \times 1.2}{0.24} = 23.75 \text{ cu. ft.}$$

Hence the spacing of cement bags is $\frac{23.75}{4.75} = 5$ ft.

APPENDIX II

Machinery and Equipments used in Construction of the Ramnad-Mandapam Road

S. No.	Name of Machinery or equipment.	Number used	Purpose.
1.	BULLDOZERS	2	For earthwork formation and stripping top sand soil to obtain clay.
2.	MOTOR GRADER	1	For sectioning to camber during profile formation and also during soil stabilization.
3.	TRACTOR WITH DISC HARROW	1	For breaking clods in the binder soil required both for sand clay and soil-cement.
4.	TRACTOR WITH SHEEPS-FOOT ROLLER	1	For compaction of sand clay sub-base.
5.	SEAMAN PULVIMIXER	1	For Pulverizing and mixing soils.
6.	TANDEM ROLLER	2	For flat final rolling for the sand-clay and soil-cement.
7.	TAR BOILER	1	For heating asphalt.
8.	MILLER MIXER	1	For mixing asphalt concrete and sand mastic.
9.	M. M. ROLLER	1	For consolidating asphaltic concrete.

Water Pumps—3, and a field laboratory.

DEFINITIONS OF HIGHWAY ENGINEERING TERMS

TURNING RADIUS MINIMUM Radius of the path of the outer front wheel of a vehicle making its sharpest possible turn.

RADIUS OF A CURVE The radius at the point of maximum curvature in a continuous curve of varying radii.

SCIENCE AND ENGINEERING

The dividing line between science and engineering is an indefinite one — a boundary without a fence; but they differ in that the pursuit of engineering unlike that of science, results in something being made — something that is useful, though it may well have other qualities such as elegance and economy.

ROADS IN UTTAR PRADESH

UTTAR Pradesh has an area of over 113,000 square miles, but there are no more than 10,000 miles of metalled and 25,000 miles of earth roads to serve such a vast tract. This works out to only 0.3 mile length of road per square mile. Two-thirds of the length of roads cannot be used during the rainy season. So, for practical purposes there is less than 1/9th of a mile of serviceable road for a square mile of the country. Huge areas of cultu-rable lands lie waste and thousands of villages remain landlocked and isolated from civilization and the barest necessities of life never reach them in time. Hence construction of adequate milage of new roads and improvement of existing ones to modern standards is the most urgent need of the State for promoting and sustaining its developing economy.

National Highways

Some of the most important highways of the State form part of the National Highway route No. 2, 7, 24, 25, 26, 27, and 28, which are maintained and improved at the cost of the Union Government. The annual ordinary expenditure on these roads is of the order of Rs 92 lakhs, of which Rs 46 lakhs spent on maintenance and the balance on upgrading the existing kankar surface to a stone water-bound macadam painted surface and on widening of narrow pavements and formations. In 1953-54 about 75 miles have been improved and 4 miles cement concreted. Working on this programme all the National Highway routes in the State would be modernized within a year or two.

Bridges on National Highways

The construction of new bridges over Baigool and Bhakhra rivers on Meerut-Bareilly road, about 17 miles west of Bareilly, have been completed and opened to traffic.

These bridges are of bow-string girder type which has been adopted for the first time in the State. Proposals for bridging the Ganga at Garh, the Sarju at Ayodhya, the Rapti at Gorakhpur, and the Betwa at Jharatghat are under consideration. The bridge over Karmanasha near the Bihar border is being widened.

There are ferry services working at Garhmukteshwar, Kalpi, Dharaghat, Bridghat and Ayodhya.

Bridges on State Roads

Major Bridges.—About 2,300 Rft of major bridges have been constructed and opened to traffic at a cost of Rs 26 lakhs; 2,700 Rft costing about Rs 36 lakhs are in an advanced state of construction, and 1,900 Rft costing Rs 28 lakhs are being taken up. One of the major bridges being started is over the Alaknanda at Kirtinagar on Hardwar-Badrinath motor road—a steel suspension bridge of 300 ft length, the first of its kind to be built in the State. On completion of this bridge, the great inconvenience caused at present to thousands of pilgrims going every year to Badrinath will be removed. Another important bridge of 325 ft single span to be constructed at Chalthi on Tanakpur-Pithogarh road is one of the largest single span R.C. arch bridges to be built in this country. The third bridge at Ghat on the same road is a 200 ft single span steel truss bridge. A prestressed concrete bridge of 12 spans of 66 ft each is under construction over Uttangan river on Agra-Bah road.

The following major bridges are under construction on the State Roads, some of them are nearing completion:

(1) Stone masonry arch bridge over Barwa Nala, on Allahabad-Banda Road.

(2) Stone masonry arch bridge over Jhuria Nala, on Allahabad-Banda Road.

(3) Bridge over Baghain river on Allahabad-Banda Road.

(4) Masonry arch bridge over Isan Nadi in Farrukhabad district.

(5) Pile bridge at Jhingaghat in Bahraich district (completed).

(6) Little Gandak bridge in Gorakhpur district.

(7) Reconstruction of bridge on Fatehpur-Banda-Saugar Road (completed).

(8) Extension of Karamansha bridge.

(9) Pinder river bridge at Karanprayag in Garhwal district.

(10) Bridge over Aril Nadi in Moradabad district.

(11) R.C. arch bridge over Ladhya Nala at Chalthi, on Tanakpur-Pithoragarh Road.

(12) Widening of Bruces bridge at Lucknow.

(13) Steel truss bridge at Ghat on Tanakpur-Pithoragarh Road.

(14) Uttangan river bridge on Agra-Bah Road.

(15) Reconstruction of bridge over Tirwa river in Faizabad district (completed).

(16) Rohin Nala bridge on Hamirpur-Kalpi Road.

(17) Chatesar bridge in Hamirpur district.

(18) Kewar Nadi bridge in Agra district.

(19) Nim Nadi bridge in Aligarh district.

(20) Re-decking of Bargadia ghat bridge over Gomti in Sitapur district (completed).

(21) Bridge over Tamsa river in Faizabad district (completed).

Fact Finding Survey

To help planning roads on scientific basis, a fact finding survey has been started. The aim is to collect all such data as have a bearing on traffic and to so plan the second phase of road construction programme that the best results are obtained at the minimum cost. The actual survey work was started in October 1953. The survey party visited all important villages, interrogated people in general, studied the existing state of traffic and communications and collected the required data.

Road Research Activities

A Research Institute has been established with the opening of separate sectional laboratories for soil mechanics and soil classification and for materials such as aggregates, cement concrete, and bitumen. The soils in Uttar Pradesh are generally of poor quality and tests are being carried out on soil samples for stabilization with cement or kankar, for determining the bearing capacities of soils and for designing bases and wearing courses.

Behaviour of different types of materials in respect of checking the capillary rise of water is also under investigation in the laboratory.

It is also proposed to lay down a test track in the compound of Research Institute. This will be utilised for testing different types of road surfaces and base courses under controlled conditions.

Besides above, work on the following problems is in progress :—

(1) Physical-chemical properties of U.P. soils.

(2) Influence of mineral composition of clays in the soil cement mixtures.

(3) Physical properties of sands and stones (coarse aggregates).

(4) Determination of cement-sand ratio in the hardened Portland cement mortar by simple method.

(5) Effect of kankar on the compaction characteristics and stability of soils.

(6) Effect of curing on strength of mortars.

(7) Adhesion of aggregates with binder and development of a suitable method for assessing this quality.

(8) Concrete mixes.

HISTORY OF ROAD DEVELOPMENT IN AMERICA

THE following are extracts from the Sixth Salzberg Memorial Lecture and relate to the history of Highway Development in the U.S.A., delivered by Thomas H. MacDonald at Syracuse University, U.S.A., 1954.

The profession of highway engineering in the United States had to wait 300 years for the opportunity to develop. To understand such long delay it is necessary first to understand that historically the facilities such as the railways, highways and runways over which the different types of transport operate have never been provided superior to, or in advance of, the current minimum standards required by each particular type. Thus so long as horses were used for highway transportation the surveyor and skilled artisan together with contractors who acquired some competence through experience, were able to produce the low standard of roads that could be made to serve and there were few notable exceptions.

The conditions which finally determined the need of and opportunity for highway engineering in the terms of our present concepts lagged through three centuries of the nation's life except for a relatively short time as follows :

1st Period - 1607 to 1785. Local control, statute labour on roads. The concept of technical competence did not generally rise above that of the surveyor or skilled artisan.

2nd Period - 1785 to 1850. Most of the roads remained under local responsibility. A few routes for inter-state and inter-regional traffic were undertaken by the States and the Federal governments and toll road companies with engineering direction.

3rd Period - 1850 to 1890. The turnpikes built by the States and Federal governments reverted to local control. Others operated by private companies were largely liquidated. Engineering and legislative principles applying to highway improvement which had emerged for a short term lapsed through the withdrawal of State and Federal interest.

After 1830, public attention and private energies were centered upon the spectacular extension of the steam railroads.

4th Period - 1890 to the present time. The Transportation Revolution.

The major events activating the transportation revolution are these :

a. 1893 - The establishment by the State of Massachusetts of the first State Highway Commission incorporating modern organizational concepts.

b. 1893 - The establishment by the Congress of the Office of Road Inquiry to enable the Secretary of Agriculture to make inquiries as to systems of road management, investigate methods of road making and to disseminate information. Thus, the Federal Government renewed in a very modest way its interest in public road improvement after a lapse of more than one half century.

c. 1893 - The first horseless buggy - involving substantially modern ideas is credited to the brothers Charles E. and J. Frank Duryea. Their first model was demonstrated on the streets of Springfield, Massachusetts, in September 1893, and a second model which had been designed to obviate defects that were apparent in the first, was also given a trial reported as successful on the streets of Springfield in January 1894.

d. 1903 - First motor driven airplane - Designed by Wilbur and Orville Wright and successfully flown at Kitty Hawk, North Carolina, December 17, 1903.

e. 1914 - Organization of the American Association of State Highway Officials.

This Association composed of the administrative and engineering personnel of the State and Federal highway departments has functioned effectively through the years to recommend legislation and **to develop administrative and engineering principles and standards that are the sound foundation of State and Federal co-operation in the joint highway improvement programme.**

f. 1916 - The Basic Federal Aid Act. This is the initial Act which began on a national scale a long series of State and Federal laws which provide both the authority and the responsibility inherent in our modern practices of highway administration. These principles may be grouped as (1) administrative requirements and (2) permissive authorities. There are no major administrative requirements that did not have State origin. The Federal legislation extended a proven principle to nation-wide utility for the joint programme.

The emergence of the principles are conveniently related to the sequential Federal Acts which determines the first nation-wide application but not usually first use by a State. Other important milestones of ancillary nature are included from the record of the years.

1. 1916. The requirement of an adequate State highway department.

2. The principle of adequate and continuous maintenance. Adequate maintenance is a condition for the continued availability of the Federal road funds. The expense rests upon the State, but does not impose the requirement of rebuilding. Reconstruction of roadways which have a good maintenance record is eligible for Federal participation.

This principle has emerged as one of the most basically important in its effect.

3. 1921. Road Classification. Required the selection of a Federal-aid system of roads not exceeding seven per cent of the total road milage from the approximately 3 million miles of rural roads, on which the joint State and Federal funds were to be expended until the system was initially improved. The roads were to have primary intra-state importance and to connect at State boundaries with the routes of similar importance in the neighbouring States, thus to insure a national system of inter-connected main routes.

4. 1921. The provision for engineering plants and specifications:

   a. to determine the adequacy of the proposed improvements to meet traffic requirements.

   b. to provide the quantities from which an estimate of cost can be made.

   c. to provide the basis for agreement between the State and Federal governments.

   d. to provide the basis for a contract with private companies for the construction of the work.

5. 1920. **Organization of the Highway Research Board.**

6. 1934. **Planning and research.** One and one-half per cent of each Federal authorization is set aside to be used, with or without State funds, for planning and research. This provision has been instrumental in establishing and maintaining in each State the State survey unit as an integral part of the State highway department organization. **This operation is a basic requirement of efficient administration.**

7. 1941. Federal aid construction halted by Executive Order.

8. 1944. The selection of an urban arterial system. The legislation provided for the selection of a system of urban roads to include the extensions of the Federal-aid systems into and through the cities, and dedicated funds for the improvement of the system.

9. 1944. Secondary or feeder road system. The legislation provided for the selection of a secondary or feeder road system to articulate with primary road system, and with each other, and to serve farm-to-market needs. Dedicated funds were provided for the improvement of the secondary sytem.

10. 1944. Inter-state System. The legislation provided for the selection of a system of major routes limited to 40,000 miles in both rural and urban areas to connect as directly as possible metropolitan and industrial areas, to serve the national defense, and to connect with national routes of Mexico and Canada.

11. 1945. Federal aid construction resumed by Act of Congress.

12. 1944. The 1934 authority to use 1½ per cent of the Federal authorization for engineering and economic research rewritten to include specifically urban and secondary road systems.

13. 1950. The legislation provided for an organizational unit within each State highway department to have administrative and engineering supervision over secondary roads.

14. 1950. Limited dedicated funds were provided for the Inter-state System.

15. From 1916 to present. The long series of State laws and Constitutional amendments bearing upon and providing for State activities in highway improvement and administration.

In this succession of principles of highway administration and engineering there is a complete charter of all the elements for highway improvement. It is the product of more than one-third century of State and Federal experience and practice, and includes full recognition of local interests.

The Highway Programme After 1945

As a result of the careful investigation by the Congress, the highway programme after 1945 was not only greatly enlarged to aid in the improvement of the primary Federal aid system but provisions were included for dedicated funds to insure the building of a system of urban arterial roads and a system of secondary roads in each State.

Compliance with the terms of this legislation required road classification by selection of two very different categories of facilities. One, the most heavily used arterial streets within urban areas, and the second, the farm to market or feeder roads which normally carry very much lighter densities of traffic.

A major new principle of road classification in this Act provided for the designation of a national system of not to exceed 40,000 miles termed the Interstate System. The objectives are :

- to inter-connect by routes as direct as practicable metropolitan and industrial areas,
- to serve the national defense, and
- to connect at border points with the routes of national importance of Canada and Mexico.

Trans-continental routes as such are not included as a major objective, since traffic of this character with very limited exceptions is a relatively small percentage of the total traffic on the main routes. The selection of routes which carry the major flows of inter-city and inter-state traffic produces as a by product an integrated pattern of routes that does serve long distance traffic. Nearly a quarter century separated the selection of the original seven per cent Federal Aid system and the Inter-state System limited to the equivalent of only one and a fraction per cent of the public road mileage. In that period the factual data from the State planning surveys had become available and this fact was principally responsible for a remarkable result. It was the responsibility of the State highway departments to select and to recommend the roads within each State to be included in the Inter-state System. It was the responsibility of the Administrator of the Federal Works Agency, acting through the Bureau of Public Roads to determine that the recommended routes articulated at State boundaries with routes of like importance, thus to create a truly national system of continuous major routes and to approve the final system. To achieve this result the Administrator found it necessary to make only one adjustment of State recommended routes to provide continuity at the boundary between two States, in a total system of 37,000 miles of the principal routes of the country.

The successful procedure to deal with a nation-wide matter filled with economic and political implications is a domonstration of the constructive results that can follow the collection and analysis of full factual data. This does not mean a rehash of the existing readily available statistics which is too frequently termed research. In highway engineering and administration the easy things have been done. The need is for basic research and source material in the science of engineering and related economic, finance, social and political sciences.

By mid-century the authority and requirements incorporating the principles of highway administration necessary to accomplish the purposes for which the Federal aid funds were authorized had been enacted into law by the Congress. A lesson of experience is that the timing of the sequential introduction of new principles or policies in affairs of acute public concern must accord with the public mind.

The Essential Quality of State Highway Legislation

A very important qualification must be applied to the whole of this discussion. To illustrate how our modern concepts of the scope and the practices of highway engineering have grown through successive steps as the need emerged and the authority was incorporated in legislation, it has been more convenient to refer to the Federal legislation since this applied to all the States.

It should be emphasized that state highway legislation for individual States introduced many principles preceding their incorporation in the Federal laws. Reference has been made to the provision for the first State highway department of modern form in Massachusetts, and to the early classification of State highway systems. All the States have had to incorporate provisions in their laws to deal with a multitude of matters. Also the State laws have had to deal with problems of finance and of large milages which are wholly outside any assumed Federal responsibility. Measures commensurate with the multiplications and dimensions of the current highway problems can only be dealt with primarily by State authority embodied in legislation.

The virtue of the Federal legislation is to provide a desirable degree of stability, co-ordination and particularly research on a nation wide scale.

(Extracted from 'Traffic Engineering' July, 1954.)

WHITE BODY

"I hate men because they take me into alleys, dance halls, taverns and bedrooms. They press me and feel me all over with their fingers. After they get me hot, they hold me to their lips and drag the life out of me. When they get what they want they throw me aside and tread me into the gutter. Why should they take advantage of my white body? After all, I'm only a cigarette!"

FULL SCALE ROAD EXPERIMENTS

Full Scale Road Experiments Essential

IN his endeavour to adapt his methods of road construction and maintenance to meet the ever increasing demands of modern traffic, the highway engineer must be continually carrying out experiments on his roads. This was equally true in the days of John London Macadam when stage-coach traffic was rapidly increasing. By road experiments, he developed a new technique of road construction that was cheaper and more durable than anything hitherto used. In more recent times, highway engineers have co-operated with manufacturers and contractors in carrying out experiments on their roads for the development of new materials and techniques. Many of the various types of bituminous surfacings were, in fact largely developed in this way. Unfortunately, it now generally takes several years before results are obtained from such experiments, and there is an urgent desire to substitute the road experiment by an accelerated traffic test such as that given by the circular track type of road-testing machine. Attempts made in the past to correlate the results from road-testing machines with the behaviour of bituminous carpets on the road were largely unsuccessful, because of the part played by weather in causing deterioration, a factor which cannot be adequately or easily accelerated on the road machine. Full-scale road experiments are consequently essential for the solution of problems in which the action of weather plays a part; they are also necessary for many other problems, and the road experiment, properly planned and executed, is now recognised as an essential part of the method of road research.

The significance of the results of new laboratory tests in terms of road performance often remains unknown until the road experiment is carried out. For example, although roadstones must obviously possess resistance to crushing and abrasion if they are to be used successfully in the road surface, the stone giving the greatest resistance in the laboratory test does not necessarily give the best road performance. In fact, measurements on the road have shown that certain stones with high resistance to crushing and abrasion may polish under heavy traffic and produce a slippery road surface. Again, as already mentioned, deterioration of some types of bituminous surfacing may arise through hardening of the binder, partly by evaporation of certain volatile constituents and partly by atmospheric oxidation. In order to decide how best to improve the weather resistance of the binder, it is necessary to know the contribution made by each of these two factors, and this again calls for the road experiment.

It will thus be seen that full-scale road experiments may be undertaken with various objectives in mind; they may be carried out for the purpose of ascertaining what basic problem should be studied in the laboratory; they may be undertaken to ascertain how far the results of laboratory tests can be correlated with road performance; and they may be required as the only method of solving certain problems. The basic problems relating to surface dressings, in particular, can be solved only by full-scale road experiments.

Many of the early experiments on surface dressing in the U.K. were undertaken before the importance of the quantity of binder was fully appreciated, and chance variations in this factor completely masked the effect of some of the other factors that were being investigated.

Types of Full Scale Experiments

As knowledge of the properties of materials increased and the value of full-scale road experiments was more and more appreciated, a new technique was adopted in appropriate cases by which premature failure of the surfacing or structure was deliberately sought by changing some variable over sufficiently wide limits.

Another type of full-scale road experiment that has been adopted in recent years in America involves the use of controlled traffic. This type of experiment is particularly suitable for investigations into the effects of traffic. The variables in construction are introduced into the road, and the procedure is to operate controlled traffic, the weight of the vehicles being increased in stages until serious failure is produced in the road.

The following notes describe briefly just a few of the more important of the ninety full-scale road experiments embracing the various aspects of design and construction of roads now in progress at the Harmondsworth Laboratary, U. K.

Settlement of Embankments

Many of the roads built between the two world wars suffered serious deterioration because of excessive and uneven settlement of the foundations and large sums of money were expended in making the necessary reconstructions. Experiments were therefore undertaken with the object of defining the degree of compaction that should be given to a soil when used for an embankment so as to avoid undue settlement after construction. Measurements were made over prolonged periods of time of the settlement of embankments constructed about ten years ago with various types of soil, ranging from clay to sand. At the same time, measurements were made of the density of the soils in the embankments. The results showed that workable limits could easily be set for ensuring absence of settlement for example, when clay fill is used at a moisture content close to its plastic limit the compaction should be that corresponding to an air content of 10 per cent, and little is gained by aiming at a lower figure unless the clay was much wetter.

A similar type of investigation involving measurements of normal work required for providing basic data was the study of the back-filling of trenches. Although laboratory work had shown what technique should be adopted to obtain the necessary compaction, observation of work in progress indicated that the compaction was not being obtained largely because the available power rammers were difficult to operate. It was apparent that the back-filling of trenches would continue to be inefficient until an improved machine has been developed for the purpose.

Flexible Construction. Although the design method for flexible construction on which most data are available is the California bearing ratio (C. B. R.) method, there are still many difficulties to be overcome before it can be accepted as a precise method. It is now possible to predict the moisture conditions to be expected in this country that should be adopted when subjecting the soil to the C. B. R. test. It is not yet possible to define traffic adequately and studies are in progress on this problem which involve the counting and weighing of vehicles on different classes of road. Furthermore, the C. B. R. method does not take into consideration any effect that the nature of the materials used in the road structure may have on the required thickness.

In the experiment in Yorkshire a range of thicknesses has been laid of hand pitching, crushed stone and tar-coated stone, and each thickness has been surfaced with a coated macadam pervious surfacing and with an impervious rolled asphalt. This work was done in 1949, and after five years of traffic of 2,000 vehicles a day, amounting to about 9,000 tons on each section a day, the experiment is giving results from which some very interesting conclusions can be drawn. Structural weakness in the road is shown by longitudinal rutting, and records have been made of the progressive deformation of each section since the road was opened to traffic. These measurements have shown least deformation in the sections with a coated stone base and most with the hand-pitched base; they have also shown that deformation of the sections surfaced with rolled asphalt was appreciably less than on the others surfaced with macadam. The superiority of the rolled asphalt was not simply due to its being impervious to water; it appears to contribute greater structural strength to the road than the macadam does. The results have also shown that for this road the thickness of construction of the macadam sections is predicted by the 20,000 lb C. B. R. design curve, an unexpectedly high value, due presumably to the nature of the traffic, which has a high proportion of commercial vehicles.

Concrete Construction.—A similar type of experiment was carried out on the Oxton By-pass in 1948. This road, which carries light to medium traffic of about 800 vehicles a day, was constructed on a gravelly sand subsoil which could be well compacted to form a good foundation. Both reinforced and unreinforced concrete slabs were laid in thicknesses varying between 3 and 8 in.; thicknesses of 4 to 8 in. were laid directly on the compacted subgrade, and thicknesses of 3 to 8 in. were laid on bases that varied in thickness from 2 to 6 in. The bases were made of sand stabilised with 7 per cent of cement. After six years, the road is now beginning to give definite results that will be of great value in the specification requirements for future concrete roads. Besides indicating the likely minimum thickness of construction for this class of road, the experiment has demonstrated the great advantage in using reinforcement: for example, unreinforced slabs, of 6 in. thickness or less have proved unsatisfactory, whereas reinforced slabs of 3 and 4 in. thickness, although showing many fine cracks, are still in a satisfactory condition.

In this experiment the length of each slab was 90 ft and the weight of reinforcement was 7 lb per sq. yd. Further experiments have been carried out in South Wales and Stafford, in which the length of slab has been varied from 40 ft to 240 ft and various weights of reinforcement have been used from 7 to 14 lb per sq. yd. Another road of unreinforced concrete had been provided with expansion joints at intervals of from 45 ft to 690 ft; dummy joints are provided in this experiment. The results from these experiments should indicate the relation between weight of reinforcement and length of slab that can be used without serious cracking; the longer the slab, the easier is construction and the better in general is the riding quality of the road.

Soil Stabilization

Full-scale road experiments by the Road Research Laboratory to obtain information on soil-cement stabilisation were commenced in 1944; the results of these experiments, together with the experience of those engineers who had also been experimenting with the process, have enabled recommendations to be drawn up for ensuring satisfactory results with quite a wide range of soil types.

As with the investigations on compaction, full-scale experiments are necessary to ascertain the actual conditions in the field and to know how far they differ from those adopted in laboratory investigations. An experiment in which mix-in-place was used for mixing in 10 per cent of Portland cement showed that the optimum moisture content for compaction by the pneumatic-tyred roller was 21 per cent as compared with 16 per cent obtained in the standard laboratory compaction test. It is possible to stabilise all types of soil with Portland cement in the laboratory. Obviously, the more granular the soil, the easier it is to mix with Portland cement at a suitable moisture content. But laboratory tests showed that even heavy clay can be stabilised by mixing with cement when lime is added, which causes it to flocculate, and provided a suitable mixer is used. Laboratory tests showed that for the clay cement to develop the necessary strength the proportions required were 15 per cent of Portland cement and 2 per cent of hydrated lime. A full-scale road experiment carried out jointly by the Road Research Laboratory and the Military Engineering Experimental Establishment of the Ministry of Supply showed that it was in fact possible to do work of this kind when a pottery-type pugmill mixer was used; the mixed material could be spread by a Barber-Greene finisher as a loose layer to a thickness of 9 in., and compacted by power rammers.

Full-scale trials have shown that limitations can arise from the presence of organic compounds in certain sandy soils which prevent the cement from setting. The addition of calcium chloride or the use of super-rapid hardening Portland cement will often enable such soils to be stabilised, but field experiments have shown the need in such cases to make a soil survey to see how far it may be advantageous to stabilise the soil below some particular depth so as to avoid the contaminated soil. The solution to this problem, however, is dependent in the first place on identification of the organic material, and this difficult laboratory investigation is now being made.

The Riding Quality of Concrete Roads

Measurements during the last few years have shown that the riding quality of machine-laid concrete roads is generally not as good as that of the best hand-finished work. The opportunity has therefore been taken to observe and make tests during the construction of a number of concrete roads so as to study the effect of the various factors that could contribute to poor riding quality of the finished surface. These factors include the method of spreading the concrete, the method of setting the forms, and rails for carrying the finishing machines. The results of these experiments have shown that all these factors influence the final riding quality of the concrete, and show the need for improvements in

(a) the type of spreading machine, so that the concrete can be laid easily to a uniform density,

(b) the design of the oscillating screeds of finishing machines so that they will remove more easily the irregularities in the surface,

(c) the method of aligning and fixing the form work.

Bituminous Materials

An account of the experimental work on roads carried out for solving many of the problems in surface dressings and carpets was given in some detail in 1950. Although, as with all road experiments, a background of knowledge of the properties of the materials is necessary, the basic problems in these fields can be solved only by full-scale road experiments.

Surface dressings.—Although the operation of applying a surface dressing to the road is simple one, the large number of factors that combine to influence the result makes the process one of some complexity. For this reasons some of the earliest experimental work did not produce any useful results. The important factors which influence the performance of a surface dressing include the nature and viscosity of the binder, the type and size of the chippings, the quantity of binder, the nature of the road surface, and the weather and the traffic. The results of the large number of experiments that have been carried out on many roads both by the Road Research Laboratory and by commercial undertakings during the past twenty years have been embodied in the present official recommendations for surface dressing with tar.

The latest experiments have been concerned with methods of preventing premature failure by wet weather. Road experiments showed that such troubles were largely confined to rainy districts on roads carrying medium to heavy traffic. Laboratory investigations showed that certain surface-active chemicals would be expected to prevent such troubles. In particular, two quaternary ammonium compounds, cetyl pyridinium bromide and cetyl trimethyl ammonium bromide when dissolved in creosote and applied to the film of binder on the road or to the stone would promote immediate adhesion and would prevent subsequent water displacement. Full scale road experiments carried out in a number of counties in the wetter parts of the country in which alternate lengths were laid of normal dressing and dressing with these agents not only confirmed the laboratory work, but also showed that the treated-stone method was the more reliable one. These experiments also gave a good idea of the additional cost involved, and showed that applying the material to the binder film added about $\frac{3}{4}$ d. per sq. yd., and that the coated stone method added about $1\frac{1}{2}$ d. per sq. yd. Neither of these agents was found to be effective when dissolved in economic quantities in the binder; certain amine compounds have since been developed in this country which laboratory tests have shown to be effective when they are dissolved in the binder in economic quantities and full scale road experiments are now required to compare their performance with the old quaternary ammonium compounds.

Carpets:—Although some commercial organizations had initiated experimental work on carpets, the work, by the Road

Research Laboratory started with the Colnbrook By-pass experiment in 1937. This was the first experiment with pre-mixed surfacings, in which the technique was adopted of varying the proportions of the constituents over such wide limits that failure was obtained at one extreme through the material disintegrating and at the other extreme through the material becoming slippery, the gap being gradually narrowed until the best combinations were located.

The experiment investigated the results given by a granite and a gravel aggregate and by certain tar and bitumen binders in commercial production at that time. By using this particular technique, it was possible to draw up recommendation for suitable composition within two years of the opening of the road to traffic. The maximum size of stone used in these carpets was $\frac{1}{2}$ in., and it is interesting to note that the latest British Standard for Bitumen Macadam (B.S. 1621 : 1954) for this aggregate does not differ in any essential from those recommendations. It may also be noted that after fifteen years on one of the most heavily trafficked roads in the country (the Colnbrook By-pass now carries, 30,000 tons of traffic a day) the surfacings complying with the recommendations are still in good condition. Although tar carpets do not generally give the life of bitumen carpets, the best compositions are still those that were decided upon in 1941.

The difference in the performance of carpets made with granite and gravel indicated the need for further experiments of this type; similar but less extensive series of compositions have therefore been laid in different parts of the country, using the local aggregates with both bitumen and the local tars as binders.

The results of all these experiments have shown that the type and quantity of binder is the most important factor affecting durability; on the whole, tar has given rather disappointing results. The fines content is a much less critical factor than binder content. On the other hand, the nature of the coarse aggregate has a marked effect on the anti-skid properties of the carpet; stones which polish rapidly under the action of traffic produce slippery surfaces within a short time on heavily trafficked roads.

This result has shown the urgent need for a laboratory test that will reproduce the type, as well as the amount of wear that occurs under modern traffic in stones that are to be used in the surface of the road. A promising laboratory test is being developed for this purpose, and full-scale road experiments are being undertaken to compare the performance of different roadstones in different types of surfacings and to provide a basis for the laboratory test.

Slag has shown a remarkable tolerance both as regards the fines content and the bitumen content. It differs from most natural stones in that a wide tolerance in bitumen content can be maintained even when there is a high fines content. This advantage is presumably a result of the nature of the surface texture of the slag and the way in which the particles pack together.

In view of the general conclusion that in an open-textured carpet grading is a less critical factor than binder content, a comprehensive experiment was carried out in 1950 in Scotland in which a series of carpets was laid with decreasing maximum size of aggregate from $\frac{3}{4}$ in. to $\frac{1}{8}$ in., in order to compare the performance of surfacings ranging from the normal open-textured carpet (as B.S. 1621) to the completely dense surfacing such as rolled asphalt and dense tar surfacing. Two such series were laid, one on a medium trafficked road (6,000 tons per day) and one on a lightly trafficked road (500 tons per day). Although final conclusions cannot be given from this experiment, it has confirmed results from other isolated experiments that with tar binder the most durable results are given by the fine-textured and dense surfacings; good results have been obtained with fine aggregate mixes made with 6 to 8 per cent of tar, laid to a consolidated thickness of $\frac{3}{4}$ in. and to which $\frac{3}{4}$ in. pre-coated chippings were applied.

A considerable number of subsidiary experiments have been carried out with the object of assessing the parts played by evaporation and oxidation in determining the durability of tar carpets and for finding out how far modifications to the properties of tar will give improved road performance. These experiments have shown the need to limit the volatilisation and oxidation susceptibility of the tar, and proposals are now under discussion for modifying the British Standard for road tar in the light of these experiments. The results of the road experiments have formed the basis for laboratory tests for assessing the oxidation limits for tars.

Adhesion Problems in Carpets

It has been noted that the open-textured carpet retains water in its voids for long periods of time, even in summer weather, and this combined with action of traffic has often caused stripping of the bitumen and occasional failure on some heavily trafficked roads by adhesion breakdown. The prevention of this stripping will prevent the risk of premature failure, and many experiments have been carried out in the laboratory and on the road with this aim. Laboratory research has been hampered in the past by the lack of a reliable performance test; it has been found that the simple immersion of coated aggregate in water is not a sufficient guide and it is necessary to combine both the action of water and traffic. The Immersion Wheel-tracking Test meets these conditions and full-scale experiments have been carried out for the purpose of correlating the results of the test with road performance. On the whole, the test has been found to correlate well with the results of road tests even in cases where all other laboratory tests have failed; the road experiments have included carpets in which various types of filler have been used, including hydrated lime and Portland cement. These fillers have prevented stripping in carpets made with bitumens containing an acid constituent. The experiments have shown that, where stripping has occurred when the normal fillers are used, it has not occurred when hydrated lime or Portland cement have been used with bitumen containing an acid constituent.

The wet Aggregate Process

The wet-sand process was successfully used during the last war for the construction of aerodromes near the seashore, the local wind-swept seashore sand being used in its naturally occurring cold and wet condition for the making of the asphalt runway. The binder was a low viscosity bitumen containing an acid constituent and 2 per cent hydrated lime was added to the sand to facilitate coating of the wet sand grains by the bitumen. This asphalt even when laid in thicknesses of 4 to 6 in. was able to carry the loads imposed by the planes in use at the time and also ordinary lorry and other motor traffic. This process has obvious advantages where normal heating and drying facilities do not exist, and road experiments have been carried out since those days to ascertain how far successful results can be obtained both with surfacings made with sand and with mixtures of coarse aggregate and sand, all the aggregates being used in the cold and naturally wet condition. Experimental surfacings have been laid on many different types of road and the results have shown that the process is suitable for a wide range of traffic conditions. As a result of this work, recommendations have been issued for suitable compositions for both open and close-textured surfacings, and for both gravel and crushed rock aggregates.

The Use of Rubber in Bituminous Surfacings

The incorporation of rubber in bitumen produces a binder with marked elastic properties, gives it greater resistance to flow at high temperatures, and make it less brittle at low temperatures. Rubber-bitumen joint sealing compounds provide an example of the practical advantages of these properties and, during the past five years a series of full-scale road experiments has been carried out to determine whether there are advantages in the wider field of bituminous surfacings. The results have so far shown that asphalt made with bitumen in which rubber has been dissolved is much less prone to the sympathetic cracking that occurs in asphalt as a result of joints and cracks in the underlying concrete. The experiments have not yet reached the condition to show in what way the durability of surface dressings or asphalt is affected by the solution of rubber in the binder.

Conclusion

It has been the intention to show the importance of experiments, and to indicate the wide field of investigation in which full scale road experiments play a part. **Without such experiments road research cannot progress; in fact, it would easily deteriorate and produce misleading results. Healthy and effective road research must, in fact, be a co-ordinated activity involving both full-scale road experiments and basic laboratory investigations;** the road experiment must be planned and controlled with the same care that is given to the laboratory experiment, and adequate instrumentation should be employed to ensure that the maximum return is obtained from it.

Some idea of the importance which American highway engineers and administrators attach to full-scale road experiments may be gathered from the expenditure made or planned on three recent projects in that country. Road Test One-MD was an experiment in concrete construction carried out in Maryland in 1951 at the cost of 250,000 dollars. The Washo Road Test is an experiment in flexible construction now in progress in Idaho, the cost of which was 650,000 dollars. The Aasho Road Test is a larger scale project planned to be constructed in Illinois at a cost estimated at between 5 and 7 million dollars.

REFERENCES

1. Salt treatment of snow and ice on roads. **Road Research Road Note,** No 18, London, 1953 (H. M. S. O.)
2. Price, W. I. J.: How to use fences to prevent roads being blocked by snow. **Roads and Road Construction,** 1954, 32 (373), 7-10.
3. Road Research Laboratory: Soil mechanics for road engineers, London, 1952 (H. M. S. O.), p. 297.
4. Croney, D. The movement and distribution of water in soils. **Geotechnique,** London, 1952, 3(1), 1-16.
5. Specification for the construction of housing estate roads using soil-cement. **Road Research Road Note,** No. 15, London, 1953 (H. M. S. O.).
6. MacLean, D. J., P. J. M. Robinson and S. B. Webb: An investigation of the stabilisation of a heavy clay soil with cement for road base construction. **Roads and Road Construction,** 1952, 30(358), 287-92.
7. Lee, A. R.: Full-scale experiments in road research with special reference to surface dressings and thin carpets. **Institution of Civil Engineers, Road Paper,** No. 31, London, 1950. (Institution of Civil Engineers.)
8. Recommendations for tar surface dresssings. **Road Research Road Note,** No. 1, London, 1952 (H. M. S. O).
9. Recommendations for open-textured asphalt carpets. **Road Research Wartime Road Note,** No. 3, London, 1941, (H. M. S. O.) (out of print).
10. Lee, A. R., and J. H. Nicholas: Adhesion in the construction and maintenance of roads. **Adhesion papers read at the Conference at London University, 22nd-24th April 1952,** London, 1952 (Society of Chemical Industry), pp. 45-56.
11. Bituminous surfacings made by the wet aggregate (hydrated lime) process. **(Road Research Road Note,** No. 16, London, 1953 (H. M. S. O.).

(Extracted from "Road Tar" Vol. 8 September 1954).

THE ENGINEER AND THE PUBLIC SERVICE

In his effort to serve the public the engineer must become accustomed to pressure and criticism and, in spite of it, maintain an impartial and professional approach to the rendering of public service.

HERE AND THERE

1. CHINA-TIBET ROAD LINK

FIRST HIGHWAY COMPLETED

THE first of three road arteries from China into Tibet which will replace the old caravan routes has now entered the Tibetan territory, the New China News Agency said on November 21.

When completed the road will connect Lhasa, capital of Tibet, with Lanchow in Kansu. Already 1,000 miles of the road, which follows the old caravan route from Lanchow and Sining through Jyekundo in the south of Chingha province, into Tibet has been opened to traffic. Only 180 miles remain to be built between Nagchuka, the Tibetan border town on the headwaters of the Salween river north-north-east of Lhasa and the Tibetan capital. Tibetans cheered when the first convoys reached Nagchuka last Tuesday.

From the newly-opened road section which runs roughly north-east from Tibet into China another road will branch off northwards into Sinking.

A third highway to the south-western provinces of China will link Lhasa with Chengtu in Szechuan.

The Chinese section of the railway which is to link China with Mongolia has now been linked with the Mongolian section. The chinese section is 338 kilometres (210 miles) long. The track-layers have pledged themselves to complete their part of the work before the end of the year.

(Extracted from 'The Times of India' 23-11-1954.)

2. DESIGN DETAILS OF TEST BASES

A LONG-RANGE research programme, initiated in 1952 in Western Germany has as its object and scope to test and evaluate different base types which are deemed suitable for bituminous surfaces. The project also is to afford comparison of two types of bases long "standard" for heavy traffic highways in Europe — the Telford base and the Portland cement concrete base.

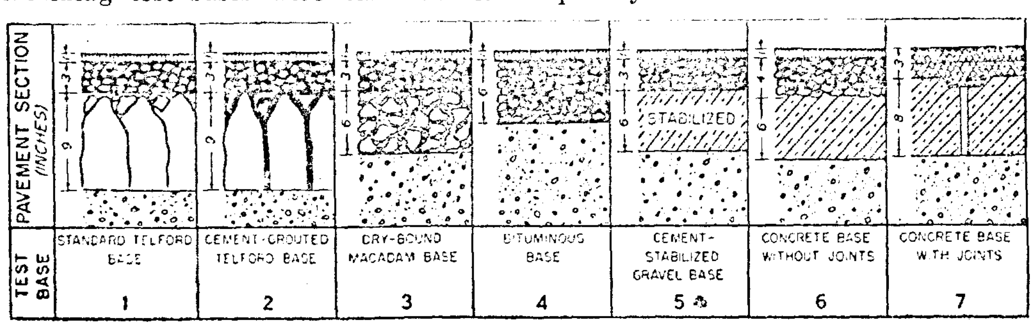
All bases except No. 4 and No. 7 were covered with an intermediate course, consisting of 3 to 4 in. of standard penetration macadam (road tar type). The surface of the wearing course for base No. 7 consisted of asphaltic concrete $1\frac{1}{2}$-in. thick on a $1\frac{1}{2}$ in. asphaltic course with 4 per cent asphalt cement content. The remaining test bases were surfaced with 55 to 130 lb. of asphaltic plant-mix surface course ($\frac{1}{2}$ to $1\frac{1}{4}$-in. thick).

Design features and material quantities of the selected sections are:

Base No. 1: Hand-packed standard Telford type base, consisting of large stones approximately 6 by 6 by 9 in., keyed with 185 lb. of sandy gravel per square yard.

Base No. 2: Telford base as above, but grouted with 11 gal. of cement mortar per sq. yd., finished with vibratory base plate compactors.

Base No. 3: Dry-bound macadam base, consisting of crushed rock $1\frac{3}{4}$ to $3\frac{1}{2}$ in. in size, 430 lb. per square yard, compacted with a 14-ton power roller, covered with 65 lb. of screenings per square yard and vibrated.



Design details of test bases.

Base No. 4: Six-in. bituminous hot-mix base course; local sand-gravel mixed with 4.7 to 5.2 per cent of 80-penetration asphalt cement in a central plant; mechanically laid in three courses compacted with a 7-ton power roller.

Base No. 5: Six-in. cement-stabilized, utilizing the sandy gravel of the embankment 420 lb. of Portland cement per cubic yard of compacted base, finished with vibratory equipment (Figure Six).

Base No. 6: Six in. of Portland cement lean concrete base without joints: local sand and gravel mix, 246 lbs. of Portland cement per cubic yard of concrete (28-day compressive strength of 1,280 to 2,280 psi) finished with vibratory baseplates.

Base No. 7: Eight in. of Portland cement concrete base with transverse expansion joints spaced at 165-ft intervals. Locally available gravel mix, 305 lbs of cement per finished cu. yd. of concrete (28-day compressive strength of 1,425 to 4,275 psi); vibration-finished.

(Extracted from "Roads and Streets, Oct. 54".)

3. PETROL FILLING STATIONS NEED ADEQUATE LIGHTS

AS PETROL FILLING STATIONS must be provided on all main roads, it is a matter of some importance that their location and layout should be such that they provide the greatest convenience to customers with the least danger and interruption to other traffic.*

Since most stations are open after the hours of darkness, and illumination forms part of the advertising of the premises, a scheme of lighting should be provided which will help the customer without hindering the passing motorist. The more common methods of lighting achieve the reverse effect, which by the internal illumination of the pump heads provides a dazzling light which can distract and confuse the passing motorist without helping the customer by lighting the entrance to the premises. A more satisfactory method would undoubtedly be provided by the indirect illumination of the pumps and forecourt in such a way as to leave no doubt as to the place of entrance and the nature of the premises without dazzling the passing driver.

(Extracted from 'The Surveyor' November 20, 1954).

4. STRUCTURAL DESIGN METHODS FOR ROADS

THE design problem can be approached either empirically or theoretically, but it is generally held that the fundamental behaviour of pavement materials and pavement structures must be more fully understood before reliable theoretical methods can be developed.

Consequently, most countries are attempting to develop empirical methods in the first instance. In Europe much work is being done in studying the bearing capacities of subgrade soils and road structures using, for example, plate-bearing techniques.

Many empirical methods of design have been proposed and while some are more reliable than others, all have two basic weaknesses. First, the methods employed to establish the moisture and density conditions at which the soil should be tested are unreliable, and, secondly, the methods used to classify the traffic do not take account of the effects of the magnitude and the number of repetitions of wheel load experienced in practice. Both these matters are now being studied actively at the Road Research Laboratory in the United Kingdom and in the U.S.A.

Dynamic Testing of Road Structures

The German Society for Soil Mechanics (Dagebo) began experiments before the war to try to relate the bearing capacity

* The Indian Roads Congress have brought out a Recommended Practice on the Siting and layout of Roadside Pumps.

of soil with the velocity in it of vibrations produced by a low-frequency vibrator. This work, although only in its very initial stages, has encouraged others to try vibration techniques for testing not only the soil but the whole road structure. In the United Kingdom attempts are being made to relate the bearing capacity of soil with the velocity of propagation of vibrations in it, while the Royal Dutch Shell Laboratories have developed a vibrator for operating on the road surface to measure the properties of both the subgrade and the road structure. Tests made with this machine in the United Kingdom with the collaboration of the Road Research Laboratory indicate that this method of testing may give very useful information.

Measurements of Stresses and Strains in the Road Structure

Different types of strain gauge are being used for checking the various theories for computing the stresses produced in and under the road by traffic. Metallic gauges carrying resistance wires have been developed by the Road Research Laboratory in the United Kingdom and the American Bureau of Standards for measuring the internal strains in concrete road slabs. Purdue University has just developed a wire strain gauge embedded in plastic for measuring internal strains. The American Waterways Experiment Station and the U. S. Corps of Engineers have developed pressure gauges containing wire resistance elements for measuring the stresses in the subgrade beneath runways due to moving loads, and the Road Research Laboratory (United Kingdom) has developed a vibrating wire gauge for measuring static stresses and a piezo-electric gauge for measuring the transient stresses. These gauges, although always introducing some error by their mere presence, are proving very useful in showing the magnitude of the stresses produced by moving traffic.

(Extracted from a Paper 'Survey of Road Research at Home and Abroad' by Dr. W. H. Glanville.—Journal of the Institution of Highway Engineers, Vol. III, Nos. 1 & 2.)

5. THE PREFIX SYSTEM OF PRESTRESSING

ONE of the bridges on the Ostend-Brussels motorway embodies a new system of prestressing — the Preflex system, developed by Professor Baes of Brussels University.

The principle, briefly, consists in loading a high tensile steel joist with a load equal to that anticipated in use, until it bends considerably (up to 1/51,000 of the length) and then clothing the lower flange with concrete of high compressive strength. The concrete is allowed to harden, after which the load is removed and the concrete is compressed as the beam regains a measure of its original shape. In practice this part of the operation is carried out in the factory, the beam being pre-loaded and partially prefabricated before transport to the site. When in position the remainder of the joist is completely clothed with concrete to form a beam of the profile and proportion required by the design. This method of construction is claimed to give the beam a shallow depth combined with strength and rigidity.

(Extracted from 'Concrete Quarterly 22' April-June 1954).

6. STABILIZED EARTH FOR BUILDINGS*

WITH a view to using stabilized soil on a large scale for buildings, the Hyderabad Engineering Research Station conducted investigations regarding the stabilizing agents to be used, the degree of compaction necessary, the type of tests, etc.

The moorum soil from the quarry at Secunderabad was found suitable for soil stabilization. It contained 36 per cent gravel, the maximum size of particles being 3/8 inch. The fraction passing 3/8 in. mesh and retained on No. 4 mesh was about 6 per cent.

* This is an abstract of the report of work done at the Hyderabad Engineering Research Station. Those interested may obtain the original from the Secretary, Indian Roads Congress, Jamnagar House, New Delhi-2.

The following stabilizers were used:—

1. Cement
2. Limestone dust
3. Slaked lime
4. Cement + Limestone dust 1 : 1 ratio and
5. Cement + Slaked lime in 1 : 1 ratio

Proctor compaction tests were conducted for the soil mixed with the stabilizers mentioned above. The percentage of admixtures ranged from 2 to 6 per cent. It was found that an admixture of 3 per cent cement yielded the highest density, viz., 130 lb per cu. ft. Using an admixture of 6 per cent of cement and limestone dust in the ratio 1 : 1 gave the next lower density of 129.6 lb per cu. ft.

Addition of 4 per cent limestone dust gave the highest compressive strength, viz, 343 lb per sq. inch. The blocks, however, did not satisfy the durability test.

The 7-day compressive strength of blocks containing 6 per cent of cement plus limestone dust in the ratio of 1 : 1 was 250 lb per sq. in. and that of blocks having 3 per cent was 210 lb per sq. in. Both types of blocks satisfied the durability test.

Addition of slaked lime did not result in satisfactory compressive strength and durability.

The different kinds of stabilizers used in the investigation were rated in the following order from consideration of compressive strength and durability:—

1. Soil + 8 per cent cement and lime stone dust in 1 : 1 ratio.
2. Soil + 4 per cent cement.
3. Soil + 6 per cent cement and lime stone dust in 1 : 1 ratio.
4. Soil + 5 per cent cement and slaked lime in 1 : 1 ratio.
5. Soil + 3 per cent cement.
6. Soil + 4 per cent cement and slaked lime in 1 : 1 ratio.

7. PRESTRESSED UNITS FOR SHORT-SPAN ROAD BRIDGES

IN the U. K. bridges of designs incorporating prestressed precast units have generally proved economical, partly because of the speed of construction and the economy in site labour which results from their use.

Prestressed precast units may be laid side by side to form structurally a wholly precast deck, or they can be designed to act compositely with concrete poured *in situ*. In the paper a comparison is made between these two types of construction, and values are given for the minimum depth of deck designed to a specified ultimate load factor. The effects of dynamic loading are also considered.

(Extracted from 'Contractors Record and Municipal Engineering' December 15, 1954)

8. ROADS

All Life is roads
For all life is movement.
Animals began it;
Then primitive man,
Then caravans, armies, ships.
With them went fabulous wares;
Rubies and gold
For the eyes' delight,
Bronze for the helmet,
Tools for the hand,
Cedar timbers to build the house
-Rainbow silks of Samarkand.
Ahead of each
Went the idea,
The true roadmaker.

—*by Madge Jenison.*

CURRENT LITERATURE

ABSTRACTS

U. D. C. No. 691.3 STATISTICAL METHODS IN CONCRETE RESEARCH by P. J. F. Wright. Magazine of Concrete Research. 1954. Vol. 5, No. 15, March 1954, pp. 139-149.

The application of statistical methods has helped greatly in planning and interpreting research at the Road Research Laboratory and, as no statistical textbook deals specifically with the problems of concrete technology, this Paper aims to bring such methods to the attention of research workers elsewhere.

The assessment of variation in test results is discussed and some useful statistical processes are introduced. These include a test for the difference between two sets of results, the method of analysing the causes of variation in test data and the fitting of equations to experimentally determined relationships between two variables. An appendix gives a method for fitting a Gaussian distribution to a series of test results.

U. D. C. No. 631.4 SUB-GRADE SOIL CLASSIFICATION SYSTEM USED IN GEORGIA-L. W. FREEMAN. Proceedings of the American Society of Civil Engineers-Separate No. 512, February, 1955.

THE density of a soil reflects both the gradation and particle shape of the material. Hogentogler brought out that density varies with gradation and showed that a compacted soil mixture, all passing the No. 10 sieve and containing 8 per cent clay, 15 per cent silt and 77 per cent sand has a weight per cubic foot of 130 pounds and after removal of sand to a gradation of 68 per cent clay, 20 per cent silt and 12 per cent sand the soil has a weight per cubic foot of 113 pounds. Sowers and Sowers in their "Introductory Soil Mechanics and Foundations" bring out that angular soil grains tend to form much looser structures or less dense structure than rounded grains because their sharp edges and points hold the grains further apart and that mica flakes tend to produce an even lower density since the flakes bridge over the voids in the bulky grains.

Density is a measure of the bearing capacity or strength. Density is also a measure of compressibility, which reflects the settlement. It has been brought out in a number of text books that settlement decreases as the density increases both as to the state of well compacted against loose, or so called relative density; as well as dense with a low void content against low density with a high void content.

U. D. C. No. 631.4 SOME APPLICATIONS OF GEOLOGY IN SOIL MECHANICS AND FOUNDATION ENGINEERING by P. D. Trosk and H. B. Seed Proceedings of the American Society of Civil Engineers. Separate No. 477 August 1954.

THE subject matter is explained by means of examples. The examples cited relate to foundations and landslides in America and England. A list of references is included.

U. D. C. No. 631.4 THE EFFECT OF CURING TEMPERATURE ON THE COMPRESSIVE STRENGTH OF SOIL-CEMENT MIXTURES by K. E. Clare and A. E. Pollard. (Geotechnique September 1954)

THE influence of the curing temperature on the compresive strength of cylindrical specimens of soil-cement has been studied at ages up to 3 months. Five soils-a clay, a silty clay, two sands and a gravel-were used, being stabilized with 10 per cent of ordinary Portland cement (15 per cent for the clay). Methods have been developed for coating or enclosing the specimens to prevent changes in their moisture contents during curing at temperatures upto 140° C.

The following conclusions have been deduced:

(1) For a soil-cement road base constructed in the spring the strength during the first three months will be some 50 to 100 per cent greater than if the base were constructed in the autumn.

(2) If compressive strength is taken as the sole criterion of soil-cement, less cement should be needed to stabilize a soil under tropical than under temperate conditions.

(3) Soil-cement will harden in cold weather provided that the temperature is not below zero degree C.

(4) The 7-day strength of soil-cement changes by 2.0–2.5 per cent with each degree centigrade change in the curing temperature when the latter is near 25° C.

(5) With the cohesive soils, the 7-day strength 25° C was approximately obtained in 1 day when the curing temperature was raised to 45° C, but only after 28 days when it was reduced to zero degree C.

(6) The nature of the strength/age relationships obtained with the cohesive soils suggests that at temperatures up to 45° C one mechanism of hardening is involved; and that this is accelerated by increased temperature. At 60° C and 100° C variable results were obtained with the silty clay, consistent with more than one type of mechanism of hardening. (Authors' summary).

U. D. C. No. 624.2 "CIVIL ENGINEERING CONSTRUCTION UNDER-WATER" by J. R. Malcolm. Proceedings of the Institution of Civil Engineers, London, Part III. Vol. 3, No. 3. December 1954.

THE Paper deals with the construction in water of permanent structures and temporary works such as cofferdams and caissons which enable permanent works to be constructed in the dry.

The Paper is divided into two parts. Part I, design and materials; Part II, methods and plant. Part I deals with the use and suitability of various construction materials underwater; the factors to be taken into consideration in the design of underwater structures, including wave action on rubble-mound foundations and breakwaters; and specifications for materials to be used for underwater work, with special reference to cement and concrete. Part II deals with dredging, types of dredgers, breaking up hard material by rock breakers or explosives, excavation in cofferdams and caissons, building caissons and placing them in position, concreting seals to caissons, diving bells, limpets, pile-driving and extracting, shuttering, concreting underwater, use of precast concrete, diving equipment, work done by divers, and the use of television under water. (Author's summary).

U. D. C. No. 620.1 Text Book of Engineering Materials. Melvin Nerd-John Wiley and Sons. Inc., New York and Chapen & Hall Ltd. London.

THE book, which is intended to be a text book for engineering students consists of the following four parts.

Part I, the Raw materials of engineering which gives the sources, formation and recovery of raw materials.

Part II gives the methods of production and extraction of the materials from the ores.

Part III deals with properties of the materials such as elasticity, hardness, plasticity, fatigue, creep etc.

Part IV has the following five sections. Section I on materials for generations of energy such as water, fuels and explosives.

Section 2 deals with ferrous and non-ferrous materials and alloys.

Section 3 dealing with natural and artificial stone has 6 chapters on building stones, gypsum and lime, portland cement, clay, refractories and glass.

The last two sections are devoted to wood, rubber and plastics and surface coating materials and lubricants.

U. D. C. No. 631.4 LOCATING STEEL REINFORCING BARS IN CONCRETE SLABS, by A. C. Whiffin, The Engineer, June 18, 1954, 197 (5134), 887-8.

DURING the past twenty to thirty years, radiographic methods have been developed for detecting flaws in metal structures, mainly employing X-ray apparatus and, since the recent war, radioactive isotopes emitting gamma radiation have begun to be employed in this work. X-ray radiographic methods have been used to detect the position of the bars in reinforced concrete, but the X-ray equipment is expensive and not usually very suitable for use on the average civil engineering site. The radiographic technique described in this article employs equipment costing less than £ 20 and its operation is quite simple.

U. D. C No. 625.7 Some Traffic and Driving Conditions Which Influence Petrol Consumption by R. D. Lister and R. N. Kemp.

Bulletin of the Motor Industry Research Association. 1954 (2).

THIS article gives the results of some measurements of the petrol consumption of three vehicles (a small and a large saloon car and a 3-ton commercial vehicle with a van body) when travelling under different traffic and road conditions.

Using as a basis of comparison the consumption at a constant speed of 30 m. p. h. on a level road, light traffic conditions in a built-up area gave an increase in consumption of up to about 35 per cent and heavy traffic conditions of up to 100 per cent, with corresponding mean speeds of about 20 and 10 m. p. h.

Climbing a gradient or accelerating were both responsible for greatly increased petrol consumption ; a gradient of 1 in 25 caused increases of 50 to 100 per cent in consumption ; during the period of acceleration from rest to 40 m. p.h., the consumption was about three times that at a constant speed of 30 m. p. h.

When travelling in a circular path of about 100 ft radius in one gear below top gear and at speeds just below that at which wheel slip was about to occur, the consumption was between two and three times that at a constant speed of 30 m. p. h.

The differences in consumption due to over- or under-inflated tyres were small.

Measurements with one vehicle made over a short stretch of road which included a busy road junction gave a relationship between the petrol used and the mean journey time ; these measurements also showed that over this short distance the consumption was nearly four times that at a constant speed of 30 m. p. h.

In comparing the effect of different operating conditions on the petrol consumption of different vehicles more consistent results were usually observed by taking as the basis of comparison the average consumption over a particular test route (which included town and country roads and traffic) instead of the consumption at a steady speed of 30 m. p. h. on a level road.

THE SAFE SIDE AND SUICIDE

Many a life would be saved, and many a motorist would avoid the inconvenience and expense of a costly accident, if all who drive cars would make it an inviolable rule to use the car door on the side away from traffic.

KEEP PACE WITH TRAFFIC

Accidents can be avoided by keeping pace with the rest of the traffic on a road or street. Motorists who drive too fast must pass many other cars, increasing their own hazard; motorists who drive too slowly cause other drivers to pass them too frequently, and often at the wrong time.

SELECTED RECENT LITERATURE IN ENGINEERING JOURNALS

XI. TRAFFIC AND ROAD USER CHARACTERISTICS

1. **Possibilities and Limits of Application in Switzerland of Modern Highway Traffic Engineering Technique**; M. JENNI, *Strasse und Verkehr*, January 1954, pp. 14-16 (in French).
2. **Road Research and Its Bearing on Road Transport**; W. H. GLANVILLE, *Road Tar*, March 1954, pp. 20-23.
3. **The Plan of Washington D. C., Evolution of the National Capital**; HARLAND BARTHOLOMEW, *Traffic Engineering*, February 1954, pp. 157-164.
4. **Traffic Count-Key to Highways of the Future**; JOHN T. NAGEL, *Traffic Engineering*, February 1954, pp. 170-171.
5. **Traffic Engineering Problems in Cities Under 50,000 Population**; CHARLES H. DAVIS, *Traffic Quarterly*, October 1953, pp. 447-456.
6. **Concreting Traffic Difficulties**; ROBERT J. ALLEN, *Traffic Quarterly*, October 1953, pp. 479-497.
7. **Loading Experience as a Basis for Zoning Requirements**; KENNETH GREEN, *Traffic Quarterly*, October 1953, pp. 458-516.
8. **Speed Limits in New Mexico**; ROBERT CONRADT, *Traffic Quarterly*, October 1953, pp. 517-530.
9. **Tests on a Mode of Algebraic Representation of the Variations in the Time of Intensity of Traffic**; P. DOYEN, *Annales des Ponts et Chaussees*, March-April 1954, pp. 187-217 (in French).
10. **Pedestrian Crossing Regulations**; *The Surveyor*, April 3, 1954, p. 274.
11. **Traffic Engineering in the U. S. A. The Demand for Qualified Engineers**; J. A. HILLER, *Contractors Record and Public Works Engineer*, March 1954, pp. 33-34, 37-38.

    —do—do—The Journal of the Institution of Highway Engineers, April 1954, pp. 4-25.
12. **Sociological Relationships of Traffic to Population and Distance**; FRED CHARLES IKLE, *Traffic Quarterly* April 1954, pp. 123-136.
13. **A Resume and some Implications of a Canadian Parking Survey**; NOEL DANT, *Traffic Quarterly*, April 1954, pp. 188-212.
14. **Chicago's New Off-street Parking and loading Ordinance**; EVERT KINCAID, *Traffic Quarterly*, April 1954, pp. 246-251.
15. **Traffic Engineering in a County Surveyor's Department**; JAMES DRAKE. *The Journal of the Institution of Highway Engineers*, April 1954, pp. 65-82.
16. **Traffic Management-A Step Child in U. S. City Government**; J. W. GIBBONS, *Road International No. 11. Winter 1953-54*, pp. 57 and 60.
17. **Trends in Traffic Volumes, Vehicle Types and Weights**; THOMAS B. DIMMICK, *Public Roads*, December 1953, pp. 235-41.
18. **Influence of Population, Sales and Employment on Parking**; S. T. HITCHCOCK, *Public Roads*, Dec. 1953, pp. 248-258.
19. **Traffic Engineering from the Police Angle**; *The Surveyor*, November 21, 1953, pp. 803-805.
20. **The most Comprehensive Study Ever Under taken**; *Traffic Engineering*, March 1954, pp. 195-197 and 200.

21. **Traffic Controls in the Vicinity of School Zones Part I**; LAWRENCE LAWTON, *Traffic Engineering*, March 1954, pp 201–203 and 206.

22. *—do* **Part II.** *Traffic Engineering*, April 1954, pp. 241 and 244.

23. **Traffic Regulation of Urban Intersections, Illustrated by an Example of the "Luzernsquare"**; LUZERN E. MAAG *Strasse und Verkehr*, April 1954, pp. 154–160 (in German).

24. **Proposed Revisions of the Uniform Manual**; WILBER S. SMITH *Traffic Engineering*, May 1954, pp. 285–292.

25. **Attendant Parking Vs Self Parking**; R. H. BURRAGE and D. A. GORMAN, *Traffic Engineering*, May 1954, pp. 280–284.

26. **Traffic Improvements for New York**; *The Engineer*, June 4, 1954, p. 833.

27. **Interpretation of Results of Measurements of Rectangular Coordinates of a Point**; M. EDGAR BATICLE, *Annales des Ponts et Chaussees*, May-June 1954, pp. 379–82 (in French).

28. **Driving in the U. S. A. - a Comparison with Conditions on British Roads**; G. GRIME. *Roads and Road Construction*, June 1954, pp. 170–176.

29. **Hamburg-traffic Problem and Plans for Their Solution**; OTTO SILL. *Road International*, Spring 1954, pp. 48-54.

30. **Driver Performance on Horizontal Curves**; ARIAL TARAGIN. *Public Roads*, June 1954, pp. 27-39.

31. **Predicting Road Traffic Demands in texas**; *The Surveyor*, July 3, 1954 pp. 558-559.

32. **Traffic Congestion and Car Parking in Britain and America**; *The Surveyor*, July 3, 1954, pp. 561-564.

33. **Easing Congestion in Crowded City Streets**; *The Surveyor*, July 3, 1954, pp. 565-566.

34. **Traffic Census and Highway Design**; *The Surveyor*, July 10, 1954, p. 574.

35. **Traffic Engineering from the Police Angle**; S. J. CHAMBERLAIN. *The Journal of the Institution of Highway Engineer*, July 1954, Vol. III, No. 3. pp. 6–23.

36 **Express Buses on Freeways**; STUART MILL BATE. *Traffic Quarterly*, July 1954, pp.325–333.

37. **Speed Vs Horsepower**; ROBERT E. SCHMIDT. *Traffic Quarterly*, July 1954, pp. 339–350.

38. **Public passenger Traffic in European Major Cities**; *Schweizerische Bauzeitung*, August 25, 1954. pp. 493–494.

39. **Traffic Problems in the North-East—Their Solution in Northumberland and Durham**; W. H. B. COTTON and G. F. GARNETT. *The Journal of the Institution of Municipal Engineers*, August 1954, pp. 73–92.

40. **Traffic Engineering: The Case for Three-Lane Roads**; *The Surveyor*, October 9, 1954, p. 875.

41. **Determination of the Capacity of Road Traffic Junctions Not Controlled by Light Signals**; Dr WALTER GRABE *Research work in Highway Engineering New Series No 11. Die Forschungs gessellschaft far das Strassenwesenl (Research Association for Highway Engineering.) Krischbaum Verlag Bielefeld.* (in German).

42. **Memorandum on Origin and destination Surveys of Road Traffic**; A. H. KNOX. *The Journal of the Institution of Municipal Engineers*, November 1954, pp. 237–248.

43. **Pedestrian "Scramble" Control**; ROBERT D. DIER. *Traffic Engineering*, August 1954, pp. 413–414.

44. **An Automatic Method of Collecting Data on Traffic Performance**; K. B. JOHNS. *Traffic Engineering*, October 1954, pp. 13–16.

BOOK REVIEW

THE INTERNATIONAL ASSOCIATION FOR BRIDGE AND STRUCTURAL ENGINEERING - Fourteenth Volume (1954). Copies are available for sale at Verlag Leemann, Zurich.

This 14th volume of "Publications" contains 14 Papers — 7 in English, 3 in French and 4 in German, of which the following are of interest to Highway Engineers :—

(1) The Calculation of Concrete Girders, Prestressed Unsymmetrically above and below. Taking more precise Account of Creep and Shrinkage. (in German)

(2) Statistical Calculation of Strength of Reinforced Concrete Beams. (in English)

The strength of reinforced concrete beams is studied in this paper with due regard to the dispersion of the strength of concrete and the strength of reinforcement. Attention is directed to the deviations from the classic methods of calculation in which the dispersion is disregarded. A study is also made of the effect produced on the strength by the variable stress distribution in the longitudinal direction of the beam (the influence of the concrete in tension between the cracks due to bending on the side in tension).

(3) An experimental Investigation of Slabs subjected to Concentrated Loads. (in English)

To obtain information about the stress distribution in reinforced concrete slabs subjected to concentrated loads, experiments have been conducted for investigation of the influence of the size of loaded surface (the concentration of the load) on the bending moments in the slab, and investigation of the stress distribution in the slab as a function of the boundary conditions and the location of the load.

(4) Measurement of the Stress and Deflection of Kanzaki Bridge. (in English)

In order to know the difference between a single beam structure and a parallel beam structure, a static load test was done on the composite beam structure of Kanzaki Bridge. From the measurement, the load distribution due to the slab was recognised in the bridge consisting of five main beams. The stress ratio and deflection ratio in which this is taken into account, are 66 % and 80 % respectively. On the other hand, the experiment of a single beam structure shows that the above ratios are 89 % and 84 %, from which it is clear that the stress ratio is smaller in parallel beam structure. This is due to the co-operation of the slab and all the beams connected by the slab.

(5) Suspension Bridges. The Aerodynamic problem and its Solution. (in English)

Some bridge failures like that of the Tacoma Bridge have led to the creation of a new science, Bridge Aerodynamics. With regard to the action of wind, its vertical component is more dangerous than the horizontal component. The stability or instability of a section depends on the "velocity ratio" V/Nb, where V signifies the wind velocity, N = the natural frequency of the oscillating structure, and b the width of the section. Methods of augmenting rigidity and structural damping are provided by cable stays, centre stays, intermediate diagonal stays, and transverse diagonal stays.

The greatest need of our country is trained personnel. It is easier to provide 10,000 overseers with jobs than to post-graduates in arts.

Jawaharlal Nehru.

PUBLICATIONS ADDED TO THE ROADS WING LIBRARY DURING DECEMBER, 1954

The American Society for Testing Materials, 1916, Race Street, Philadelphia 3, Pa.

1. **1953 Supplement to Book of ASTM standards including Tentatives; Part I—Ferrous Metals.**

2. **do do Part 2— Non-ferrous Metals**

3. **do do Part 3—Cement, Concrete, Ceramics, Thermal Insulation, Road Materials, Water-proofing Soils.**

4. **Card Index system for technical reports** by C. G. W. Ebbutt. (The Heston Aircraft Company Ltd., Heston Airport, Hounslow, Middex—1951)

5. **Report on experiment surfacings tested on the road test track at Majherhat, Alipore, Calcutta (1942-47)-(Road Research Bulletin** No. 2) (Indian Roads Congress, Jamnagar House, Shahjahan Road, New Delhi- 2, 1954).

6. **Model analysis of structures** by T. M. Charlton (E. & F. N. Spon Ltd., 22, Henrietta Street, London, W. C. 2. 1954)

7. **Second Engineers Seminar, Roorkee, from 19th to 21st July, 1954, Vol. I** (Ministry of Irrigation and Power, Central Water and Power Commission, New Delhi).

8. **Sedimentation Procedures for determining particle size distribution. (Bulletin Series No. 54), contained in Engineering progress, at the University of Florida, V, VI, No. 6, June, 1952.** by Herbert E. Schmeyer (Florida Engineering and Industrial Experiment Station, College of Engineering, University of Florida, Gainesville).

9. **Final report on Road Test One-MD effect of controlled Truck axle loadings on concrete pavement-Highway Research Board Special report No. 4.** (Highway Research Board, 2101, Constitution Avenue, Washington 25, D. C., 1952)

10. **Rapid Control tests for bituminous paving mixtures-Bulletin No. 175** by Ting Ye Chu (Iowa State College of Agriculture and Mechanic Arts, Ames, Iowa, 1953).

University of Illinois, Urbana, 1953.

11. **Frequency and analysis of hydrologic data with special application to rainfall intensities (Bulletin** Series No. 414) by Ven Te Chow.

12. **Studies of slab and beam highway bridges; part III small scale tests of shear connectors and composite T-Beams (Bulletin Series 396)** by Chester P. Siess, Ivan M. Viest and Nathan M. Newmark.

13. **Studies of slab and beam highway bridges, Part V-Tests of Continuous right I—Beam bridges (Bulletin Series No. 416)** by Chester P. Siess and M. Viest.

14. **Least weight proportions of bridge trusses (Bulletin series 417)** by Joseph Waling.

Verlag Von Wilhem Ernst & Sohn, Berlin,

15. **Spannbeton - Erlauterungen - DIN** 4227 (Prestressed Concrete Commentory) by Hubert Rusch. (in German)

16. **Beitrag zur Berechnung Kreuzweise gespannter Fahrbahnplatten im Stahlbruckenbau** by Gerhard Fischer. (in German)

17. **Die Berechnung signal gesteuerter Knotenpunkte des Straf Benverkehrs-Beratender Ingenieur VBI. (The design of road traffic junctions controlled by signals)** by-Erich Feuchtinger (Kirschbaum Verlag, Bielefeld).

BUDGETS AND ADMINISTRATION REPORTS

Government of Mysore Budget Estimates for the year 1954-55

The following extracts have been taken from the Government of Mysore Civil Works Budget for the year 1954-55.

	(In lakhs of rupees)		
	Budget Estimates 1954-55	Revised Estimates 1953-54	Accounts 1952-53
Civil Works (Revenue)			
(a) Rents	2.15	1.45	2.02
(b) Recoveries of Expenditure	0.64	6.55	0.01
(c) Transfer from Central Road Fund	25.00	24.87	0.35
(d) Miscellaneous	3.57	4.25	11.25
(e) Deduct-Refunds	-0.05	-0.06	-0.03
Total	31.31	37.06	13.60
Expenditure			
Original Works			
Buildings	65.67	62.88	38.58
Communications	6.07	6.03	3.21
Repairs			
Buildings	10.50	10.42	8.89
Communications	49.69	48.36	34.54
Establishment	25.42	22.76	16.02
Tools and Plant	5.00	7.41	3.78
Grants-in aid	5.75	4.07	19.35
Suspense	10.00	15.00	9.55
Development Schemes Communications — Original Works	72.18	61.02	37.04
Development Schemes Communications — Repairs	35.00	32.40	15.45
Development Schemes Communications — Tools & Plant	6.00	8.14	0.74
Development Schemes Communications — Grants-in-aid	—	0.35	—
Total	291.28	278.84	187.15
Capital Account of Civil Works outside the Revenue Account			
(a) Original Works (b) Establishment charges (c) Tools and Plant (d) Suspense (e) Deduct-Receipt on Capital Account	25.00	15.00	4.04
(f) Development-Schemes (Original Works-Roads)	3.00	—	—
Total	28.00	15.00	4.04

(Continued)

	In lakhs of rupees)		
	Budget Estimates 1954-55	Revised Estimates 1953-54	Accounts 1952-53
Revenue from Roads			
I. (a) Receipts under the Indian Motor Vehicles Act	1.03	0.88	0.47
(b) Receipts under the State Motor Vehicles Taxation Act	87.06	81.48	56.73
(c) Other Receipts	0.30	0.30	1.11
(d) Deduct-Refunds	-0.16	-0.15	-0.39
Total I	88.23	82.51	57.92
II. Sales Tax on Petrol	24.35	22.26	15.61
Sales Tax on Motor Spirit other than Petrol	2.61	2.10	2.10
*Total II	26.96	24.36	17.71

* gross receipts.

GOVERNMENT OF MYSORE BUDGET FOR THE YEAR 1954-55.

(A brief review with reference to Civil Works)

THE revenue and expenditure on revenue account of the Government of Mysore for 1954-55 are estimated at Rs 2121 lakhs and Rs 2430 lakhs respectively with an anticipated deficit of Rs 309 lakhs. The revised estimates for 1953-54 place the revenue at Rs 1966 lakhs and expenditure at Rs 2204 lakhs indicating a deficit of about Rs 238 lakhs while the accounts for 1952-53 recorded a surplus of over Rs 75 lakhs, the revenue amounting to Rs 1879 lakhs against and expenditure of Rs 1804 lakhs.

The expenditure on Civil Works for the year 1954-55 is estimated at Rs 291.28 lakhs which works out to 13.7% of the total revenue of the State. In 1953-54 (Revised Estimates) and in 1952-53 (Accounts) the expenditure on Civil Works amounted to Rs 278.84 lakhs and Rs 187.15 lakhs respectively, representing 14.2% and 10.0% of the total revenue. These figures include the expenditure under "Development Schemes" met from the revenue account.

The expenditure on Communications alone (Original Works and Repairs only) works out to Rs 162.94 lakhs for 1954-55 (Budget Estimates) which is 7.7% of the total revenue. Corresponding proportions for 1953-54 (Revised Estimates) and 1952-53 (Accounts) are 7.5% and 4.8% respectively.

The Capital outlay on Civil Works outside the revenue account is estimated at Rs 28.00 lakhs for 1954-55 as against Rs 15.00 lakhs in 1953-54 (Revised Estimates) and Rs 4.04 lakhs in 1952-53 (Accounts). The complete break-down of the figures under different heads such as buildings, communications etc. is not available. It is however found that the budget has set apart Rs 3 lakhs out of the total provision of Rs 28.00 lakhs for 1954-55 for development schemes which are entirely original road works.

LIST OF APPROVED WORKS ON NATIONAL HIGHWAYS

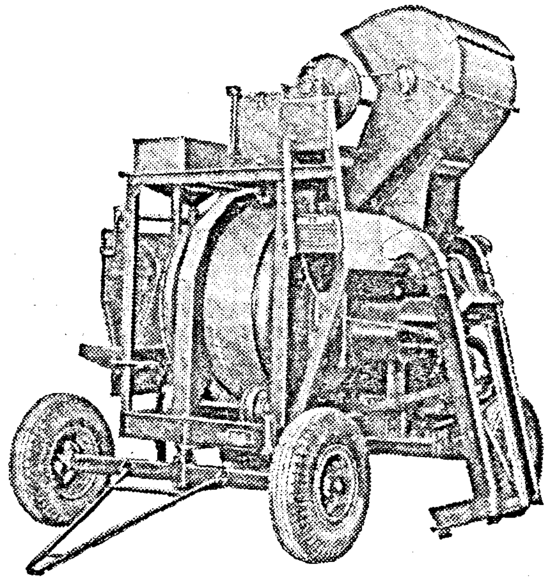
S. No.	Job No.	Name of work	Amount (Rs in Lakhs)
		RAJASTHAN	
1.	1023 RJ 8	Providing 3 ft wide shoulders in a length of 23 miles of Alwar-Delhi road, N. H. No. 8 from Punjab border to Alwar.	1.00
2.	1024 RJ 8	Alwar-Delhi Road, N. H. No. 8: Widening the road formation to 32 ft width from 28 ft width in a length of 6 miles and from 20 ft width up remaining miles.	0.29
3.	1025 RJ 8	Widening and fencing road width near Naogaon village in mile 22 of Alwar-Delhi Road.N. H. No. 8.	0.09
4.	1058 RJ 8	Construction of a bypass at Nathdwara between miles 29-32 of Udaipur-Kankroli Section of N. H. No. 8.	4.52
5.	1081 RJ 8	Widening ghat section of Udaipur-Kherwara Road, N. H. No. 8 in miles 14 and 15.	0.41
		ANDHRA	
6.	1026 AH 5	Black topping M. 528 to 543 of N. H. No. 5 excluding the length within the Municipal limits of Chicacole of the Madras Calcutta Road N. H. No. 5.	3.33
7.	1027 AH 5	Black topping M. 510 to 528 of the Madras Calcutta Road, N. H. No. 5.	2.98
8.	1028 AH 5	Black topping M. 567/0 to 580/0 of the Madras Calcutta Road N. H. No. 5.	1.81
9.	1040 AH 5	Widening the Black topped surface from M. 544/0 to 550/0 of the Madras Calcutta Road N. H. No.5.	1.98
10.	1041 AH 9	Widening the black topped surface from M. 44/3 to 51/6 of the Sholapur Hyderabad Vijayawada Road N. H. No. 9.	3.67
11.	1046 AH 4	Black topping M. 81/6 to 134/7 of the Madras- Chittoor Bangalore Road N. H. No. 4 excluding M. 95/7 to 97/6 passing through Chittoor town.	9.52

LIST OF APPROVED WORKS ON NATIONAL HIGHWAYS—*(Continued)*

S. No.	Job No.	Name of work	Amount (Rs in Lakhs)
		BIHAR	
12.	1029 BR 2	Widening of the Cilajan causeway in mile 204 of G. T. Road in Gaya Distt.	0.21
13.	1030 BR 2	Widening and raising of the Botane causeway in mile 327 to G. T. Road - N. H. No. 2.	0.65
14.	1036 BR 31	Widening of the Bakhtiarpur-Barh-Mokameh Road - Section of N. H. No. 31.	6.56
15.	1064 BR 30	Widening of Patna-bye-pass Road from 32′ to 40′ (Length 4 miles 40 ft)-N. H. No. 30.	5.04
		ASSAM	
16.	1031 AS 31	Remetalling and surfacing certain miles (from Jagighopa to Bilashipara N. H. No. 31.	4.10
17.	1032 AS 37	Remetalling and surfacing certain miles (from mile 15 to 32nd mile) A. T. Road East. N. H. No. 37 in Gauhati Divison.	4.63
18.	1033 AS 38	Metalling and surfacing Digboi-Margheritta and Lekhapani - Ledo Road N. H. No. 38.	4.47
19.	1034 AS 37	Remetalling and surfacing certain miles of A. T. Road East between miles 109 to 128 of N. H. No. 37.	3.79
20.	1035 AS 37	Remetalling and surfacing certain miles of A. T. Road between miles 47 to 74 of N. H. No. 37.	4.22
21.	1037 AS 31	Replacement of thatch roofing B. C. I. sheets in North Salmara Inspection Bungalow on N. H. No. 31.	0.01
22.	1038 AS 37	Remetalling and surfacing certain miles of A. T. Road East from Baguri towards Numaligarh (between miles 129 and 156) N. H. No. 37.	8.48
23.	1039 AS 37	Remetalling and surfacing certain miles A. T. Road West (from Goalpara to Chaygaon) N. H. No. 37 in Goalpara Division.	6.65
24.	1043 AS 39	Providing stone paved drains within the slip area between miles 34 to 65 of D. I. Road-N. H. No. 39 in Kohima sub-division.	0.62

MILLARS'

HIGHWAY COMBINED DRYING AND MIXING MOBILE UNIT



Single and two-coat Asphalt—Hot process.

* The production of Pre-coated Chips.
* Sand drying; drying and warming Chips for Surface Gritting.
* Re-heating old Asphalt for relaying on maintenance contracts.
* The production of all types of Bituminous Macadams and Cold Asphalts.
* The Unit is completely self-contained with its own Diesel Driving Engine and Oil-firing Equipment and easily transportable.

MILLARS' TIMBER & TRADING CO., LTD.

(Estd : 1902)

VICTORIA HOUSE, VICTORIA ROAD, BOMBAY - 27.

THE HINDUSTAN CONSTRUCTION CO. LIMITED.

CIVIL ENGINEERS, BUILDERS & CONTRACTORS.

Foremost in the field in

Designing & Construction of Dams for Multi-purpose Projects,	Heavy Earthworks,
Railway & Road Bridges with all types of foundations (including Caisson & Monolith Sinking),	Buildings—Industrial & Administrative,
Docks & Jetties,	Marine & Land Pipe Lines,
Water Supply & Drainage Schemes,	Road Construction,
Aerodromes & Hangars,	Guniting, Core Drilling & Grouting, Public Health Engineering, including Sewage Purification and water treatment.
Tunnels,	

We also undertake Piling works under HINDUSTAN-ZEISSL system.

Head Office:

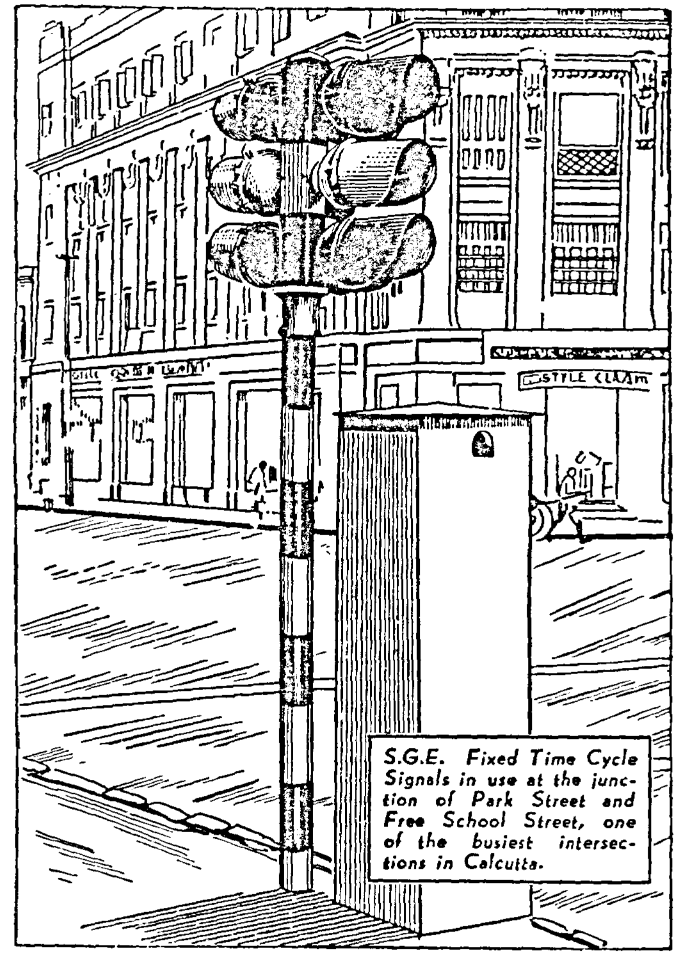
Construction House - Ballard Estate - Bombay I.

SGE

ROAD TRAFFIC SIGNALS

greatly increase

ROAD SAFETY



S.G.E. Fixed Time Cycle Signals in use at the junction of Park Street and Free School Street, one of the busiest intersections in Calcutta.

The rapid growth of vehicular traffic in the cities of India has greatly increased the problem of efficiently controlling traffic, with safety to road users. SGE can help you solve this problem. Experience with installations in many parts of the world, apart from hundreds of signalled Intersections in Great Britain, provide the background of knowledge and resource of which you can have the advantage.

Two methods of control are available—the AUTOFLEX System which is vehicle actuated, and SGE Fixed Time Cycle—both of which are fully automatic. Facility is provided with both systems for the control of traffic by hand.

● Our Engineers will be pleased to co-operate in the preparation of schemes for road traffic control, and invite you to submit your problems for consideration.

THE SIEMENS AND GENERAL ELECTRIC RAILWAY SIGNAL COMPANY LTD.

Represented by

THE GENERAL ELECTRIC COMPANY OF INDIA LTD.

Head Office:

Magnet House, Chittaranjan Avenue, Calcutta 13

Branches at:

Bombay Madras Kanpur Delhi Bangalore Coimbatore Secunderabad

Also represented in: Karachi Lahore Chittagong Rangoon

99530

D411m2, N48 N55-94

... copies of
Publications of the Indian Roads Congress
are available for sale.

No.	Publications.	Price inclusive of postage, etc. Rs	A.	P.
1.	Volume IX—Part 4—October 1945	3	0	0
2.	Volume IX—Bound—Madras 1945	10	0	0
3.	Volume X—Part 4—August 1946	3	0	0
4.	Volume XI—Part 4—May 1947	3	0	0
5.	Volume XII—Part 2—January 1948	3	0	0
6.	Volume XII—Part 3—April 1948	3	0	0
7.	Volume XII—Part 4—March 1948	3	0	0
8.	Volume XII—Part 5—September 1948	3	0	0
9.	Volume XII—Bound—1947-48	12	0	0
10.	Volume XIII—Part 1—December 1948	3	0	0
11.	Volume XIII—Part 2—January 1949	3	0	0
12.	Volume XIII—Part 3—January 1949	3	0	0
13.	Volume XIII—Bound—1948-49	11	0	0
14.	Volume XIV—Part 1—September 1949	3	0	0
15.	Volume XIV—Part 2—December 1949	3	0	0
16.	Volume XIV—Part 3—December 1949	3	0	0
17.	Volume XIV—Part 4—July 1950	3	0	0
18.	Volume XIV—Bound—1949-50	8	0	0
19.	Volume XV—Part 1—August 1950	3	0	0
20.	Volume XV—Part 2—November 1950	3	0	0
21.	Volume XV—Part 3—January 1951	3	0	0
22.	Volume XV—Part 4—August 1951	3	0	0
23.	Volume XV—Bound—1950-51	9	0	0
24.	Volume XVI—Part 2—March 1952	3	0	0
25.	Volume XVI—Part 3—April 1952	3	0	0
26.	Volume XVI—Part 4—October 1952	3	0	0
27.	Volume XVI—Bound—1951-52	8	0	0
28.	Volume XVII—Part 1—December 1952	3	0	0
29.	Volume XVII—Part 2—January 1953	3	0	0
30.	Volume XVII—Part 3—January 1953	3	0	0
31.	Volume XVII—Bound—1952-53	9	0	0
32.	Volume XVII—Part 4—December 1953	3	0	0
33.	Volume XVIII—Part 1—December 1953	3	0	0
34.	Volume XVIII—Part 2—December 1953	3	0	0
35.	Volume XVIII—Part 3—January 1954	3	0	0
36.	Road Research Bulletin No. 1	5	0	0
37.	Road Research Bulletin No. 2	5	0	0
38.	I. R. C. Standard Specifications and Code of Practice for Road Bridges in India (1937)	1	8	0
39.	Proceedings of the Chief Engineers' Conference at Nagpur on the Post-war Road Development in India	2	8	0
40.	Type Designs for Highway Milestones	0	8	0 plus packing and postage
41.	Route Marker Signs for National Highways	0	8	0 plus packing and postage
42.	Dimensions and Weights of Road-Design Vehicles	0	8	0 plus packing and postage
43.	Recommended Practice for the Location and Layout of roadside Motor Fuel Filling stations.	0	8	0 plus packing and postage

Copies can be had from the Secretary,

INDIAN ROADS CONGRESS,
JAMNAGAR HOUSE, SHAHJAHAN ROAD,
NEW DELHI-2.

Printed by K. S. Krishnan at The Progressive Printers, 17, Coral Merchant Street, Madras-1, & Edited and Published by J. Subrahmanyam, Hony. Secretary, Indian Roads Congress, Jamnagar House, Shahjahan Road, New Delhi-2—900.