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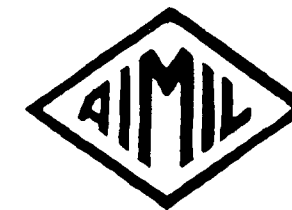
MONTHLY REVIEW

JANUARY 1959—No. 141

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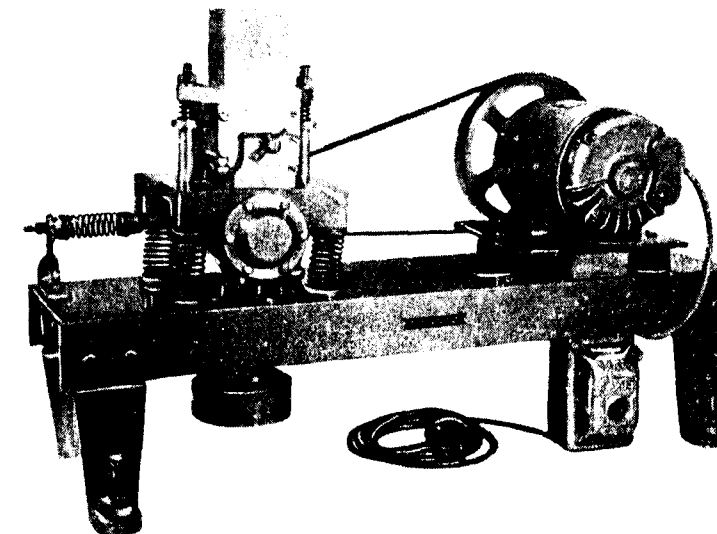


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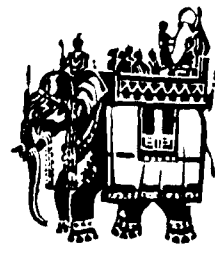
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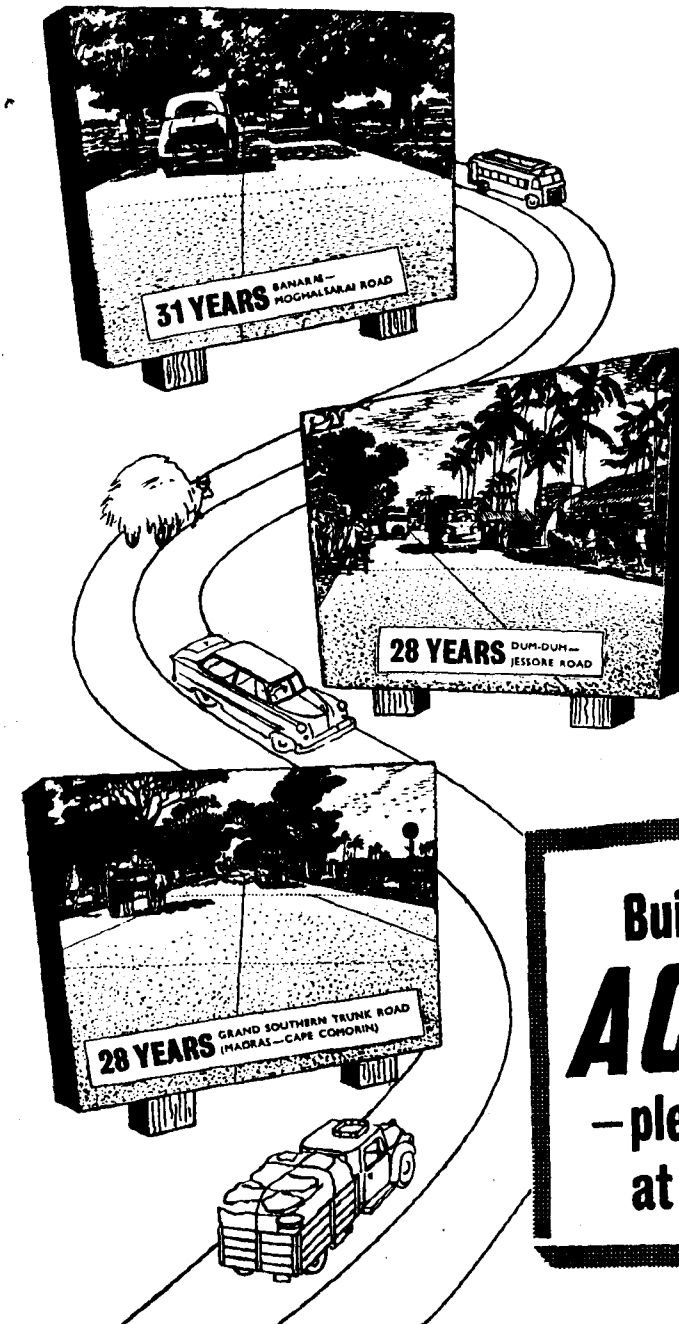
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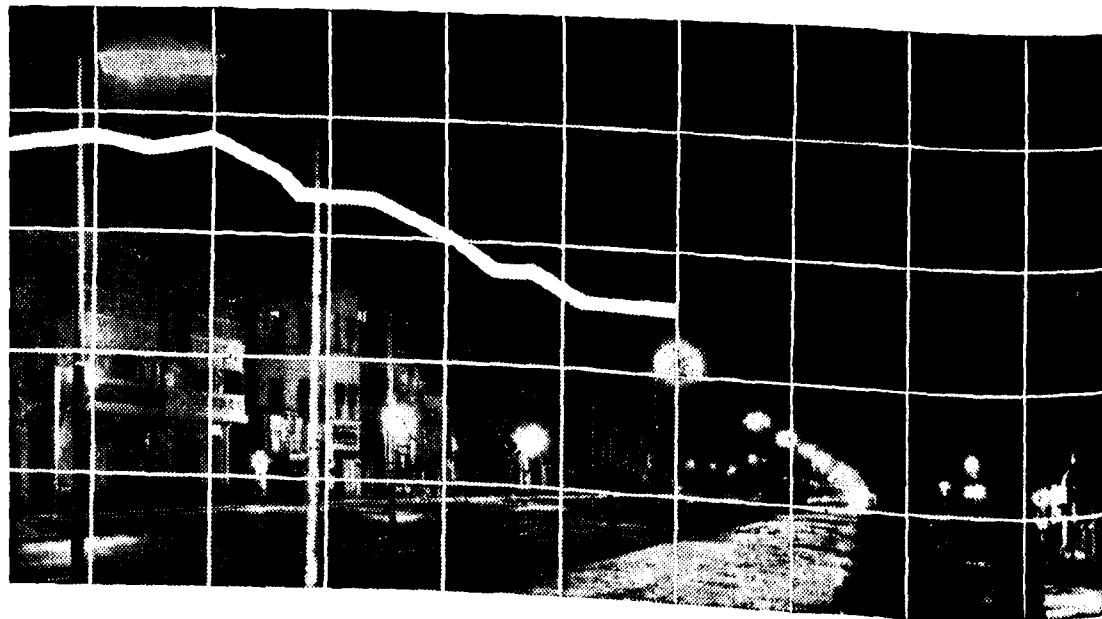
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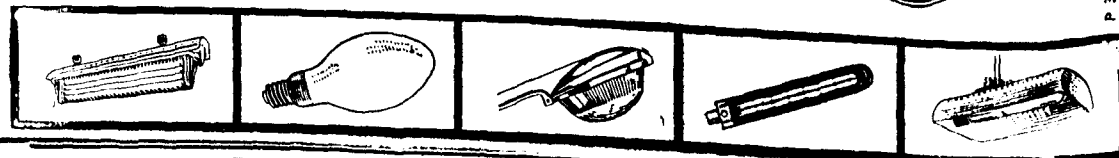
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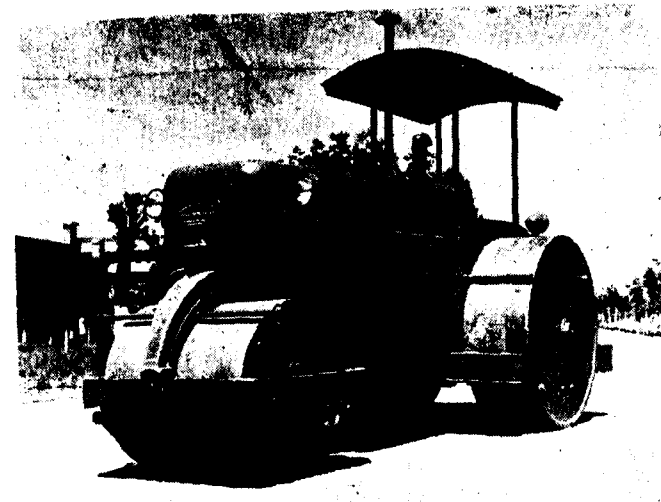
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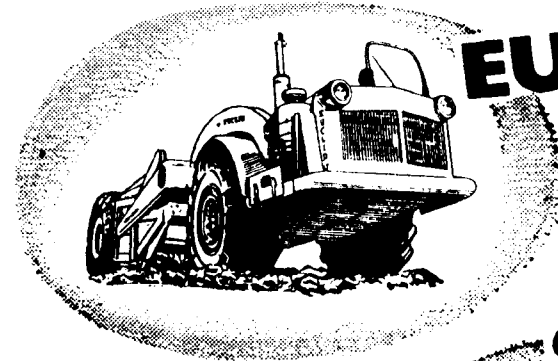
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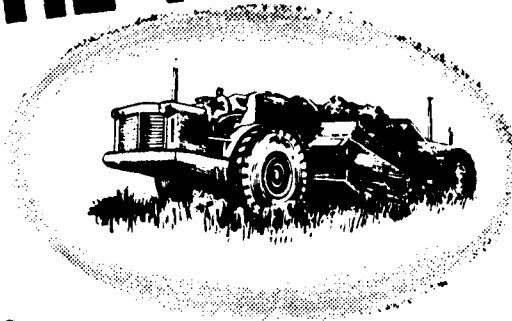
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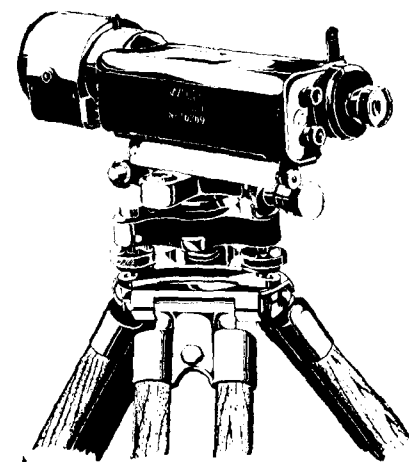
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PAMPA BRIDGE IN ANDHRA PRADESH (see page 7)

TRANSPORT-COMMUNICATIONS MONTHLY REVIEW

A REVIEW OF
ROAD ENGINEERING, DEVELOPMENT & TRANSPORT

JANUARY 1959

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FORUM OF HIGHWAY PROBLEMS

HYDERABAD, the Capital of the newly formed State of Andhra Pradesh, will be the venue for the annual session of the Indian Roads Congress for the second time, the first session having been held here in 1938. A City of rich historical and cultural associations, its glittering lakes, beautiful gardens and parks, magnificent edifices and other imposing public works and, what is more appropriate, its good roads, will be an inspiring background for the discussion of India's road problems. These, it is now agreed by all, centre round the provision of more and better roads for the country. The Nagpur Plan was the first concrete evidence of the realisation of this need and its successor, the Second Road Development Plan, following the same trend, provides for doubling the road mileage with due emphasis on higher types of roads.

Side by side with construction of new roads and improvement of the existing ones, maintenance of the road system in a satisfactory condition is important in the interest of overall transport economy. The needs of modern transport point towards progressive attainment of uniformity throughout the major routes and, for this purpose, it is necessary to have a measurable and uniform yard-stick to assess the condition of a road in relation to the various elements which affect its efficiency and performance. Such a measure would be a guide not only for the preparation of planned programmes and priorities but also for the correct utilization of available funds.

In addition to the heavy traffic loads to which the roads are now subject, the floods of recent years have caused considerable damage to roads. Even concrete and black-top pavements have given way under the ravages of floods, much to the detriment of smooth flow of traffic. Studies of pavement failures are, therefore, important for evolving remedial and precautionary measures. In the case of concrete pavements, failures may be due to higher induced stresses due to load and temperature effects as compared to the flexural strength of concrete, effect of repetition of load stresses, swelling and shrinkage effects of the underlying soil, etc. In the case of black-top roads, failures may be due to insufficient thickness of the pavement, weathering of the binder,

waterlogging, etc. In all these cases, it is only after careful observations and investigations both in the field and in the laboratory that the causes of failures can be traced and recommendations made to avoid their recurrence.

Not only traffic loads are increasing but the traffic tangle on our roads is becoming complicated, especially in urban areas. In the case of new cities, we can build wide roads, limit access to them, provide over and under-passes, introduce properly designed intersections and so on, but in the case of old cities it is a question of making the best use of the existing roads. There is probably no hard and fast rule by which we can do it, but the approach seems to lie in the rehabilitation of over-loaded roads and streets by effecting various engineering improvements, rearrangement of the traffic pattern in some cases, and adjustment to the traffic pattern in others by proper regulation and control. However, before any of these methods are adopted, a detailed study of the traffic conditions in a city is required without which no satisfactory solutions can be found.

From traffic to pavement is but a small step as the pavement has to suit the traffic which it is meant to carry. Brick is an old material which has been used in building construction including roads with remarkable results. By a proper selection of the soil and regulation and control of temperature for burning bricks, their quality can be considerably improved for use in road pavement. Field experiments carried out in certain parts of the country indicate that this material can be economically used on certain types of roads. More study and experimentation are, however, required in this direction.

Transporting ourselves to the hilly regions, it might appear at first sight that roads in the hills do not bristle with difficult problems once they are constructed. But a hill road is as difficult to maintain as it is to construct, on account of landslides and hill slips to which it is frequently subject. Here again, detailed investigations are required with the aid of latest advances in soil mechanics before any recommendations are made regarding both remedial and precautionary measures to be adopted. Mere judgement and rule of thumb may lead to uneconomical results.

Roads are not complete without bridges and consequently bridge building forms an integral part of highway development schemes. The type of bridge to be built at any place depends upon several factors and different alternatives are generally worked out before the most suitable and economical design is selected. Box girders are not very common in India, but experience so far available shows that where there are no serious difficulties of construction, the cellular type of bridge deck design may be suitable and economical.

These are some of the highway problems round which the discussion will centre at the general session. There may not be any surety of arrival at general solutions for specific highway problems but the forum of a professional body like that of the Indian Roads Congress can certainly build a fund of knowledge and experience to be used and drawn upon by the members.

THE 23RD SESSION OF THE INDIAN ROADS CONGRESS—HYDERABAD—JANUARY 1959

AT the invitation of the Government of Andhra Pradesh, the 23rd Session of the Indian Roads Congress is being held at Hyderabad from the 6th to the 13th January 1959. Seven Papers, brief summaries of which are given below, will be discussed at the I.R.C. Session. A general report on road research done in India will also come up for discussion on the 7th Jan. There will be a panel discussion on "Roads in Water-logged Areas". Many technical Committees of the Congress will meet during the Session. It is expected that about 300 delegates from all parts of India and some delegates from abroad will attend the Session. An Engineering exhibition in which the Ministry of Transport & Communications, Government of India, State P.W.Ds. E-in-C., A.H.Q., and engineering firms will participate, is also to be held on this occasion. A special feature of this year's exhibition is that it will form part of the All-India Industrial Exhibition being held at Hyderabad. The Governor of Andhra Pradesh will inaugurate the Session on the 7th January morning.

Summaries of Papers

1. **Paper No. 206— "Construction of an R.C. Cantilever Hollow Girder Bridge over Betwa River at Jharaghat"**—P.N. Srivastava.

The Paper describes the investigations, salient features of design and the construction of an R.C. hollow box girder bridge over the Betwa river in Jhansi District in mile 25 of N.H. 26. The bridge consists of 31 spans, 66 ft 8 in. each, of hollow girders continuous over 3 spans with 12 ft cantilevers on either side of which 42 ft 8 in. suspended spans rest over cast steel rocker and roller bearings. The bridge has open foundations resting on solid rock. The abutments, wing walls and piers are of coursed rubble masonry in 1:5 cement mortar. Features regarding centering and shuttering for hollow girders and their concreting are described,

so also the construction of approaches of the bridge.

2. **Paper No. 207—"Adequacy Assessment of Highways"**—D.G. Bhagat.

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

3. **Paper No. 208 — "Traffic Survey In and Around Calcutta"**—S.K. Laha, A.K. Das Gupta and S. Chatterjee.

The Paper deals firstly with the study of external traffic on roads leading to Calcutta City. For this purpose, traffic counts were taken at eleven stations on the outskirts of the city in September 1957. A similar study was carried out earlier in 1950. The city was divided into various zones and the average daily traffic flow between the counting stations and the various zones was determined. Thus traffic flow diagrams for daily traffic were obtained from which hourly average could be deduced.

The traffic flow on various important roads in the city due to external traffic is then analysed and the effect of the proposed Greater Circular Road in relieving congestion on other busy roads is shown.

The Paper then describes the study of internal traffic for which traffic counts were taken at each important crossing within the city during rush hours. Both fast and slow traffic was counted and equivalent fast traffic worked out. The traffic capacities of carriageways and intersections of different internal roads are then analysed and various improvements are suggested to relieve congestion in the city.

4. Paper No. 209—"An Investigation of a Concrete Pavement Failure"—Dr. Bh. Subbaraju and Y. C. Gokhale.

An investigation carried out for determining the probable reasons for an early development of cracking of slabs of a cement concrete pavement has been described in this Paper. The probable cause of failure was attributed to the excessive differential swelling and shrinkage properties of the particular subgrade soil. Utilizing existing knowledge, an attempt has been made to evaluate induced stresses based on theoretical considerations and also to estimate the probable crack expectancy period based on flexural strength values obtained from beams cut out from the road slabs. Some remedial and precautionary methods have been suggested both for already laid concrete pavements as well as for new concrete Pavement construction on highly expansive soil subgrades.

5. Paper No. 210—"Brick Pavement in Highway Construction"—D. C. Chaturvedi and J. C. Tayal.

The Paper outlines the possibilities of using bricks in highway construction in India. Brick roads are already existing in Western countries like Holland and Germany.

A Bull's kiln was established on Lucknow-Sultanpur road to produce bricks of superior quality to be used on this road. The factors affecting the quality of bricks are discussed and the effect of increasing the duration of firing on the quality of bricks is shown. The temperatures obtained in the kiln and the results of tests on bricks and brick ballast are discussed.

Specifications adopted in laying different types of brick pavements and their behaviour are described. The behaviour of surface dressing and premix carpet on brick pavement is also discussed and broad conclusions given.

6. Paper No. 211—"Investigation of Failures of a Bituminous Road"—C. G. Swaminathan and S. Arumuga Swami.

This Paper deals with a detailed investigation that was carried out on an

important road to study the causes of the extensive surface cracks that had developed on it. Trenches were cut in the road to expose the subgrade in various locations along the road, where the road was sound and at others where the road had failed. Data regarding the type and the thickness of the courses, the properties of the road material, the consistency of the extracted binder as well as field C.B.R. and plate bearing values of the subgrade soils saturated in places, were determined.

McLeod's chart for the design of flexible pavements was used to determine as to whether the failures of the pavement were due to inadequate thickness or not, based on the field C.B.R., plate bearing and cone bearing values. An approximate correlation between the field C.B.R. and non-repetitive plate bearing test values within specific limits is set forth based on the investigation data.

Causes of the failures were grouped into three categories, viz., those arising from an unsatisfactory foundation or inadequate thickness of pavement, those due to failures of the base course or local subsidence, and those due to the weathering of the binder.

In certain sandy subgrade sites the presence of hair cracks was observed during the investigation and an attempt is made to explain this.

7. Paper No. 212—"Landslide Investigation and Treatment in Assam"—G. C. Sharma.

This Paper describes the landslide problems in the State of Assam in general and mainly on Dimapur-Imphal Road, National Highway No. 39. Methods adopted so far to control landslides are described and suggestions are made to prevent their occurrence.

Present day information regarding the theory and causes of landslides and subsidences, investigation procedures with the knowledge of soil mechanics and geology, analysis of soil studies and assessment of correct solutions of individual problems faced by highway engineers have, as far as possible, been incorporated in the Paper.

BRIDGING INDIA'S RIVERS

THE PAMPA BRIDGE

(By Courtesy of the Highways Department, Andhra Pradesh)

The Site

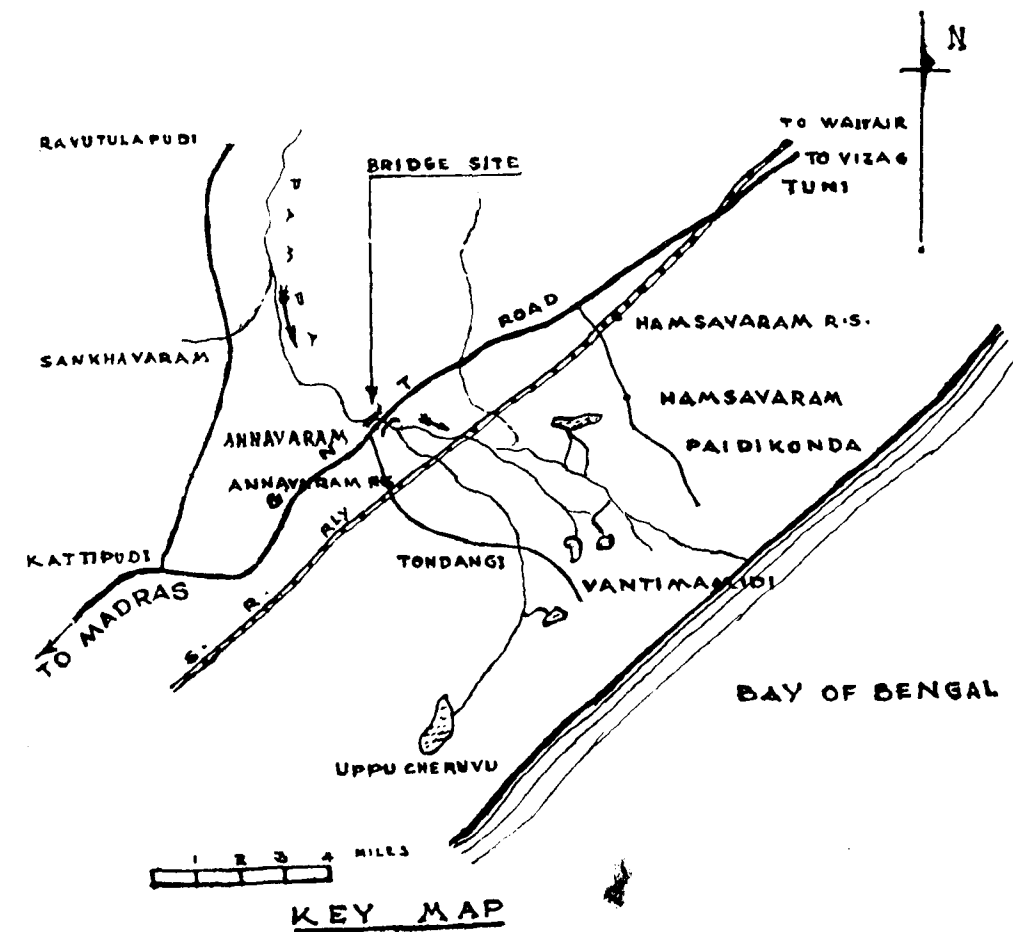
THE River Pampa rises in the Eastern Ghats and passing through the East Godavari District of Andhra Pradesh crosses the Madras-Calcutta road, i.e., National Highway No. 5 in Mile 413/1, 2 and joins the Bay of Bengal. Formerly there was an arched bridge of 4 spans of 28 ft 6 in. at this point, which was breached during floods in the year 1949 due to the inadequacy of the ventway. This being a road of strategic importance, the reconstruction of the damaged bridge had to be taken up. The newly constructed bridge is located 100 ft-0 in. on the downstream side of the damaged bridge.

Hydraulic Data and Waterway

The catchment area of the river above the site of the bridge is 136.89 square miles. The discharge calculated from Ryves' formula with the coefficient of 1,200 comes to 31,420 cusecs. The active channel in summer is only about 50 ft wide but in floods the water spreads to nearly 300 ft. At the point of the bridge there are two hillocks on either side not very far. The bridge is designed as a high level bridge.

General Features of Design

The bridge consists of 5 spans of 50 ft clear at bed block level. The superstructure



is of reinforced cement concrete with deck slab over T-beams and is designed for one lane of I.R.C. class "AA" loading. The beams rest on piers of coursed rubble masonry on open foundations. The working stresses adopted for concrete and steel are 750 lb per square in. and 18,000 lb per square in. respectively. The bottom of decking will have a free board of 3 ft above the maximum flood level of 100.00.

Foundations

Trial borings at the bridge site showed sandy soil for a depth of 5 ft over hard clay 12 ft thick overlying hard rock. But as it was found unnecessary from considerations of scour and bearing capacity of soil to take the foundations to the rock bottom, they were taken to sufficient depth to have a grip of 6 ft in hard clay. The foundations adopted are of the open type. No major springs were met with. The maximum intensity of pressure on the soil in foundations comes to 2.3 tons per sq. ft.

Piers and Abutments

Piers are constructed in coursed rubble masonry, 1st sort in cement mortar 1:5 and are 5 ft wide at bed block level (101.50) and 6 ft wide at sill level (87.00). The thickness of piers has been increased by providing suitable offsets at different heights as shown in Fig. 1. They are provided with individual R.C.C. bed blocks on top. The abutments have a batter of 1 in 12 in front. The wings are separated from the abutments and are kept at a higher level.

The width of abutment at top is 5 ft-0 in. and 11 ft-0 in. at level 81.00, the length being 32 ft-2 in. The width of

wing wall at level 81.00 is 11 ft-0 in., gradually decreasing to 2 ft-0 in. at level 108.70, with part face vertical and a length of 13 ft-0 in. at level 81.00.

Superstructure

The superstructure consists of 4 R.C. T-beams and deck slab. The beam ribs are 20 in. x 58 in. and the deck slab 7.5 in. thick. The decking provides for a 22 ft clear roadway with 9 in. thick kerbs and protected on the sides with R.C.C. hand railing. The beams rest on R.C.C. individual bed blocks 5 ft-0 in. x 6 ft-8 in. x 1 ft 6 in. The deck slab is designed as spanning in one direction only and also as a slab continuous over the beams. It is designed for I.R.C. Class AA loading, the main reinforcement adopted being 5/8 in. diameter M.S. rods at 6 1/2 c/c, the transverse reinforcement being 3/8 in. diameter M.S. rods at 4 1/2 in. c/c. The T-beams are designed for I.R.C. Class AA single lane loading. Each of the two intermediate beams is designed for a track load placed directly on the beam. The same moments are assumed for the end beams also, although the moments and shear in the end beams will be slightly less than the intermediate beams. For constructional facility the same sections with the same details of reinforcement are adopted for all the 4 beams. The main reinforcement in each beam consists of 5 M.S. rods of 1 3/4 in. diameter and 5 Nos. M.S. rods of 1 1/2 in. diameter.

The centring for the beams and deck slab was put up in teakwood planks supported by wooden frames. The locally available casuarina posts were erected in stages from the bed level to support the planking for the R.C.C. decking. Wedges

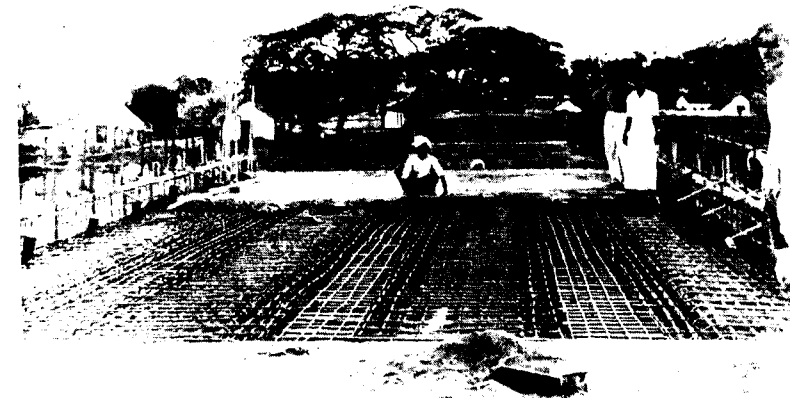
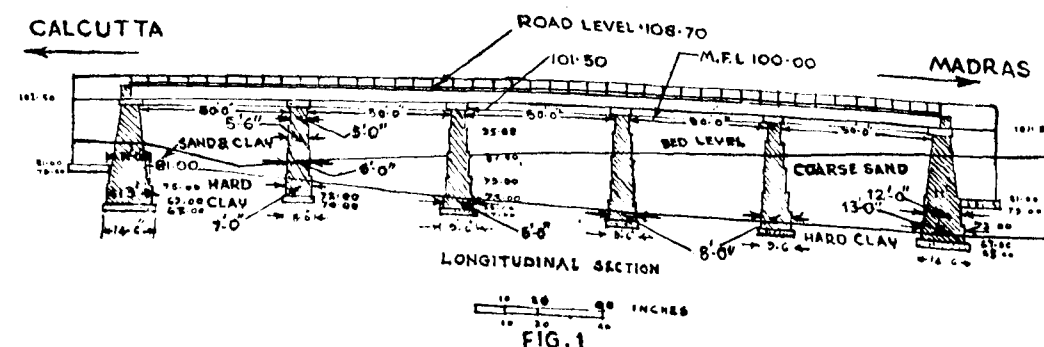


Photo 1. Laying Reinforcement for the deck slabs.

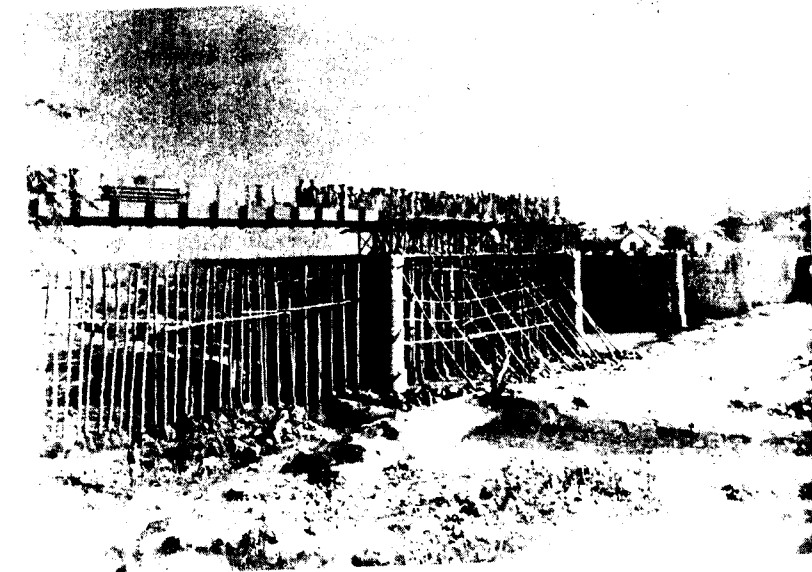
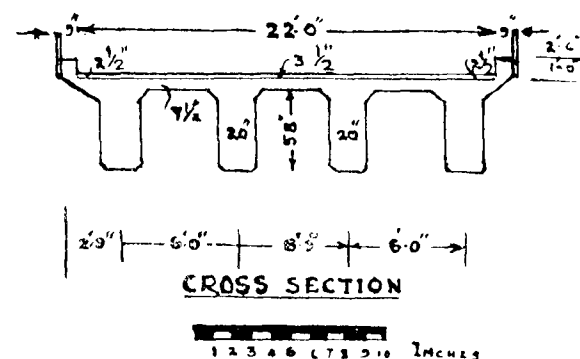


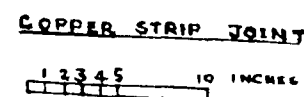
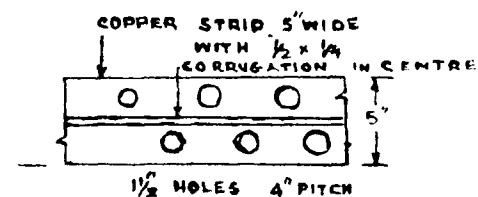
Photo 2. Centring for the beams and deck slab

were used wherever necessary for fine adjustments to get the centring to the correct levels.

The concrete (1 : 2 : 4) ordinary grade was mixed with concrete mixers. Granite chips 3/4 in. size were obtained from a quarry at Yeleswaram, 27 miles away from the work spot. The sand available in the river bed was found to be well suited for the work and was used in the bridge construction. As it was not possible to concrete a complete span in one day, the beams were first concreted. On the succeeding day, the top surface was lightly scraped, neat cement in water was applied and the deck slab was laid.



To make up the required lengths, the main reinforcement for the beams was welded from considerations of space and economy. Samples of welded pieces were picked up at random and were tested in the laboratory for tension. The results obtained were good. None of them broke at the welds. This was also convenient in concreting the deck slab as, other-



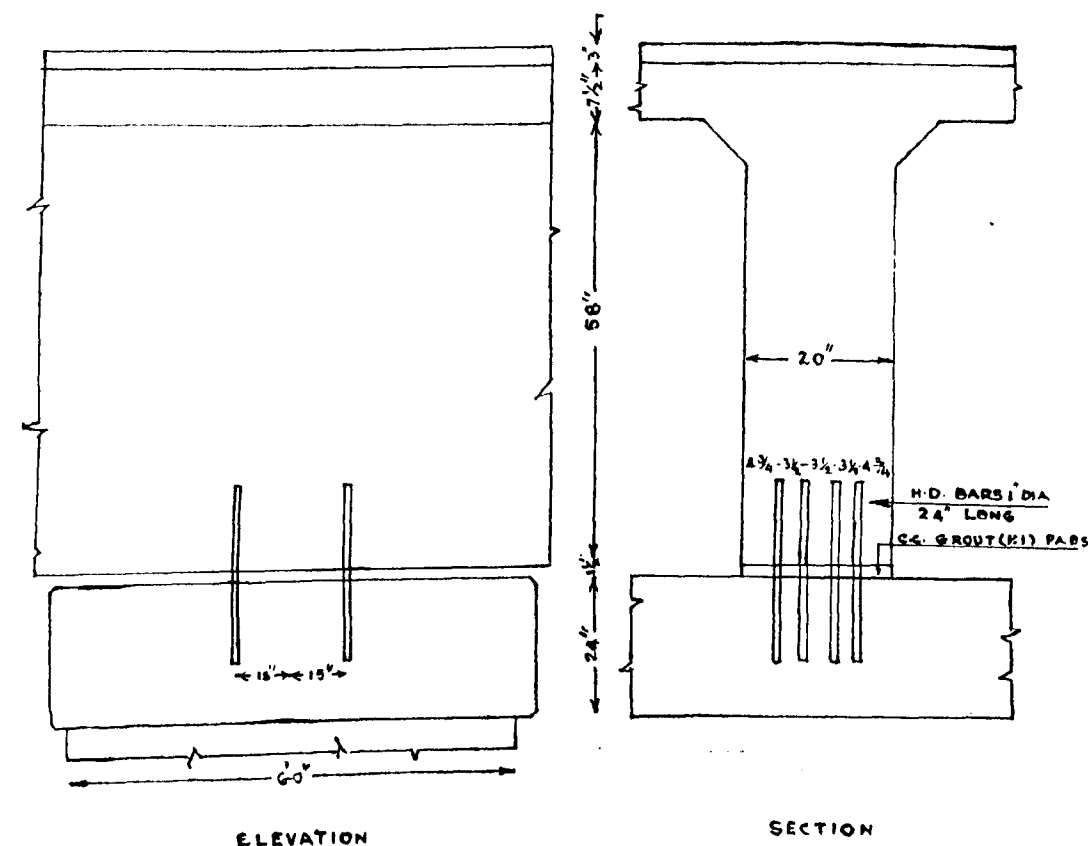
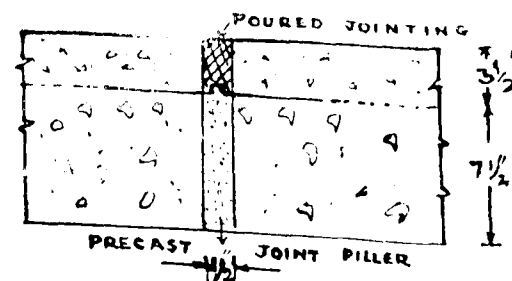
wise, it would have been difficult if the short lengths of 18 ft rods were to be spliced with the required overlaps.

One end of the beams was fixed and the other end was free over the supports. Any one of the piers had either of the ends of adjacent beams with fixed or free bearings on it. The fixed ends of the beams were anchored to the pier by means of dowel rods 1 in. diameter, 24 in. long and spaced at $3\frac{1}{2}$ in. centres, jutting through cast-in-situ cement mortar (1:1) grout pad $1\frac{1}{2}$ in. thick. The free ends of beams were shod with $5\frac{1}{8}$ in. mild steel foot plate juttred with inverted bolts 1 in. diameter anchored into the beam and sliding over a sandwiched copper sheet $1/16$ in. thick over similar mild steel bottom bearing plate fixed to the pier.

The expansion joints were provided with bitumen-hemp filler held in position by a copper sheet.

The wearing coat is 1:1½:3 cement concrete 3½ in. thick at centre and 2½ in. at sides. It was compacted by tamper-enscreed vibrator. The aggregate was 66-2 3 per cent of 1 in. size metal and 33-1 3 per cent of 3/16 in. to 3/4 in. size graded chips. The wearing coat was laid after all the slabs were completed and the centring for the decking removed.

Drain holes were provided near the kerbs at 6 ft centres with 3 in. diameter pipes dipping 6 in. below the bottom of slab.



FIXED BEARING FOR GIRDERS

12045	10	15	20	INCHES
12045				

Approaches

The abutments having been designed for equivalent earth surcharge due to moving loads, approach slabs were dispensed with. The approaches on either side are taken at a gradient of 1 in 30 with 100 ft flat lengths from the bridge. The approaches are aligned in suitable curves to join the old road.

Costs

The cost analysis for the bridge is given below:—

Foundations	...	24,000
Piers and Abutments	...	74,000
Superstructure	...	1,13,000
Approaches	...	64,000
		<u>2,75,000</u>

Analysed Costs

- (a) Per running foot of the bridge Rs 982.
- (b) Per square foot of the carriage-way Rs 45.
- (c) Per square foot of entire elevation area enclosed between the line connecting the lowest part of the foundation and the line connecting the uppermost points of superstructure Rs 28.
- (d) Per cubic foot of bridge from bottom of foundation to top of roadway Rs 1.25.

ROADS AND ROAD TRANSPORT

By

GURU PERSHAD,* B.Sc. (MANCHESTER), M.I.E. (INDIA).

ON the occasion of the Annual Session of the Indian Roads Congress to be held in Hyderabad, the Capital of Andhra Pradesh, it would be proper for one connected with the State Road Transport Undertaking to give his views on matters concerning roads, as the S.T.C. happens to be the principal user of the highways. It is, therefore, a matter for gratification to take the opportunity of contributing a short article on the subject to the annual number of the Transport-Communications Monthly Review published by the Indian Roads Congress.

Greater emphasis is just now being laid on conserving foreign exchange and it is stated that by spending money on roads we shall not save foreign exchange, which otherwise can be done if the same amount is spent on the development of industries which can produce goods that are now being imported. A Road Transport Engineer has a very much different view in this matter. The maintenance cost of vehicles operating on good roads is half that of the cost of operation on bad roads. With the improvement of roads, therefore, there is substantial saving in the expenditure on maintenance of vehicles. The expenditure involved in the import of spare parts is so heavy that this will result in considerable saving in foreign exchange. It is, therefore, but proper to stress the importance of upgrading the roads as a significant factor in the national economy.

The intensity of traffic has to be taken into consideration before such upgrading is taken up and in this connection it is felt that a close liaison is necessary between the large transport operators (Nationalised Road Transport Undertakings) and the Highways Department in the matter of planning the upgrading of roads and fixing priorities.

It is, therefore, suggested that to facilitate alround improvement in road transport, a close co-ordination should be brought about by having the Highways Department, the Nationalised Road Transport Undertakings and the State Transport Authority (in charge of the enforcement of the Motor Vehicles Act) under one Ministry of the State Government.

To illustrate the point further, instances are not lacking when bridges have been constructed without proper approach roads. This results in locking up of a huge amount of capital which otherwise would have begun to give returns immediately. National Highways have been constructed to facilitate faster movement of traffic; yet, we find at numerous places obstructions which not only reduce the speed of motor vehicles but create situations which can result in a serious accident or damage to the vehicles. Actually, serious accidents have taken place on such spots where there are pronounced humps on culverts or steep depressions in nallahs or streams, both of which are very dangerous for motor vehicles. Again, we have some patches of roads where the surface is so bad that the speed is reduced to less than 20 miles or even 15 miles an hour. On the highways, it is often noticed that berms are not consolidated with the result that it is difficult for two vehicles travelling even at 15 m.p.h. to cross each other with safety. Both the vehicles have therefore to come to a halt and one of them has to get off the track for the other to pass by, and in doing so, it gets stuck in the loose soil on the berms and this causes unnecessary delays during the rainy season. With the introduction of 8-feet wide vehicles the problem has become still more acute, as the main

portion of the road is not generally wide enough for two such vehicles to cross each other with safety at a reasonable speed and without getting stuck up during the rains in the loose mud on the fringes. There are still curves in many places which contribute both to a reduction in speed and, if one is not careful, to an accident. Further, there are no road sign boards at the above mentioned points. Every one will agree that this is a serious matter for our present day traffic on roads. A narrow culvert on a wide National Highway is a death trap for a driver. Very serious accidents have taken place at such points. Yet again, both National and State Highway stretches pass through municipal limits of towns which are unattended. There is, therefore, immediate necessity to bring all roads under one management.

It will also not be out of place to mention that the Highways Departments have been rather conservative in restricting the movement of heavier loads on roads. This has been causing great handicap in development of goods traffic

by road. It is more economical to operate a vehicle with a bigger pay load than five tons. A culvert or a small bridge that cannot take loads higher than, say, five tons, should not be the restricting factor on a stretch of road which is otherwise capable of taking the traffic. It would be far more economical in the long run to remove this obstacle than to restrict carrying heavier loads. This matter requires careful examination by the authorities concerned.

There is another aspect which also requires emphasis. While we are concentrating on the construction of more and more new roads or upgrading some of the existing ones, the maintenance of roads already constructed is sometimes sadly neglected. While we imagine that we are getting the benefit of more good roads on one side, we are losing on the others already laid. It is, therefore, imperative that these two aspects must go hand in hand. There is no doubt that it is much better to spend on keeping uniformly satisfactory surface on all roads than to up-grade some and neglect the others.

DEFINITIONS OF HIGHWAY ENGINEERING TERMS

- CURTAIN WALL:** A thin wall used as a shield or protection against scouring action.
- CUT-OFF WALL:** A wall, collar, or other structure intended to cut off or reduce percolation of water along smooth surfaces, or through porous strata.

WORDS OF WISDOM

Although this may seem a paradox, all exact science is dominated by the idea of approximation. When a man tells you that he knows the exact truth about anything, you are safe in inferring that he is an inexact man.

—BERTRAND RUSSELL

*Chief Executive Officer, Andhra Pradesh, State Road Transport Corporation.

ROADS IN ISRAEL

by

S. TOISTER,

Chief Engineer of Roads and Bridges

History and Development

ROADS were not unknown in Ancient Israel. The Romans had also built strategic roads, traces of which can still be seen. Later the country was laid bare for a number of centuries. The Turkish Administration however, had made a new start in road building around the beginning of the present century, which was intensified during World War I. During the British Mandate (1918-1948) road building came to the fore, in the wake of the introduction of the motor vehicle. A network of asphalted main roads was built, during this period, with the object of connecting all urban centres. During World War II, a wide programme of road construction had been undertaken to meet strategic needs.

When New Israel took over from the British Administration in 1948, it soon became evident that the existing highway system was not adequate to meet the ever increasing demands of the New State. Among the major causes necessitating a wide road construction and improvement programme the following may be cited:

1. Discontinuity of several main roads as a result of changes in the international boundaries. The cut off sections had to be by-passed by new roads.

2. Prior to 1948 most agricultural villages had access from main roads only via tracks suitable for horse drawn carts. From the first days of the new State, agriculture and the transport of its produce became highly mechanised. This necessitated a net of all-weather farm-to-market roads.

3. Development of new agricultural areas and industrial centres which were

spread intentionally all over the country for the absorption of increasing inflow of returning sons of Israel.

4. Exploitation of the mineral resources of the country especially in the Negev zone.

5. Development of the most southerly town, Eilat, a port on the Red Sea and construction of its harbour.

6. The growth of commercial traffic in number and weight of vehicles.

Present Constitution

Different categories of highways and their administration—The Israel Highway system comprises three categories of roads:

—Main Trunk Roads, which serve cross-country and inter-urban traffic;

—District Feeder Roads, which link up main roads and as the name implies link up several places in one district;

—Approach roads, giving access to villages.

These roads are constructed, administered and maintained by the Public Works Department of the Ministry of Labour.

There are also communal roads which serve internal communication in built up areas. The management of these roads is in the hands of the Local Authority of each community.

For administrative purposes and execution of works the country is divided into districts, each headed by a District Engineer responsible to the Director of Public Works. The Districts are further subdivided into sub-districts managed by

foremen in charge responsible to the District Engineer concerned.

Each sub-district is adequately staffed and equipped to be able to carry out independently all maintenance and construction works. Only in special cases, the sub-districts receive reinforcement in personnel, and in equipment, from the District or from the Head Office.

The Design of roads and bridges is the duty of Head Office staff who are also in charge of supervising the technical aspects of the execution of the works and control the expenditure incurred thereon.

Statistical Information

The lengths and growth of the Israel Highway system excluding communal roads are given in the following table:

	Year 1948	Year 1958
Main Roads	1,035 kms	1,500 kms
District Roads	835 kms	1,475 kms
Approach Roads	100 kms	575 kms
Total	1,970 kms	3,550 kms

The expenditure on maintenance and improvement of roads is not chargeable to special funds. It is provided for in the state yearly budget under one general item. Funds for construction of new roads are also provided in the state yearly budget, each project appearing under a separate item. With regard to approach roads to villages, however, local authorities, such as Regional Councils, do participate, to a certain extent, in the expenditure on these roads.

For the last four years amounts spent on roads have been, in millions of Israel pounds, as shown below:—

	1955	1956	1957	1958
Maintenance and improvement of existing roads.	4.2	4.2	4.3	4.4
Construction of new roads.	6.5	5.0	6.5	6.0

During the first decade of its existence Israel has spent a total amount of eighty million pounds on Highway activities.

Design and Construction

(Standards, Methods and Materials)

The minimum design standards adopted for the various types of roads are given below:

	Main Roads	District Roads	Approach Roads
Right of way reservation	40 m	30 m	20 m
Total width of road	11 m	8 m	6 m
Width of asphalted carriageway	7 m	5 m	4 m
Design weight (wheel load)	6 tons	4 tons	3 tons
Design speed	100 km/hr.	80 km/hr.	60 km/hr.
Maximum gradient (*)	4 p. 100	6 p. 100	8 p. 100
Minimum horizontal curve radius (*)	500 m	300 m	100 m
Minimum vertical curve radius (*)			
Convex	7,000 m	3,000 m	1,200 m
Concave	2,000 m	1,200 m	400 m
Minimum sight distance (*)	180 m	130 m	90 m

* These figures are relaxed somewhat in mountainous regions.

Israel, though being a small country, is confronted with the whole variety of problems in design and execution of road construction arising from types of soils and terrain, which are: peat bogs, heavy clay (black cotton soil), sand dunes, rocky mountains and desert zones with deep layers of loes. These problems are tackled and solved by the use of modern principles of soil mechanics, bituminous mixtures and mechanical equipment. The Public Works Department has its own central laboratory at the head office, fully equipped to perform routine tests on all kinds of road materials, necessary for design purposes. The district staff have at their disposal the necessary tools for carrying out the tests needed to ensure compliance with the prescribed design standards in the execution of works. The suitability of a soil for fill is investigated and determined by the Atterberg limits. The compaction of fills are controlled by measuring the dry density in comparison to the previously determined maximum density by the Proctor compaction test. The thickness of the pavement is determined by the C.B.R. method.

In various parts of the country there are important deposits of natural granular road materials, known under the local names of:

Hizrieh: A metamorphosed, disintegrated basalt stone containing a percentage, usually not excessive of clay particles:

Kurkar: A calcareous sand-stone, in the making stage, with various proportions of free lime spread in the granular mass and serving as binder:

Wadi gravel: River pebbles varying in grading and consistency.

These materials if properly excavated and carefully selected are suitable for sub-base or base courses. When used locally, the cost of construction is reduced materially. The Kurkar is also used with an admixture of bitumen as a kurkar-asphalt base or even binder-course of district roads. The wadi gravel in the Negev zone is of suitable grading and very clean, free from clay: mixed with bitumen, it forms a very good low cost

wearing course. The hand laid Telford base which was in common use years ago, has now been substituted by All in crusher run material, graded from 2½ in. down to dust. Stones are bound together by a slurry formed by a liberal application of water during rolling.

Out of 3,550 kms of roads maintained by the Public Works Department 2,880 kms are asphalted. The asphaltic mixtures generally used are either cold-laid Plant Mix or hot-laid Plant Mix.

Plants for cold-laid mixes are abundant in the country, and such mixtures can be supplied in practically unlimited quantities.



Jerusalem-Hartuv road. Typical view of terrain prior to earthworks

However, plants for hot-laid mixes, or namely asphaltic concrete, are still rare. Those available are not capable of meeting the demands made on them. The existing quarries are also not yet in a position to supply aggregates to standard specifications in sufficient quantities. The matter is now well in hand and it is hoped that conditions will be improved in the near future. Nevertheless, all asphalt surfaces on most of the main trunk roads



Jerusalem-Hartuv Road.—Hewn out of rock, 12 m deep

are made of asphaltic concrete, meeting the following minimum requirements:

Aggregates, per cent wear determined by Los Angeles abrasion test: 40 p. 100.

Asphalt Mixture:

Stability (Marshall Test): 450 kgs.

Flow (Marshall Test): 8-18.

Voids: 3-5 p. 100.

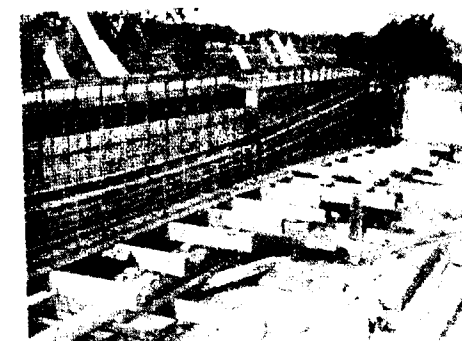
Voids filled with bitumen: 75-85 p. 100.

Asphaltic cold-laid mixes are used on secondary roads. In remote places asphalt macadam surface courses (Penetration Method with Hot Asphalt Cement) are resorted to.

All-weather earth road surfaces are treated with Calcium and Magnesium Chloride, with satisfactory results. Surfaces are dustless and vehicles can travel at 60 kms. p.h. without discomfort.

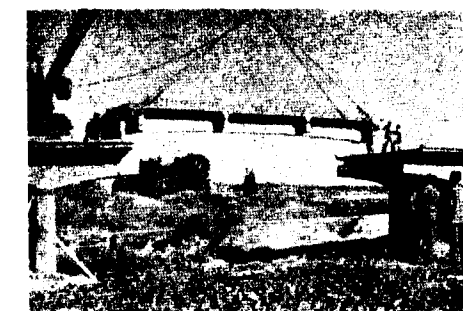
All road works: grading, earth moving, paving and surfacing are mechanised. The mechanical equipment available for

this purpose consists of bull-dozer, scrapers, motor-graders, various kinds of power loaders, mechanical pavers, sheeps-foot, pneumatic and smooth iron wheels rollers, asphalt mixing plants. It is



Ashdod Prestressed Concrete Bridge.—Precast Central Girder, Reinforcement and Cables in position

expected to complete shortly this list with the addition of soil stabilizers and vibratory rollers.



Ashdod Prestressed Concrete Bridge.—Launching Central Girder, length 13 m, weight 28 tons

Maintenance works are also mechanised as far as possible. Motor-graders are used for reshaping ditches and shoulders, mechanical grass mowers are used to dispose of the vegetation at the sides of the road. Chemical weed killers have been tried, but these have proved too costly and causing damages to cultivated areas adjoining the roads. The matter is still under investigation by Government staff dealing with conservation of land.

Drainage

Pipe culverts, single and multiple types, are used to drain catchment basins across roads. These are either precast spun concrete pipes or cast-in-situ reinforced concrete pipes. The minimum diameter used is 80 cms to permit easy cleaning.

Single or multiple reinforced concrete box culverts have also been standardized upto 4 meters spans, and are used to cross small water courses.

During the last two years three major bridges have been built and the design of three more are in hand.

A bowstring steel bridge has been erected over the Yarkon river in Tel Aviv: it is a single span bridge of 53 metres opening founded on precast rein-

forced concrete piles. Two precast prestressed and post-tensioned concrete bridges have been erected, one in the north and the other in the south. These are three spans structures with a maximum central span of 20 metres: the deck is carried on reinforced concrete piers and abutments founded in on spread footings.

Israel stands now at the dawn of its second decade. Among the great economic development activities lying ahead, highway construction will surely not be rated as the least. For the completion of this task the state is now far better equipped in tools and plants and knowledge of the art of Highway Building, than it was ten years ago.

(From "Bulletin De L' Association Internationale Permanente Des Congres De La Route," 1958).

ALUMINIUM ROADS

Possibly the most valuable—though not the costliest—road in the world is the "Million-Dollar Highway" built by U.S. Army Engineers in 1943 to link Zandery Field, Dutch Guiana, with the capital city of Paramaribo. The road has a solid mahogany base and is surfaced with aluminium—cheap in Dutch Guiana, where mahogany may be had for the cutting and where a rich deposit of bauxite is located.

AMERICAN BRIDGE, TUNNEL AND TURNPIKE ASSOCIATION, INC. QUARTERLY TOLL REVIEW (SUMMER 1958).

CAUSES AND TREATMENT OF HILL SLIPS

By

A. C. DUTT, *B.Sc. (Glas), A.M.I.E.,
ASSOC. M. ASCE.

General

SLIPS or slides—as the American terminology goes—cause considerable loss in men and money, and result in serious communication bottlenecks, unless cleared without the least delay. They, therefore, call for serious studies and investigations. The object of this article is to describe the various problems and their solutions as evolved by experience over a long period in the Himalayan areas of West Bengal, and to describe in detail the various methods in use for various types of slips.

Causes of Slips

Generally, land slips or slides develop due to either of the following causes:—

- Super-saturation of the soil cap.
- Defective or blocked drainage.
- Springs.
- Erosion at the foot of steep banks.
- Quarrying and resulting denudation of vegetable cover of slopes.
- Loosening of tree roots by strong wind.

It has been noticed that even continuous downpour of approximately 6 in. over 6 hours or over a slightly longer period, would cause disastrous slips in the Darjeeling Area. This indicates that for the particular slope and terrain of the Darjeeling Area, 6 in. of rainfall over a period of 6 hours, i.e., 1 in. an hour is sufficient to super-saturate the particular soil cap, resulting in slips of catastrophic magnitude. It is similarly possible in other areas to determine the total rainfall over a period of time that would contribute to such disastrous consequences. Local populations may then be given a

warning by the concerned authorities on the basis of such forecasts to evacuate to safer zones so that at least death and injury may be minimized.

During the monsoon season in West Bengal, the gullies and depressions or "Jhoras", as locally termed, through which the accumulated rain water run-off from a particular catchment area finds its way down the hill slope, may be incapable of accommodating the ever-increasing volume of run-off, due to inadequate capacity or due to partial blockage of the depression by displaced debris. If incapable to take the full discharge for either of the two reasons, the water accumulates as long as the blockage can act as a dam, but with greater and greater pressure being built up behind the blockage, it is dislodged along with a little of the adjacent land and this goes down and along its way may also act in a chain reaction sort of way in dislodging and carrying with it more and more rocks and boulders and finally constituting a major land slip.

A part of "Jhoras" or gullies may be underground and in a similar way as explained above, the original channel may get blocked and the water may find another way down through a nearby soft rock, thus making a new underground channel. These underground waterways get exposed due to difference of grade of the channel and the hill slopes and emerge as springs. The boulders and rocks in the way are thereby displaced and depending on the number and volume of debris so displaced, constitute slips of varying magnitude.

In the mountainous areas of West Bengal, hill slopes are considered stable as long as the slopes are not steeper than

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37°, but steeper slopes exist in many locations and they manage to stay on as long as the soil cap is covered by vegetation. But a stream of a "Jhora" may gradually encroach and ultimately start cutting the toe of such a steep slope, resulting in slip of the unstable portion of the hill side.

Denudation of vegetation cover either for agricultural purposes or even by grazing of cattle affects the stability of hill slopes. Not only do the roots of trees, shrubs and grass help to hold the soil together but the leaves also break the force of rain and allow the water to drain off the land very slowly, thus lessening the risk of soil cap being least disturbed.

The question that may well be asked is: "Are such damages inevitable and can nothing be done to prevent or at least anticipate or lessen the damages?" The answer fortunately would be in the affirmative, as much of the damage can be anticipated, and some prevented, and may be repaired in a comparatively simple and inexpensive manner.

In the hilly areas, jungles are arbitrarily cleared by the hill people, and trees cut down for raising crops. Often the value of crop is far below that of the timber destroyed, but due to want of a set policy and bold and vigorous action by Government, no success in stopping this destruction has so far been achieved. If people have to have some sort of cash crops, the authorities may induce them to plant such money earners as cashewnuts, pepper or coffee instead of the present rice or potato. Grazing leaves the soil cap bare and pelting rain does the rest and so grazing must also be controlled. The easiest solution is to declare such areas as Forest Reserves.

It has been noticed that even big trees get uprooted due to storm and in that process the surrounding rocks and boulders get dislodged and in coming down they further dislodge some more jutting out crops, which are not strongly embedded, and thus a slip develops, the seriousness of which depends on the looseness of the slope over which the up-rooted trees roll down. It may not be out of place to state that slips may be caused due to this reason even when there is no rain.

Finally, quarrying, unless quarries are very carefully selected and located, would obviously induce slips due to loosening of the soil cap.

Examination and Treatment of Slips

Slips occurring due to super-saturation of soil cap are usually due to water percolating through the surface soil which may have badly weathered and cracked or is of permeable nature. Water generally percolates through such pervious rocks until it meets an impervious one, the top pervious rock then glides over the impervious one, causing it to slide. In such cases, the slips uncover the hard rocks the surface of which is unlikely to cause further trouble, at any rate due to the particular cause under discussion.

Since a certain area thus gets its loose and deleterious terrain shaved off so to say, the soil cap just above it is usually left overhanging or at a dangerously steep angle. If further slipping of the soil cap is not likely to extend to any great distance or seriously to affect land in use or valuable property above, it is usual and preferable to let nature take its course till all the loose soil is removed, leaving a hard sound slope. Watch should, however, be kept to see that no deep seated cracks are revealed in the new rock face, but if unfortunately these are present, action should be taken to revet the slope without loss of time.

The unsheathing, so to say, of a hard crackless soil cap by slipping, as described above, occurs but very rarely. It is unfortunately more usual to find the newly uncovered soil cap to be composed of badly broken up loose boulders or even earth clods; much of the surface may even be of mucky consistency which will not stand at a slope angle considerably flatter than the angle of repose of the adjacent slopes. Conditions such as these generally indicate the presence of springs within the slope itself or entrance of water at the head of the slipped surface from the slope above. When this happens, the first step is to examine the affected area and locate the suspected ingressing water and limit its flow within a catch-water drain arrangement and divert it to

one or preferably both sides of the slip over sound soil.

These catch-water drains are usually made of local wood planking in the form of chutes, being locally available at comparatively cheap rate. The up hill side of the chutes should be lower than the down hill side and they should be sunk into the ground wherever possible or if the ground over which the chute is placed is not very sound, the sides of the chutes should be anchored and the hill side should also be strengthened by a row of pegs driven so that they go through the soil below the chutes. If a defined stream is located, such a stream also should be carried over a wooden chute clear of broken and mucky grounds to prevent erosion.

Should the surface of the slip be sufficiently firm to allow mazdoors to walk over it, the ultimate damage can be minimised by driving a row of local wood planking deep into the surface at more or less 30 ft distance measured along the slope of the hill. This treatment would generally be applied in the case of comparatively small slips. In the case of large slips, wooden stakes at say 5 ft 0 in. intervals in a row whose axis would be at right angles to the axis of the slip, each such row being 10 to 12 ft distance vertically, may be driven hard till at least 1/3rd of the stakes are securely fixed into the sound soil under the slipping surface. The value of this form of protection is considerably enhanced by twining creepers about the stakes in the form of rough basket work.

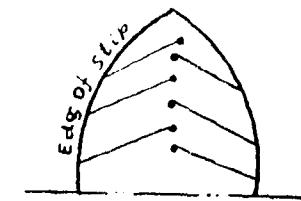
The treatments described above are of an "expedient type" which are called for to minimize or prevent hold-ups during the slips, but for permanent treatment the following points must be attended to:—

1. Proper drainage.
2. Retvetting.
3. Planting.
4. Horizontal drains.

Proper Drainage

On a slipping surface, catch water drains should be constructed above the broken edge of the slip if possible.

As regards drainage on the surface of a slip it is necessary either to slope the slip surface from either side towards a central drain running down from the top to the

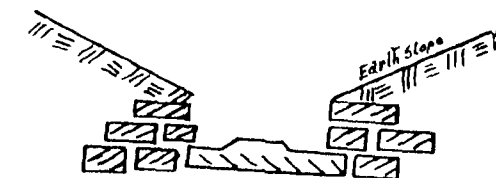


PLAN

Fig-1.

bottom of the slip or drain away from the centre by means of a series of drains (Fig. 1).

The central drain may be of the ordinary square section with dry rubble masonry as ordinarily used in road side drains, or it may be roughly dressed stone laid as a broad shallow saucer in courses at right angles to the line of flow. This form of drain is generally called a dyke. Both the types are shown in Figs. 2 & 3.



Dry Rubble Masonry Drain

Fig-2.



Cement Rubble Masonry Dykes

Fig-3.

Catch water drains should have the soling and downhill wall cement pointed or at least "pugged" with stiff clay to make them as water tight as possible, the uphill wall being however of dry rubble

masonry in order to admit seepage to the greatest possible extent.

Defective drainage may specifically affect the following:

(i) "Benching" i.e., cutting flat of the hill side to accommodate a building, tennis court, play-ground or terrace for cultivation. In order to obviate damage accruing due to bad drainage it is necessary to make the flat slope inwards, i.e., towards the hill side, sufficient to carry all surface water into a drain running along the foot of the inner slope of the flat as in Fig. 4.

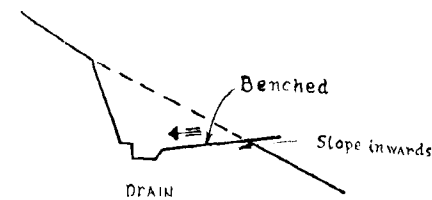


Fig 4

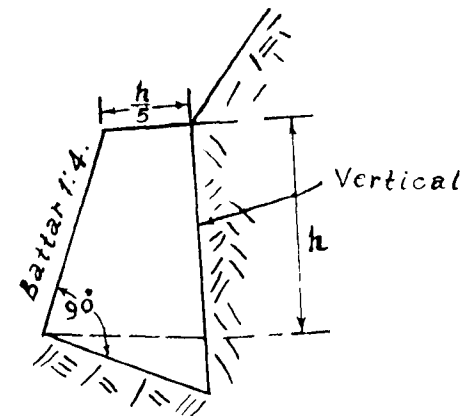
(ii) Construction of a road or pathway. In this case also the same principle as in (i) above should be followed. The water in the drain being discharged at frequent intervals into the nearest natural water course.

(iii) In case of seepage of water into a pocket or depression already saturated with moisture, the treatment should be to disperse the seepage through a herring boned system of drainage, as already mentioned and finally leading the collected water through the central or main drains on the boundary of the pocket or depression.

Revetting

Revetment walls are toe walls built up at the bottom of the slip to support and prevent further slide of the slope above such revetment or wall at the toe. The usual practice is to build walls up to 14 ft height in dry rubble masonry, and above that height to lay a band of cement masonry rubble preferably 2 ft thick at each 14 ft interval.

The rule of thumb method used where time or personnel for exact calculation is not available for determining the section



Typical Section

Fig-5.

of dry rubble masonry walls in the case of a non-surcharged or surcharged wall is as given in Fig. 5.

$$\text{Thickness at top} = \frac{h}{5}$$

where h = vertical height

Batter the outer face at 1 : 4

Keep the back face of wall vertical

Keep the base at right angles to the batter.

For surcharged walls the rule adopted is the same except that the height is assumed to be 1.5 times the actual height.

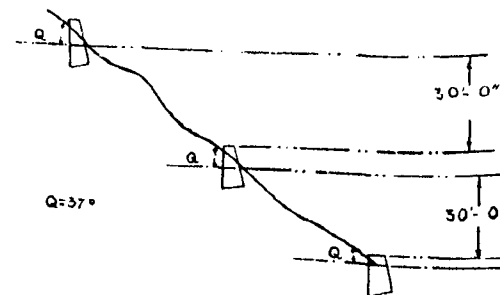


Fig-6.

When the height of the slip is so great that one wall is impractical or insufficient to retain the earth slope from top to

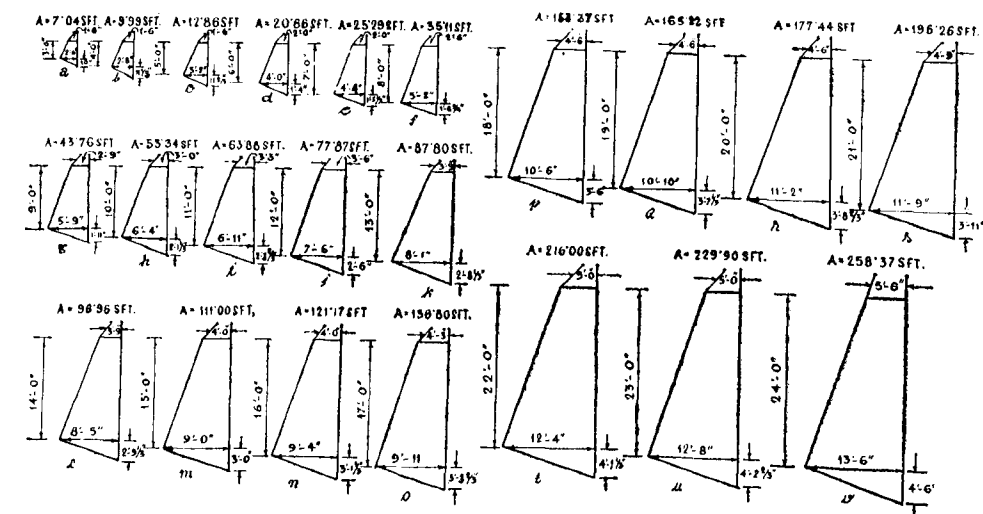
bottom the usual practice is to break up the slip-surface by building walls at intervals, such intervals being regulated by the rule that the slope of the soil above should never be steeper than "the angle of repose" i.e., the angle at which the earthen slope would rest without artificial support. In the area under discussion, the angle of repose is approximately 37°. Further, such walls must not be interspaced at more than 30 ft vertically. Fig. 6 illustrates clearly how a series of revetments is built for different cases.

As such revetment walls have to be built with the least delay during the slipping period in all locations in the

All stones, both in length and width, should generally be arranged so as to break joints. A through stone or a line of bond stones should be laid at five feet intervals in each course and should not fall immediately over the bonding line in the course below.

No stone should be greater in height than its breadth or length and they should be laid on their natural beds. Every stone should be a header rather than a stretcher.

All dry stone revetments should be built with a face batter of 1 in 3 with vertical backs and with the courses laid at right angles to the face.



SECTION FOR SURCHARGED WALLS OF DRY RUBBLE. BATTER 1:3.

Fig. 7.

hilly areas, the typical sections of such revetment walls correctly designed for surcharged and unsurcharged walls are given in Figures 7 & 8.

The general specification followed in the case of such walls is given below:

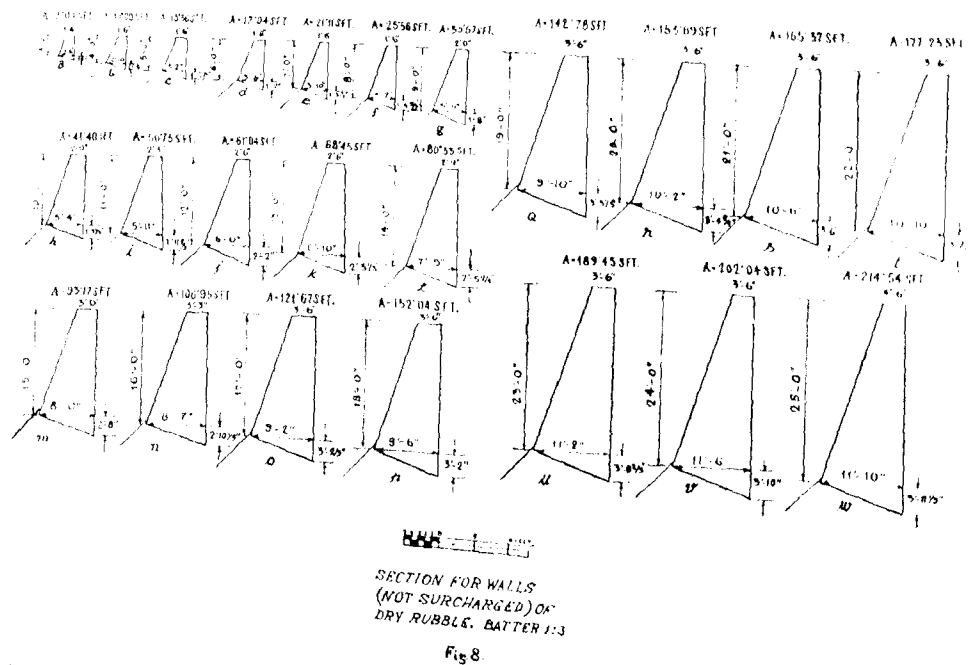
Foundation to the required section should at least go down two feet into firm soil or preferably to bed rock. The bed is to be made at right angles to the batter.

All revetment walls should be built up solid to the required section and the use of unnecessary spall or chips should not be allowed.

Weep-holes should be provided at every 4 ft horizontal and every 4 ft vertical intervals in walls, commencing with the first course above the ground level.

Planting

The planting up and turfing of slip areas is one of the most important and



NOTE:

In case where sufficient space between the hill side and the edge of the road-bench is available, the wall should as far as possible be raised in steps setting back at suitable height. The width of base at each set-back will be determined by the height of wall from the level of set-back to top of wall.

effective methods of protection, and together with efficient drainage will often suffice even on slopes which are steeper than the angle of repose without revetments. Trees and shrubs for the purpose of planting should be selected with regard to the ultimate size and the root binding power. In the Darjeeling District of West Bengal State, the indigenous plants and trees most useful for the purpose are grouped according to elevation as given below:

(a) High Elevation (5000 ft to 7000 ft) — Asare (*Viburnum* Spp.) and Falido (*Erythrina* Spp.). Sdur (*Betula alnoides*) sowings are also useful.

(b) Medium Elevation (3000 ft to 5000 ft) — Cuttings of Falido and planting of local bamboo offsets are useful. Sowings of Utis (*Alnus nepalensis*), birch (*Betula*

alnoides and *B. Cyindrostachys*) and Malata (*Maca-ranga* Spp.), Sowings of Chilaune (*Schima wallichii*) might be useful.

(c) Low Elevation (up to 3000 ft)

— Cuttings of bamboo rhizomes and Falido, Jharu grass (*Thyssonaloena agrostis*) and Jeol (*Lanea grandis*) would be useful. Planting and sowings of Chilaune as well as Falido, Malata, Lampate (*Duabanga* Spp.) are also useful.

Grass and bamboos having spreading root system can cover up slips easily. Root cuttings of Kikuyu grass offer good

protective covering for bare surfaces between 4000 ft to 8000 ft. Willow cuttings are good provided these are close to Jhoras. *Cryptomeria japonica* (Dhupi) and Pipli need elaborate nurseries and even then *Cryptomeria* is not very effective as a soil cover and Pipli is very severely lopped off by villagers and therefore it is advisable not to be planted. Perhaps the most effective, when a quick growing tree for immediate protection is required, is Phalida.

The planting of seedlings or broadcast scattering of seeds are methods resorted to in order to economise.

Horizontal Drains

These have not been tried in West Bengal so far due to difficulty in obtaining equipment due to import restrictions but these have been tried extensively in the State of California in U.S.A. with very satisfactory results.

The procedure is to drill horizontally into the unstable hill side, and when the desired depth of drilling is made the holes are cased. The holes are made in all directions and are made to converge into a central hole which ultimately emerges out from the slope and discharges the water through a proper drain into a culvert outside the unstable area. It has been noticed that by inserting horizontal drills, a progressively worsening slide is gradually stabilized as long as the inserted drains function properly.

A modified version of this method has been used by the Railway Authorities in Assam and is known as 'Adit Drain'. In this the drain is of a bigger size so that a man can borrow in and as he goes in the sides and tops are supported by old railway sleepers more or less in the same way as the coal mine galleries are hewed out. This has been very recently tried out but the success of this method in the Darjeeling Area has yet to be observed.

PARKING METERS

Parking meters have finally come to Great Britain and the public doesn't like them. The Royal Automobile Club and the Automobile Association are up in arms over the 650 meters just installed in Westminster, a London administrative unit. All money collected from the meters is to be used for construction of off-street parking lots.

—AMERICAN MUNICIPAL NEWS (August 30, 1958).

WORDS OF WISDOM

Ideas must work through the brains and the arms of good and brave men, or they are no better than dreams.

—EMERSON

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THE TESTING METHODS IN VOGUE FOR EVALUATING THE BEARING VALUES OF SUBGRADE SOILS - A REVIEW

By

H. L. UPPAL & BHUPINDER SINGH^{*}

THE bearing value is defined as the intensity of pressure which a given soil can withstand for a given amount of settlement under a set of known conditions. As such, it depends, apart from the characteristics of soil, on many other variables such as the size of the loaded area, the type of structure coming over it and the amount of specified settlement. The various tests empirically evolved for evaluating the bearing value of subgrade soils widely differ in testing procedures and work under certain limitations, thereby making the subject of bearing value yet more complex. The calculated bearing value of each soil stratum differs for different types of structures coming over it and varies with each test method for designing the thickness of the pavement. Hence each test result has a specific meaning and reference when used with a particular design¹ procedure.

A study of the different tests and their testing procedures would reveal that there are numerous limitations to each test, and it is felt that a knowledge of their limitations and relative merits should be a necessary pre-requisite for the judicious choice of a particular method for evaluating the bearing value of subgrade soil.

Of the numerous tests and the testing procedures only the main tests in vogue are discussed in the order presented below:

Plate Bearing Test

California Bearing Ratio Test

North Dakota Cone Test, and shear test such as

Direct Shear Test

Triaxial Compression Test

Torsional Shear Test (Vane Test) and

Unconfined Compression Test.

Plate Bearing Test

The Plate Bearing Test enjoys a wide acceptance in the U.K. and the U.S.A., perhaps because of the fact that it has already been in vogue in the design of building foundations and other structures. It is a field test usually carried out right at the spot wherever one is interested to know the bearing value, which may either be subgrade, base or surface.

The test essentially consists of loading a rigid steel plate of the required size and noting the load required for obtaining a specified deflection. The test data is used in some of the design procedures of both flexible and rigid pavements. In practice the size of the plate used is selected depending upon the load dispersion area due to the prevailing traffic on the strata under test, thus simulating the exact conditions under which the subgrade is loaded under actual traffic conditions.

Brief Description of the test: (Fig. 1)

There is no standard test procedure; the usual procedure adopted by various organisations is as follows:

The plate is set as level as possible on the spot to be tested. Loads are applied by means of a hydraulic jack working against a jacking frame. The reaction for loading may be a loaded truck, trailer or any other structure, such that its reactions are at least 8 ft away from the bearing plate. The actual load is

applied after seating the equipment properly. The load is applied at a specified rate. Each load increment is allowed to act either for a period of time such that the rate of settlement of the plate is equal to or less than 0.001 in. per minute or until the individual load increment has acted for a period of 30 minutes, depending on whichever is earlier. The load increments are continued till the required settlement is reached. Load settlement curves are then drawn. From the curve, the value of the modulus of subgrade reaction 'K' (stress deformation) is calculated and expressed as lb/sq. in., in. or as ton/sq. ft./in.

For the design of flexible pavements the bearing value of the subgrade has been used by Gold Beck⁴, Hubbard and Field⁵, Campon and Smith⁶, Committee on flexible Pavement Design⁷, Vokac and U.S. Navy Department⁸ Bureau of Yards and Docks. Velz and Vokne Roland¹⁰ took the bearing value as the unit-load required to produce 0.2 in. deflection from the load settlement curve using the bearing plate of 12 in. diameter.

Variation in bearing value with size of bearing area

The bearing value decreases as the size of the bearing area increases and hence there is a considerable difference in the results when plates of different diameter are used for the same deformation. W. S. Housel¹¹ plotted applied load in lb/sq. ft. for a given deflection against perimeter—area ratio in ft./per sq. ft. and found that it resulted in a linear equation. Straight line equation has a distinct

advantage in correlating the bearing value for a plate of any bearing area, having known the value with a given area. Such a straight line equation as shown in the figure has been derived on the basis that the total load carried by a given bearing area may be expressed as the combined effect of the two stress reactions, one as perimeter shear and second as developed pressure.

The equation is as follows:

$$W = (mP + nA)$$

in which W = Total load in pounds

m = Perimeter shear in pounds per lineal foot of perimeter.

n = Developed pressure in pounds per sq. ft.

P = Perimeter in ft

A = Area in sq. ft.

The above equation in terms of bearing value may be obtained by dividing both sides of the equation by the area of the load application and is as follows:—

$$p = \left(\frac{mP}{A} + n \right)$$

Where p is bearing value in pounds/sq. ft.

The values of m and n can be found from any two linear equations obtained by using two different bearing areas at any given amount of settlement. Variation in bearing value with dimensional properties of an area is shown in Table I and Fig. 1.

Table 1
Variation in bearing capacity with dimensional properties of an area

Size of the area sq. ft.	Diameter ft.	Perimeter Area Ratio ft/sq. ft.	Bearing Capacity	
			Tested lbs/sq. ft.	Figured lbs/sq. ft.
1	1.13	3.55	15,300	15,250
2	1.60	2.51	11,550	11,900
4	2.26	1.77	10,150	9,500
9	3.39	1.19	7,300	7,570

^{*} Central Road Research Institute, New Delhi.

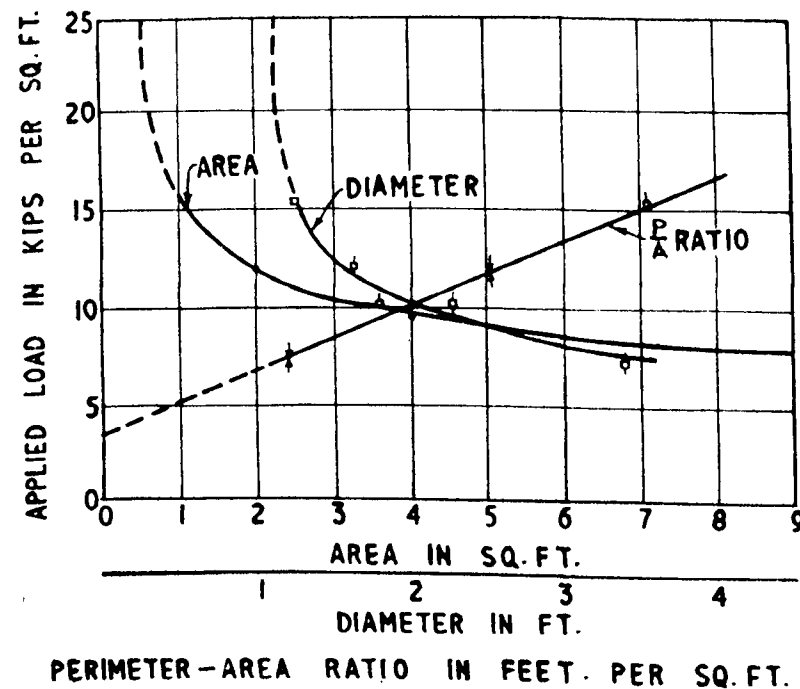


FIG-1.

Showing variation in bearing capacity with dimensional properties of an area.

General Limitations

These are :

- (1) The difficulty in selecting a proper critical deflection value.
- (2) Deformations produced are both due to volume change and shear deformation, whereas in general the latter need only be considered.
- (3) It needs massive equipment and hence very expensive.
- (4) In practice it is difficult to bring the test area to the anticipated worst moisture condition and from the existing information it is also not possible from field tests alone to predict the test results from one moisture content to another. However, an attempt has been made by Middle Brooks and Bertram in order to approximate the 'K' value for subgrade soil after it has reached its maximum moisture content in situ by performing consolidation tests in the

laboratory on representative subgrade soil samples. The soil for one test is placed in the consolidation device at a density and moisture content equivalent to those at the time of field testing. The soil for second test is placed in the same manner as in the first after which it is saturated by immersion. During the immersion period, a load of 5 lb/sq. in. is applied to prevent surface expansion of the sample. If P is the pressure required in the plate bearing test to cause a settlement of 0.05 in. and P_s is the pressure required in the consolidation test on the soaked sample to cause a deformation equal to that produced by pressure P in the consolidation test on the unsoaked sample, the value K_s of the modulus of subgrade reaction allowing for soaking is obtained from the equation

$$K_s = K_u \times \frac{P_s}{P}$$

California Bearing Ratio Test

The California Bearing Ratio (C.B.R.) test was developed by the California State Highway Department. Compared to other tests for the design of flexible pavements, this test has gained a wider acceptance in the U.K. and the continent. This is an empirical method of design and was developed by an extensive field performance study of the highway pavements in California: a set of design curves were evolved to suit different wheel loads. Later, the U. S. Dept. explored the curve upto wheel load value of 75,000 lb for airfield construction. The test was modified by the Army Engineers by substituting a dynamic method of compacting the soil and this change is now accepted as the standard procedure. The test is made use of in evaluating the relative value of bearing strength of base course and subgrade materials as compared to the standard bearing strength of compacted crushed stone.

The C.B.R. value is expressed as a percentage of the unit load required to force a piston (3 sq. in. in area) into the soil divided by the unit load required to force the same piston to the same depth into a standard sample of compacted crushed stone.

$$CBR = \frac{\text{Test unit load}}{\text{Standard unit load}} \times 100$$

The standard loads for various values of penetration for the standard crushed stone which are used for calculating C.B.R. are given in Table 2 below :

TABLE 2
Standard Loads versus Penetration in C.B.R. test

Penetration in inches.	Standard load in pounds per square inch.
0.1	1,000
0.2	1,500
0.3	1,900
0.4	2,300
0.5	2,600

This test can be used to determine the relative bearing value of base, sub-base and subgrade materials either in soaked or unsoaked conditions and can be conducted either in situ or in the laboratory. The laboratory samples may be either undisturbed or remoulded.

Brief Description of the Test.^{13,14}

Briefly, the test consists of causing a cylindrical plunger, 3 sq. in. in end cross-section, to penetrate a sample of soil at the rate of 1/20 inch per minute and measuring the load required to cause a penetration of 0.1 in. or 0.2 in. This load is expressed as a percentage of a standard load and is known as the California Bearing Ratio. The Standard U.S. Corps of Engineers procedure requires the sample to be tested after soaking it for four days or such time till the volume expansion is negligible, with a view to simulate worst field condition. Before test, the sample is allowed to drain for 15 minutes. In order to obtain true penetration loads from the test data, the stress-deformation curves should be drawn and the zero point adjusted to eliminate the initial error. In application, the bearing ratio is determined for the subgrade soil and base materials and the required thickness taken from the design curve for a specified wheel load. Areas subjected to vibrations of slow-moving or warming-up planes such as aprons or taxi-ways are designed for wheel loads 25 per cent greater than the static load. For areas used less frequently, the thickness is selected as 80 per cent of that given by the design curves.

General Limitations of the Test

These are as follows :

- (1) This test is applicable to all types of soils, except to those which contain materials larger than 3/4 in. Such coarse materials should be removed and replaced with an equal proportion of materials between 0.18 in. and 3/4 in. in size. With such substitution, it is doubtful how far the test sample represents the prototype material which is actually used in the pavement or in the road bed where size, larger than 3/4 in. are involved.

(2) In flexible pavement design, the use of this test has been mainly limited with respect to subgrade or sub-base.

(3) The results of C.B.R. in the case of clean sands are usually inconsistent and hence the test is not reliable for pure sands.

(4) The test does not provide information with respect to the amount of settlement to be expected in the pavement surface as a result of consolidation in the base courses and in the subgrades.

(5) C.B.R. test does not specifically furnish information about the quality of the material to be used as base course or sub-base and hence the criticism that a base composed throughout of a high quality material is not considered to have any advantage over a layered base of the same thickness with inferior materials in the lower part.

(6) It is to be admitted that an entirely satisfactory method of preparing the specimen to duplicate the condition in the prototype has not been developed.

(7) There is no definite relationship between the laboratory C.B.R. and the field C.B.R. tests.

(8) Under the conditions and limitations when test were conducted by Baker and Drake¹⁵, it was found that designs based on this method were successful only with 83 per cent probability.

(9) C.B.R. test results give an insight only for a thin layer of the soil as the distribution of pressure under the C.B.R. plunger does not go farther than 10 cm.¹⁶, yet pressure distribution by large pneumatic wheels of trucks and aeroplanes reach deeper layers which may differ in nature, moisture and density.

(10) C.B.R. results often vary in situ with the moisture content of the soils. This being a main disadvantage of the test, this phase needs further study.

(11) In extremely clayey soils, C.B.R. test procedure needs some modifications, as the initial applied load and load of the piston itself can cause some settlement and hence lead to a totally wrong C.B.R.

(12) Another criticism of the C.B.R. method is that the amount of base thickness obtained by this method is too high. The test in the laboratory is done on remoulded soils when they are completely saturated. To ensure complete saturation, samples are kept in water for nearly four days, but in the prototype the conditions of maximum field moisture may occur (a) immediately, (b) over a period of years and (c) never in some instances where ground water, drainage conditions and soil types are particularly favourable. Hence C.B.R. method tends to be criticised because its use results in pavements which are too conservatively designed.

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(Continued on page 48)

SOIL EXPLORATION FOR FOUNDATIONS*

Eldridge B. WARD, Laboratory Engineer

Houston Urban Expressways

THE field of soil mechanics has made great progress in the past ten to twenty years. Even with all the improved exploration and testing equipment, there are still a few engineers who regard foundation exploration and testing as a waste of time and money. Some of these engineers may not have been exposed to soil mechanics, others may have been just plain lucky, so to speak. Still others may have had a failure or have taken the exploration and test data but still have had a failure due to the improper analysis of the results. Examples of subsurface failures which could have been prevented by proper foundation investigation would fill a couple of books. The time and money spent in soil exploration and testing is only a small fraction of the cost compared to life and property damage resulting from subsurface failures.

Our main purpose in soil exploration for foundations is, first of all, to make the structure safe for the public; and second, to arrive at a safe foundation with a minimum cost. The quality of our work can result in tremendous savings, or waste a great deal of the tax-payers' money.

Only last summer I witnessed an example of what not to do in soil exploration. I went on a job to help familiarize myself with a new drilling rig that belonged to one of the local companies. While waiting for the drill truck to arrive, the representative of the engineer came on the site and paced off a location where the greatest loads would be according to the plans he was holding. He made a small clearing with his foot about the size of a shoe. Then, he stepped into the area and placed all his weight on the heel of his shoe and bounced up and down a couple of times. Stepping back and seeing no depression where he had made this test,

he remarked, "Since I weigh approximately 180 pounds and my heel has almost ten square inches that makes 18 lbs per square inch, or 1.3 tons per square foot." He then looked around and said, "About a sixteen inch grade beam should do it." The soil boring along with the testing results proved to be a lot more reliable than his test. It just so happened that there were about two feet of stiff material on the surface and below that, eight to ten feet of soft to medium silty clay with an allowable bearing capacity of 900 pounds per square foot. We could say this fellow falls in the group which has not been exposed to soil mechanics, or has been just plain lucky.

All structures must have a foundation. It is the purpose of the foundation to transmit the loads of the structure to the material beneath it. The ideal condition would be to place the foundation in solid rock. Those of us from east Texas or the Gulf Coast know that it will probably be anything but rock; that is, unless we penetrate some 1,500 to 2,100 feet. Since a foundation cannot be carried to such extreme depth, we must be content to find a material beneath the structure which will support it without excessive or harmful settlement. The foundation may be piles, spread footings, under-ream footings, or a heavily reinforced concrete mat. Since there is a great difference in the cost of these foundations, we must determine which is the most economical. This problem cannot be approached without first having made some type of soil exploration or foundation investigation. The purpose of such an investigation is to determine the extent and physical characteristics of the principal soil strata, the ground-water table, and to obtain the necessary field test and samples from the various strata for testing.

* Speech presented at the Thirty-second short course.

Subsurface investigations can be divided into two groups, preliminary and detail. In both cases, the majority of the explorations are made by borings.

Preliminary explorations are usually made to locate and classify the various strata. These explorations consist of hand-auger borings, continuous power-auger borings, wash borings, fishtail borings, and thickwall core-barrel borings. The use of the hand-auger is somewhat limited to depth and is slow, besides being hard work. Information obtained by use of the continuous power auger, wash boring, and fishtail borings is very unreliable and about all you have to show for your efforts is a hole in the ground. However, they are helpful in locating rock formations. Most widely used for preliminary borings is the thick-wall core barrel, or what the Highway Department calls a dry-barrel sampler. It can penetrate a wide range of formations with a good percentage of sample recovery. Due to the thick walls, the sample will be disturbed but can be easily classified. The strata changes can be located with more reliability with this type of boring than with any of the types mentioned before. Very few tests can be made on any of the samples taken from preliminary borings.

Detail investigations are by far the most beneficial, but the most expensive. They consist of test pits and undisturbed core borings. Test pits are seldom employed, except where large undisturbed box samples are required. The undisturbed core boring is the most widely used in foundation investigations. In recent years, a wide variety of core barrels for taking undisturbed soil samples has appeared. As most of you know, the Texas Highway Department uses the four-inch Denison double-tube core barrel as standard equipment on its drilling rigs. The Houston Urban Expressway uses the three-inch Shelby tube. Some of you might immediately ask, why use the Shelby tube when the State-owned rigs are equipped with Denison barrels? There are a couple of good reasons for employing the Shelby tube, the most important being the higher percentage of sample recovery—at least for this area. Another reason is that a

Shelby tube is easier to handle and does not require the time to assemble or disassemble that the Denison barrel does.

All structures of any major importance should have detailed subsurface investigations made. For building, the minimum number of borings to locate the extent of the strata is three. However, if any unusual condition is encountered, there should be additional borings made to define the horizontal limits of such stratas. There is no set rule for the depth of a boring, but it is a general practice on borings for building to carry them to a depth of one and one-half to two times the least dimension of the building. As for bridge investigation, there are too many intangibles involved to state the number of borings and their depth. The Bridge Division in Austin requests one boring at each abutment and a sufficient number between the abutments, not to exceed 250 feet. I would like to add to this. If adverse conditions exist, it would be advisable to have a boring at each bent in the bridge. If it is evident from the borings that piles are going to be used, at least one of the borings should extend to a depth of 100 to 150 feet to disclose unusual soft deposits, if any.

In the Houston area there is a wide variation in the ground-water table, so we prefer to begin our push barrels with a dry hole until the water-table is reached. Then the use of circulating water carries the boring below the ground-water table. The main disadvantage in starting with a dry hole is that the sample is often difficult to remove from the push-barrel.

Normally, push-barrel samples are taken continuously. When the push-barrel is brought to the surface, it is clamped into a hydraulic jack, known as a sample extractor, and the undisturbed sample is ejected from the tube. It is immediately classified and logged in the field book. If the sample is to be tested in field, it is prepared for testing. If the sample is to be sent to the laboratory for testing, it is wrapped in aluminium foil and placed in an ice cream carton, then sealed with paraffin to prevent loss of moisture. A jar sample should always be taken whether it is tested in the field or sent to the laboratory. Our office has used

both methods of handling the sample, that is, field testing and laboratory testing. There are certain advantages and disadvantages to either method, but I personally believe that better and more consistent results are obtained with laboratory testing.

The Bridge Division in Austin requests that penetrometer tests be made at least every ten feet, whether the material is sand or clay. However, if all the test data is to be forwarded to the Bridge Division and they are to design the foundation, it would be advisable to have the penetrometer test made as often as every four feet.

The penetrometer test consists of driving a three-inch solid metal conical point into a formation by dropping a 170-pound weight a distance of 24 inches at the rate of 24 to 30 blows per minute and recording the number of blows it takes to drive the point a total of twelve inches. The blows are recorded for the first six inches and the second six inches. If, however, the point is driven into a very dense or hard formation, the blows are recorded as the inches travel for each 50 blows of the hammer.

In case someone might have a question concerning the penetrometer test, I took all our triaxial test results, which covered approximately 90 test holes, and used only those tests that were in the same stratum and within two feet of the penetrometer test and plotted our own curves to check the curves furnished by the Bridge Division. Our curves were about 30 per cent higher than the 1952 correlation curves. The Bridge Division revised their correlation curves in 1955, and we are still higher. After having checked on these correlation curves, I have no fear in using them. They are well on the conservative side for design.

The field classification of the soil contained in the various strata is very important, and only competent persons should be in charge of logging and classification of the material. When the material is taken to the laboratory for testing, it should be checked and reclassified. To my knowledge, there is no standard terminology for classifying soils. The recommended terminology and basic soil

symbols, as set forth in the "Texas Highway Department's Foundation Exploration and Design Manual", are very good and should be used in preference to any other. However, there are a few additions I use which I have found to be helpful for field identification of consistency of cohesive and cohesionless materials.

Improper soil classification can be misleading and very costly. One example of such an incident might insure more thoroughness in classifying material properly.

About three years ago, a soil investigation was made on an overpass structure with all classifying and testing of samples carried on in the field. To my knowledge, there were no jar samples taken. The boring logs and test data were turned over to the laboratory, and it was decided that an under-ream-type foundation could be used, based on the logs and triaxial test. Footings were to sit in a stiff sandy clay at about 20 to 24 feet.

The contract was let and construction started. Material removed by the under-reaming company indicated that the material was a clayey sand. The shaft was carried to 80 feet and still nothing could be belled for an under-ream. The contractor moved to the other side of the structure and the same procedure was followed. Still no stiff, sandy clay. The contractor was ordered to stop, and a foundation core rig was put on the site. Six borings were taken and the sandy-clay strata turned out to be a clayey sand. The entire foundation had to be redesigned and steel H-piling used. Field change alone was approximately 18,000 dollars. All this extra work and cost resulted from mis-classifying the material.

Recently we have found it money well spent if an under-ream is actually attempted prior to letting a contract. We drilled nine shafts and bells to the size shown on the plans for a cost of 2,300 dollars. This is only a small percentage of what a field change might cost if the material cannot be successfully under-reamed.

I would like to bring to your attention that there are a number of well-qualified

men in the Bridge Division in Austin who are willing to help you with either exploration or design with normal or unusual soil conditions.

COLOR

In color description of sample, the predominating color is stated first

Consistency of cohesive soils		
Classification	Field identification	Laboratory identification
Very Soft	Tall core will sag under own weight.	Less than 0.25 Tsf unconfined compressive strength.
Soft	Core can be pinched between thumb and forefinger.	0.25-0.50 "
Medium stiff	Core can be easily imprinted with fingers.	0.50-1.00 "
Stiff	Can be imprinted with considerable pressure from finger.	1.00-2.00 "
Very stiff	Can be imprinted very slightly with pressure from fingers.	2.00-4.00 "
Hard	Cannot be imprinted with fingers: may be penetrated with pencil.	Over 4.00 "

Relative density of cohesionless soils
Classification by Standard Highway Penetration Resistance:

Loose	— 0 to 12 blows per ft	Dense—30 to 50 blows per ft.
Medium dense	— 12 to 30 blows per ft	Very dense—50 and above.

Soil Structure	
Slickensided—Cut by old fracture planes which are slick and glossy in appearance.	Varved — Composed of thin laminae of varying color and soil types.
Fractured — Containing old shrinkage cracks, frequently filled with fine sand, silt, or clay of color differing from main soil.	Interbedded— Composed of alternate layers of different soil types.
	Calcareous — Contains deposits of calcium carbonate.

(From: "Texas Highways", October, 1958.

TRAFFIC AND SAFETY

THE WORK OF THE HARMONDSWORTH ROAD RESEARCH LABORATORY

The following information which is of particular interest to our readers has been extracted from the report of the Director of Road Research which is published in "Road Research, 1957" the Annual Report of the Road Research Board.

TRAFFIC ECONOMICS

The highway needs of Great Britain

A survey indicated that 1 per cent of the whole road system carried 25 per cent of the traffic and more than 10,000 vehicles a day, 10 per cent carried 60 per cent of traffic and more than 3,000 vehicles a day. On the other hand the least busy 50 per cent of the road system carried only 5 per cent of vehicle-milage and less than 5000 vehicles a day, so that a large proportion of traffic could be affected by improving a small proportion of total road milage.

The number of motor vehicles in Great Britain was shown to have increased at a compound rate of 8.2 per cent since 1946 and at this rate would be doubled by 1966. Vehicle-milage had been increasing by about 7.4 per cent equivalent to a doubling in 10 years' time. Trends of vehicle ownership and real income suggested that this present rate of increase would continue.

The importance of reducing delays to road vehicles was illustrated by the following facts:

(i) 27 per cent of total vehicle-milage was performed by commercial vehicles.

(ii) 50 per cent of the drivers of private cars travelling between London and Birmingham during working hours were travelling on business, and in London 27 per cent of car drivers, 22 per cent of taxi occupants and 5 per cent of bus passengers were travelling on business.

(iii) A reduction in speed from 20 mile/h to 10 mile/h due to congestion in Central London increased fuel consumption of traffic by about 50 per cent.

(iv) Tests comparing car fuel consumption on a rural trunk road with that under motorway conditions suggest that the same steady speed on the motorway as on the ordinary road would save about 24 per cent in fuel consumption, whilst an increase in motorway speed to consume the same quantity of fuel as on the trunk road would reduce journey time by 25-40 per cent.

It was estimated that in 1956, about 25,000 million vehicle-miles were travelled in urban areas at an average speed of about 20 mile/h, and about 30,000 million vehicle-miles were travelled in rural areas at an average speed of about 32 mile/h. Making no allowance for non-working time it was estimated that 7 million pounds per annum in rural areas and 29 million pounds in urban areas would be saved if traffic could be speeded up by 1 mile/h and that further, if the speed of traffic under congested conditions could be raised to that under light traffic conditions, there would be a total saving of 170 million pounds per annum, excluding the value of non-working time. If non-working time were valued at the same rate as working time, the estimated cost of congestion would be 510 million pounds per annum. These costs were now increasing at more than twice the rate of growth of traffic, i.e., by more than 14 per cent per annum.

It was estimated that in 1956 road accidents cost property about 110 million pounds of which damage to property cost 27 million pounds, loss of output due to injury 40 million pounds and medical treatment 9 million pounds. Of the total costs of accidents some 70 million pounds

* Published for D. S. I. R. by H. M. Stationery Office.

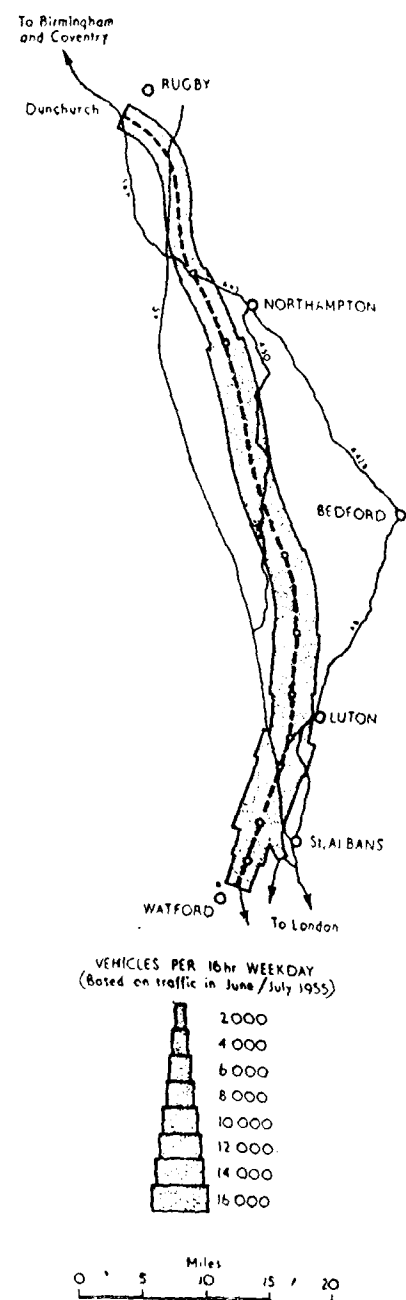


Fig. 1. Estimated traffic on London - Midlands Motorway

was attributable to accidents in urban areas whilst 40 million pounds was attributable to accidents in rural areas. In an investigation of roadworks which reduced accidents and for which costs were available it was estimated that 121

personal-injury accidents per annum were saved by an expenditure of 490,000 pounds, i.e., on average an expenditure of 4,000 pounds resulted in saving one personal-injury accident a year. Unless special steps were to be taken, increase in traffic could confidently be expected to result in an increase in casualties, although these increases are likely to be somewhat less than the increase in traffic. Between 1952 and 1956, vehicle-miles in Britain increased at a rate of 7.4 per cent per annum, fatalities by 3.4 per cent per annum, serious casualties by 5.1 per cent per annum and reported slight casualties by 7.1 per cent per annum.

A sample investigation indicated that for rural roads, the traffic on 62 per cent of trunk roads, 23 per cent of class I roads and 6 per cent of class II roads now exceeds the design capacity of these roads, as given in Ministry of Transport and Civil Aviation Circular No. 727. The traffic on 13 per cent of trunk roads exceeds twice the design capacity. The mileage of road on which traffic exceeds design capacity is about 8,000 miles and is increasing at the rate of about 700 miles per annum. It was estimated that to provide the additional lanes at present required for these rural roads would cost about 420 million pounds, and, with a feasible doubling of traffic, an expenditure of about 1,200 million pounds would be required in order to catch up within 10 years.

London-Midlands Motorway Study

The investigation being carried out in conjunction with the University of Birmingham into the economic effect of the proposed motorway between London and the Midlands has provided estimates of the traffic flow on the motorway and the time savings to this traffic. These were obtained by studying the origins and destinations of traffic, on existing roads in conjunction with measurements of journey time, and by assigning to the motorway all journeys that would take less time by using it. Because of uncertainty as to the speeds which would be obtained on the motorway, three different assignments were carried out for the three sets of assumed mean speeds given in Table 1.

The final choice from the three assignments will depend mainly upon the speed limits adopted for goods vehicles on the motorway. The values used in the first assignment are based upon measurements on existing good rural roads carrying light traffic and would probably be applicable if speed limits were the same as on ordinary roads. However, if higher speeds

were permitted on the motorway, the second or possibly the third assignment might be more appropriate. This problem is being investigated by studying vehicle speeds on roads on the Continent.

Estimates of traffic flow and time savings are given in Table 2.

Table 1—Assumed mean speeds on the London-Midlands motorway

Class of vehicle	First assignment (mile/h)	Second assignment (mile/h)	Third assignment (mile/h)
Car	50	50	50
Light goods (up to 1½ tons unladen)	40	45	50
Medium goods (1½-3 tons unladen)	35	40	45
Heavy (over 3 tons unladen)	30	35	40

Table 2—Estimated traffic flow and time savings on London-Midlands motorway (Based on 1955 traffic)

	First assignment	Second assignment	Third assignment
Traffic flow (vehicles per day*)			
On most heavily trafficked section of the motorway	15,200	16,500	17,200
Average over whole of motorway	10,700	11,700	12,100
Percentage of light vehicles in the traffic	54	50	48
Annual time savings** (millions of vehicle-hours)	1.56	2.20	2.74
Additional mileage incurred per annum (millions of vehicle-miles)	13.1	16.2	18.9

* In both directions per 16-hour week-day, June/July.
** Includes week-ends and nights.

The results in Table 2 refer to 1955, when the traffic studies were carried out, and, because of the general growth in traffic, they underestimate the savings which will occur when the motorway is opened to traffic. Table 2 shows that the predicted traffic flow is not very sensitive to the assumptions made but that the time savings show considerable variation, being almost twice as high for the third assignment as for the first assignment.

The flows on individual sections of the motorway for the first assignment are given in Fig. 1.

RURAL TRAFFIC

Speeds on roads on the Continent

During 1957, members of the Laboratory staff visited the Continent to investigate speeds on motorways and ordinary rural main roads in Belgium, Holland, Germany and France. This work was undertaken as part of the investigation into the economic effect of the proposed London-Midlands motorway, with the object of checking the validity of the speeds assumed on the motorway and of assessing the effect of adopting higher speed

limits for goods vehicles. The measurements, which were carried out with the co-operation of the highway authorities in the various countries, embraced 21 sites on straight level sections of road. The results obtained are summarised in Tables 3 and 4.

Table 3 shows a marked degree of consistency between the mean speeds obtained on the various continental motorways. These mean speeds are somewhat higher than the value of 50 mile/h assumed above for the London-Midlands motorway, and speeds on ordinary main roads on the Continent are also higher than on their counterparts in England.

In Table 4 the mean speeds for individual classes of vehicle are consistently higher on continental motorways than on ordinary continental roads. The heavier the vehicle, the smaller is the difference. The Table also shows that on comparable roads goods vehicles travel faster on the Continent than in England. This is probably at least partly due to the higher legal speed limits in force on the Continent (in some cases there is no limit at all).

TABLE 3
Mean speeds of cars on straight and level sections of motorways and ordinary rural main roads in different countries

Country		(1)	(2)	Difference in speed (1) — (2) (mile/h)
		Motorways	Ordinary roads	
		Mean speed (mile/h)		
Belgium	...	52	—	—
Holland	...	53	47	6
Germany	...	54	45	9
France	...	52	50	2
Average for continental countries	...	53	47	6
England	...	50*	42	8

* Assumed on London-Midlands route.

* Assumed on London-Midlands motorway.

TABLE 4
Mean speeds of different classes of vehicle on the Continent and in England
(Straight and level sections of rural road)

Class of vehicle	Motorways on the Continent	Ordinary main roads	
		Continent	England
Car	...	53	47
Light goods	...	44	42
Lorries and heavy vans (2 axles)	...	39	38
Lorries and heavy vans (3 or more axles)	...	37	36

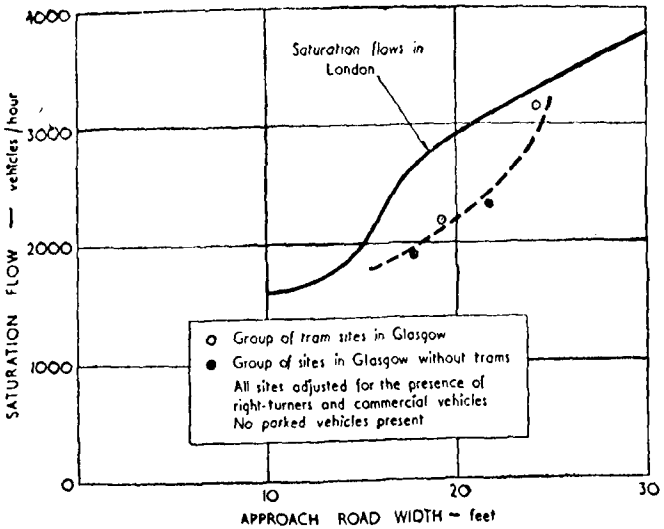


Fig. 2 (left) Comparison of saturation flows in London and Glasgow

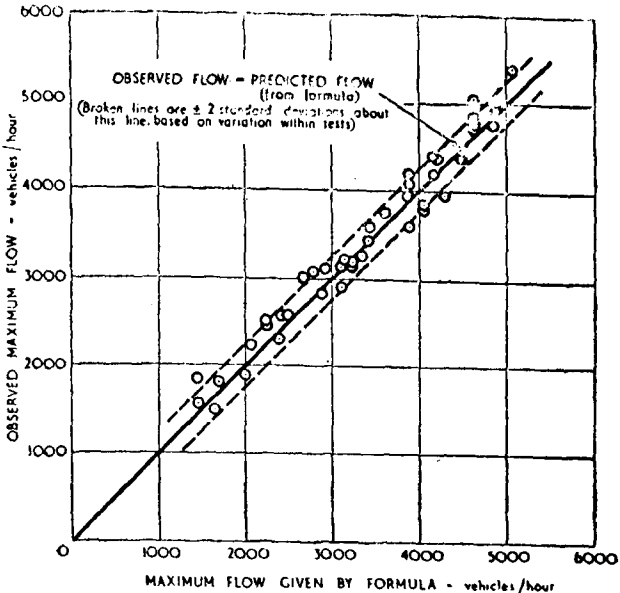


Fig. 3 (right) Weaving tests: comparisons of observed maximum flow with value given by formula (where necessary the predicted maximum flows have been corrected for wet weather)

INTERSECTIONS

Traffic capacity of some intersections in Glasgow:

An investigation of the capacity of some intersections controlled by traffic signals was made in Glasgow in May, 1956. Fig. 3 compares the saturation

flow, i.e., the maximum rate of discharge of vehicles from the queue during the green period, for some groups of Glasgow intersections with some London results obtained previously. The reduced capacity in Glasgow was mainly due to vehicles not always queueing up in lanes and making full use of the

available road space. It is estimated that, on the average, 3 to 4 ft of road width is not used at some of the narrower Glasgow intersections. As a result, a parked vehicle on the approach side of the junction was found to have little effect on the capacity of the junction, except on those streets with trams, as shown in Table 5.

The vehicles turning right at an intersection reduced the saturation flow not only of the stream containing the right-turner but also of the opposing stream. Although there was considerable scatter in the results, the average effect was a reduction of about $\frac{1}{4}$ per cent in the saturation flow of each stream for each 1 per cent turning right from either of the streams. The effect is unlike the one found at many places in London where the reduction in general occurred almost entirely in the stream containing the right-turner. This difference may be due to a difference in driver behaviour. In Glasgow the opposing stream often allows the right-turners to pass in front of it but this is not the case in London. A high proportion of right-turning traffic caused the saturation flow to fall off after about 10 seconds of green period both with and without trams. In either case it would appear to be better to have signal cycles rather shorter than would normally be used in order to prevent this effect becoming too serious.

A tram was found to have the same effect on capacity as $2\frac{1}{2}$ private cars. This is not much greater than the effect of a bus in London. However, it would be relatively greater if vehicles made fuller use of the available road space. The effect of heavy and medium commercial vehicles was slightly greater than in London, being a reduction in capacity of $\frac{3}{4}$ per cent for each 1 per cent of medium and heavy vehicles.

Traffic capacity of a weaving section of a roundabout :

In "Road Research, 1955" the results were given of experiments at Northolt Airport to determine the ultimate capacity of a weaving section of a large roundabout, the lengths of the

weaving sections considered being either 200 or 300 ft. Further experiments have been made at the same place and with a similar layout to extend the earlier results to cover a comprehensive range of the dimensions of a weaving section.

As before, upto 120 vehicles took part, including a number of London Transport double-decker buses, goods vehicles of various sizes, cars and taxis.

On the basis of all the experiments a new formula has been derived which takes account of the weaving length and includes the effect of "heavy" goods vehicles,* as well as buses. The revised formula is :

$$Q = \frac{4.9 (w + c) (4l - 3w) (3 - p)}{1 (0.56 + h)}$$

where Q = Maximum flow in weaving section in dry weather, daylight, without pedal cycles or pedestrians, in vehicles per hour.

w = width of weaving section in ft (range 20 to 60 ft).

c = mean width of the two entries to the weaving section in ft (range $0.4 w$ to w).

l = weaving length in ft (range $2.5 w$ to $7.5 w$).

p = proportion of weaving traffic (range 0.4 to 1.0).

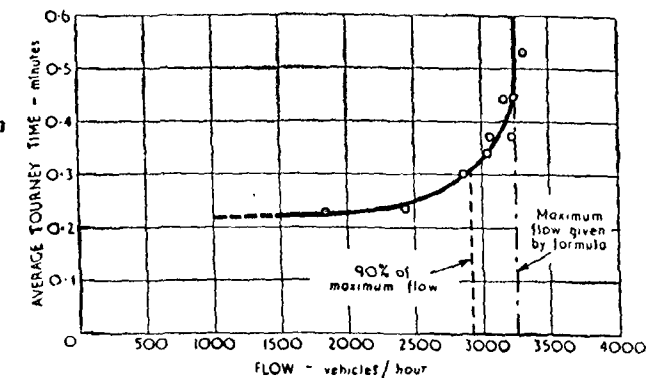
h = proportion of heavy vehicles including buses (range 0 to 0.25).

In wet weather the ultimate capacity is reduced by 10 per cent.

The degree to which the above formula fits the maximum flows observed during the tests is shown in Fig. 3. The average error is about 5 per cent and almost all the experimental results lie within 10 per cent of the value given by the formula. The errors are not much greater than those due to the inherent variability of the data. Comparison with observed maximum flows on a fully loaded weaving section at Hyde Park Corner, 55 ft wide and 180 ft long, showed very good agreement. Observed maximum flows under

*According to the definition used by the Ministry of Transport and Civil Aviation, i.e., over $1\frac{1}{2}$ tons unladen.

Fig. 4
Weaving tests:
relation between
journey time
and flow as
the number
of vehicles
was varied
in one test



normal conditions at Chiswick roundabout were about 20 per cent below those given by the formula, possibly because of the absence of full loading, the awkward shape of some of the weaving sections and the presence of pedal cycles.

The formula shows that one "heavy" goods vehicle or bus is equivalent to 2.8 "light" vehicles (cars, taxis, or light vans) in terms of the capacity of a weaving section. In three of the tests police control of traffic entering the weaving section raised the maximum flow by about 20 per cent.

TABLE 5
Effect of parked vehicle on capacity
of a junction
(Glasgow)

Clear distance of parked vehicle from stop line (ft)	Percentage drop in capacity	
	Sites with trams	Sites without trams
0-40	28	6
40-80	20	7
Over 80	No effect	No effect

In one test the number of vehicles taking part was varied, thus increasing

the flow to the maximum which the weaving section could handle. The relation between the average journey time through the section and its approaches (including all queueing time), and the flow, is shown in Fig. 4: the average journey time started to increase rapidly as the flow increased above 90 per cent of the maximum value.

Although there had been an exceptionally high accident rate (almost all damage only) in the earlier tests, there was only one damage accident during the two days of the second series. This may be partly due to the much smaller number of non-professional drivers who took part (15 instead of 40).

The results of these tests provide useful information on the design of roundabouts, although they must be treated with caution. The ultimate capacity of a roundabout cannot be greater than that of each individual weaving section, and owing to the possibility of interference between adjoining weaving sections and "locking" it may be considerably less. Further research is required on these points, but meanwhile the value of maximum flow given by the formula must be modified to take account of wet weather, darkness and other factors, and should be regarded as "an upper limit which should only be reached on rare occasions if at all".

(To be continued)

HERE AND THERE

1. BRIDGES OF PRESTRESSED CONCRETE

● THE application of prestressing to bridge work has increased rapidly and over 250 bridges have been built in this country since 1950, the majority for spans of less than 50 ft. This span is not, of course, the economic limit but merely reflects the nature of the bridge building programme. In this country we were not faced with the mass destruction of bridges suffered on the Continent and so have not

abroad that it is the most economical solution of most bridge designs and at the same time it releases steel for other engineering works. For short spans the most common solution has been the use of inverted T-units and there are many standard designs on the market to-day. For larger spans composite construction using prestressed I or T-beams with an in-situ deck has been more common. For

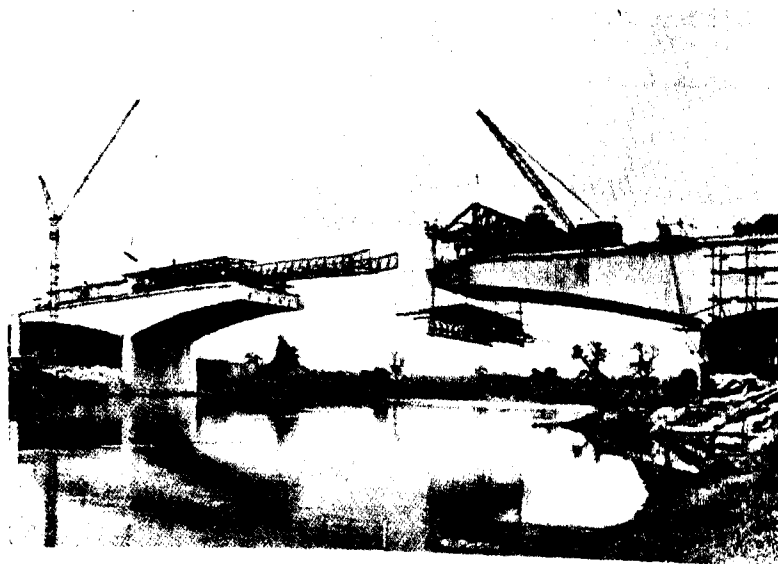


Photo 1.

had the opportunity of constructing many long span bridges. A few greater than a 100 ft span have, however, been constructed, although the economic limit for prestressed bridges is at least of the order of 500 ft. An excellent resume of long span bridge construction in prestressed concrete is given in reference 3* although even this does not cover many of the German and other Continental bridges.

It appears from experience at home and

larger span bridges cantilever and suspended span construction such as Clifton bridge, Nottingham (Photo 1), has been used although portal construction with sloping legs might be the form of construction of the future.

Prestressed concrete has been applied to many foot bridges of which the latest is in St. James's Park (Photo 2) and is often economical since the greatest part of the load is usually the self weight.

* Guyon, Y. "Long-span Prestressed Concrete Bridges constructed by the Freyssinet System," Proc., I.C.E. May 1957.

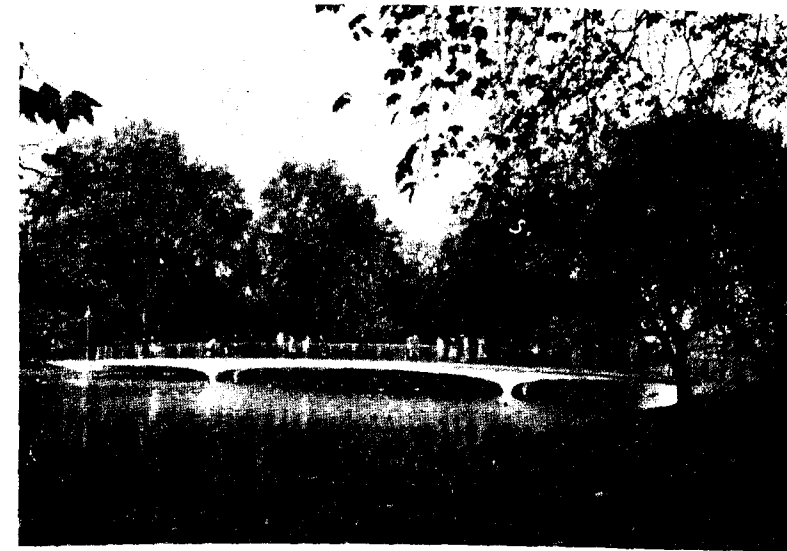


Photo 2.

Except for the Clifton bridge mentioned above little use has been made of the German method of cantilevering out of form work from the finished work, a

process to which prestressing lends itself admirably.

(From "Reinforced Concrete Review", June 1958).

2. TIME TABLE AT BUS STOPS

● TO merchandise city bus service, Detroit's Department of Street Railways (DSR) posted bus schedule signs at bus stops along the route of its new Imperial Express. The signs are black letters painted on a white metal background. They are bolted to the posts that hold the regular coach-stop signs.

Riders say they like the posting of time schedules because, knowing exactly when a bus will arrive, they spend less time waiting at the bus stop. Especially enthusiastic are those who ride during the off-peak hours when the time between buses may be as long as 30 to 45 minutes. During off-peak hours on the Imperial Express line, buses run every 30 minutes, every 10 minutes during rush hours.

This is the first time in eight years that the DSR has attempted to post bus-stop schedules. A previous attempt using plastic-coated schedules was abandoned when the schedules were destroyed by juveniles almost as soon as they were posted.

(From "The American City", October 1958).



3. OLD ASPHALTIC CRUST SALVAGED IN RESURFACE

● THE Florida State Road Department in the United States recently rebuilt a section of State Road 361 in an unusual way.

The old surface was badly broken as the $\frac{1}{2}$ to 1 in. of sand asphalt had been laid on a soft sandy base.

Scarifying the old surface with the State's Huber-Warco 4D-115 motor grader was the first step. Next the broken pieces were windrowed into the middle of the road. A seaman-Andwall pulverizer pulled by an Oliver super 77 tractor made six or eight passes through the windrow to break up the hard mixture. To further pulverize the sand asphalt, an older model H-W 10-ton 3-wheel roller made approximately 40 passes over the windrow.

The motor grader spread the windrow

over the road and then scarified the road-bed 6 to 8 in. deep. The asphalt and sandy base were mixed 12 separate times, to a depth of 6 in. by the pulverizer. During this phase, a Ford tractor pulling a disc harrow went over the road many times to assure complete mixing.

Hot liquid asphalt was spread during the last few mixing passes. This produced a fine sand asphalt approximately 6 in. thick.

After the asphalt and sand base were thoroughly mixed the grader spread the mixture evenly over the road. A large tandem roller compacted the asphalt.

This procedure reportedly resulted in one of the "smoothest roads possible".

(From "World Construction", October 1958.)

4. SAHARA DESERT ROADS

● WORLDWIDE interest to-day is centering in the Sahara Desert because of oil and mineral deposits discovered there and awaiting development. What is little known, according to African roads and transport, is the fact that at present 20,000 km. of pistes or tracks more or less negotiable by motor vehicles exist in the Sahara region.

These roads, built haphazardly, have been intended until recent years to link oasis and military outposts. Several of the lines have developed into tourist routes, such as Hoggar Imperial Piste.

Most areas of the Sahara are stony desert, with sand dunes confined to cer-

tain regions only. Special techniques are required to build roads of any durability to sand dune regions. Any road project quickly involves a plan of drilling for water to supply workers and machinery.

According to African Roads and Transport, a program of building at least 1 km. of highway per day is needed to reach some of the oil field outposts in a period of less than 10 years. Huge concentrations of road building machinery must be installed and high speed techniques adopted.

(From "World Construction", October 1958.)

5. NEW 62-MILE AUTOBAHN OPENED

Great European Motorway Network Extended

● LAST week, with little ceremony, a new stretch of Autobahn, 62 miles long, connecting Hanover and Hamburg, was opened to traffic. It will form part of a

560 mile motorway stretching right across the country from Baste to Hamburg, which is scheduled for completion in 1961. This, in turn, will form the German part

of European Route Four, a great motorway chain stretching from the Baltic to the Mediterranean.

No tolls are charged on these roads, the cost of construction 470,000 pounds a mile being met by the Federal Government.

Under the revised programme approved last year, 3,000 million pounds is to be spent on extending the Autobahnen and improving other main roads. About 1,250 miles of Autobahn are to be built, doubling the length of the present system within the length of the present system within the federal frontiers. About 170 miles have been completed and 250 miles are under construction.

The proposed European network has also called for more extensions. Apart from Route Four, extensions are being

built for Route Three, connecting Paris with Northern Europe. Others are already reaching out to the Low Countries.

Generally speaking, it is impossible to drive through most of the large cities without making detours, and the new plan is designed to remove many of the corners.

Medium-sized cars, it is claimed, can travel from Bonn to Berlin, about 400 miles, in six and a half hours. If this is too long for the busy business man, he can arrange to receive telephone calls along the way at road-houses displaying the names and car numbers of those who are wanted. The food served in the road-houses can be good and cars are serviced and cleaned while their drivers are eating.

(From "Highways and Bridges and Engineering Works", October 1, 1958.)

6. A NEW WEDGE ANCHOR GRIP FOR PRESTRESSING

● McCALLS Macalloy, Ltd., have now developed a wedge anchor grip for use with the Lee McCall prestressing system.

This new anchorage does not replace the threaded anchorage, but is an addition to increase the range of application of

Macalloy bars. The basic difference between the two anchorages is that the wedge can be anchored anywhere in the bar, whereas the threaded end is limited to units of predetermined lengths.

The stressing operation with wedge grips is simple and speedier even than the threaded anchorage.

Advantages claimed for the new anchorage are that:

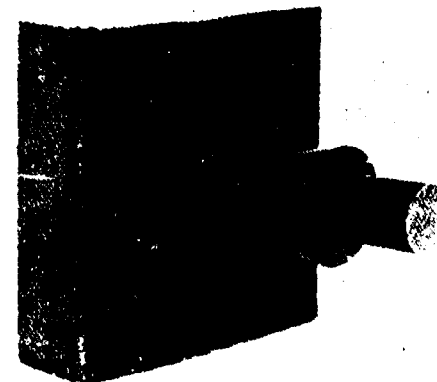
1. Length tolerances in manufacture of concrete members are not exacting.

2. Bars in stock lengths can be ordered and used for any size of concrete member.

3. The tensioned member presents a nearly flush end.

The recommended initial jacking stress for Macalloy bars anchored with wedge grips is 45 tons per sq. in. The present threaded anchorage remains at 42 tons per sq. in.

(From "Highways and Bridges and Engineering Works", October 8, 1958.)



Macalloy wedge grip anchor and end plate with taper hole. The two small holes are 7/16 in. dia. for fixing plate to formwork and holding grouting flanges if used.

7. ELECTRONIC CHAUFFEURS FOR U.S. SOON

● DRIVERS in the United States may soon be able to nap, read a newspaper or watch television while motoring on electronic highways, according to highway authorities now concerned with developing controlled, automatic roads to reduce accidents and tedium.

When all the difficulties are solved, a driver will be able to travel to an electronic highway, push an "automatic pilot-type" button and relax and forget about travel problems as his driving at prescribed safety speeds will be handled by electronics.

The electronic roads, according to

technicians, will function from buried cables and strands of wire in or alongside the highway which radiate signals that can be received by tiny transistorised receivers inside the car.

There will be three different frequencies, one controlling the steering mechanism, another warning of obstacles ahead, while the third will announce exits from the highway to nearby cities. Once the driver leaves the controlled highways, he switches off his electronic drive and reverts to regular motoring.

(From "African Roads and Transport", September/October, 1958).

8. BRIDGE TO AFRICA PLANNED

● A proposal for a 24-kilometre (14½-mile) bridge to link Europe and Africa across the Straits of Gibraltar was outlined in a lecture given in Madrid.

Senor Alfonso Pena Boeuf, the ex-Minister of Public Works in Spain, explained the scheme, which he has been working on for some years, to build a bridge across the Straits at an estimated cost of some 5,000 million pesetas (43,000,000 pounds).

The bridge would carry six lanes of road traffic and two rail tracks, and would have seven arches of 3 kilometres (nearly 2 miles) each and two "half-arches".

The Longest

Nothing like such a bridge has so far been attempted. Famous bridges include the "Golden Gate" bridge, 1,270 metres (4,200 feet) in length—the longest single span of suspended steel in the world—which crosses the channel leading into San Francisco port at a height of 72 metres (238 feet) above the water.

Senor Pena Boeuf believes that by using modern techniques spans of 3 kilometres (nearly 2 miles) long, resting on concrete towers, are quite feasible.

(From "African Roads and Transport", September/October 1958.)

9. GERMAN ROAD FINANCE

● WESTERN Germany is to channel almost the entire revenue derived from oil, diesel oil and petrol taxes into a road-building fund. From 1959 (when the scheme is to come into existence) to 1963 revenue from oil is expected to total some 448 million pounds for the four years, while increased diesel oil and petrol taxes are estimated to produce between 12 and 16 million pounds annually. The road

programme between 1959-63 will require some 560 million pounds. Any balance needed will be made up by raising money through public loans or bonds. According to the proposals as agreed by the Bundestag only 48 million pounds annually from oil and petrol taxes may be spent on projects other than road.

(From "British Road Federation Bulletin", November 1958).

10. ROADS IN CITIES

Study Groups to be Set Up

● SPEAKING during his tour of road schemes in the West Midlands last month, Mr. Harold Watkinson, Minister of Transport, announced that "urban road study groups" were to be set up in the larger cities to plan new roads in built-up areas that would be complementary to the fast inter-city motorways.

The aim was to prevent new motorways from beginning and ending in traffic bottlenecks. "It would be frustrating for a driver to reach the end of one of the motorways and find a major traffic jam awaiting him", he says.

Eventually, every big city would need a study group to investigate its particular problems. He envisaged that each group would include representatives of the local authority, business interests and

the Ministry, and would have the technical assistance of the traffic engineer.

In planning new roads in urban areas, the Minister said, one of the chief aims must be to separate the pedestrian from motor traffic to a far greater extent than at present.

The Minister was not yet convinced that the American type expressway through motor traffic in towns was the right answer for Britain. In many cities, as in London, it would not be right to demolish large areas of existing property, much of it with historic associations, to make way for elevated motorways.* In some places double-deck roads might be the answer; elsewhere roads might have to go underground.

(From "British Road Federation Bulletin", November 1958.)

* See Urban Motorway for Newport, page 207.

FOR BETTER, FOR WORSE

A friend of mine, awakened by her husband's snoring, called to him, "Frank, turn over—you're snoring".

"Okay", he said, and stopped for a while. But he tuned up again several times, and she had to tell him to stop. Next morning at breakfast, she said, "What a night I had!"

"I'll say you did!" her husband exclaimed. "You talked in your sleep all night."

ROAD SIGN

"Main road open for traffic while detour is being repaired".

WORDS OF WISDOM

The great pleasure in life is doing what people say you cannot do.

—WALTER BAGEHOT

CURRENT LITERATURE

ABSTRACTS

NATURAL BUILDING STONES—DETERMINATION OF RESISTANCE TO WEAR BY ABRASION; Press Note No. 218, Indian Standards Institution, 29th August, 1958.

THE Indian Standards Institution has issued a draft Indian Standard Method for Determination of Resistance to Wear by Abrasion of Natural Building Stones Doc: BDC 6 (399) for the com-

ments of interested persons.

Natural Building Stones, used in steps, flooring and pavements of buildings, are subject to heavy wear and friction. Their durability under such circumstances can be ensured only when they have adequate hardness or abrasive (wear) resistance. This standard gives a laboratory method for ascertaining abrasive values of stones intended for use in buildings.

(Continued from page 30)

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(To be continued)

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8. The Use of Welding in the Construction of the New Road Bridge Over Save at Belgrade; M. M. RADOJKOVIC and M. WIDMAN, *Annales de L' Institut Technique du Bâtiment des Travaux Publics*, Vol. 20, No. 117, September 1957, pp. 863-876 (In French).
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(Continued on page 54)

BUDGETS AND ADMINISTRATION REPORTS

GOVERNMENT OF WEST BENGAL BUDGET FOR 1958-59

The following extracts have been taken from the Govt. of West Bengal (Civil Works) Budget for the year 1958-59.

Revenue (civil works)

Heads	(In lakhs of Rupees)		
	Actuals 1956-57	Revised Estimate 1957-58	Budget Estimate 1958-59
Rents	6.71	7.00	7.00
Ferry Receipts	2.44	2.00	2.00
Tolls on roads	4.55	5.00	5.00
Recoveries of Expenditure	3.18	3.50	2.00
Transfer from Central Road Development Account	37.96	44.46	40.46
Miscellaneous	14.22	21.50	19.00
Grant from Govt. of India on account of construction of State roads of economic or inter-State Importance	21.30	14.55	11.85
Deduct—Refunds	— .05	— .04	— .04
	90.31	97.97	87.27

Expenditure (civil works)

Buildings			
Original works	12.45	13.73	9.09
Repairs	105.60	108.70	107.00
Communications			
Original works	93.05	56.79	49.61
Repairs	107.70	96.20	92.00
Miscellaneous			
Original works	...	...	...
Repairs	.20	.20	.20
Establishment	50.07	49.07	51.10
Tools and Plant	11.80	9.55	9.55
Grants-in-aid	20.29	21.65	— 11.21
Suspense	2.02	— 9.98	— 3.98
Development Schemes	43.97	46.51	52.21
Deduct—Recoveries on account of Establishment, Tools and Plant	— 5.75	— 6.00	— 6.00
	441.40	386.42	349.57

Capital Account of Civil Works outside the Revenue Account (excluding Development of State Roads).

Heads	(In lakhs of Rupees)		
	Actuals 1956-57	Revised Estimate 1957-58	Budget Estimate 1958-59
Original works			
Buildings	166.86	147.16	127.22
Communications	8.20	5.49	7.04
Miscellaneous	1.27	2.37	2.15
Development Schemes			
(i) Other Development schemes	328.78	211.53	179.93
(ii) Centrally sponsored schemes outside the State Plan	—	16.42	11.00
Deduct—Receipts and Recoveries on Capital Accounts—Other Receipts	— 12.37	— 3.77	—
Total	492.74	379.20	327.34

Budget Estimate of Expenditure under “81—Capital Account of Civil Works Outside the Revenue Account—Development Schemes—Development of State Roads” in West Bengal for the year 1958-59.

Name of minor heads	(In lakhs of Rupees)			
	Provision in the approved Second Five Year road programme	Actual Expendi- ture during 1956-57	Revised Estimate 1957-58	Budget Estimate 1958-59
I	2	3	4	5
Development Schemes				
Development of State Roads				
Original works	—	.08	.06	.20
Buildings	—	250.48	261.10	217.33
Communications	—	23.62	23.20	31.00
Establishment	—	—	—	—
Deduct—Recoveries of Establishment	—	— 3.04	— 2.84	— 3.91
Tools and Plant	—	23.81	26.85	26.00
Deduct Recoveries on account of tools and plant	—	— .54	— .71	— .98
Suspense	—	16.31	1.34	19.36
Deduct—Receipt and recoveries on Capital Account	—	— 8.89	— 9.00	— 9.00
Total—Development of State Roads	1710.00	301.83	300.00	280.00

(A Brief Review of the Budget)

THE revenue and expenditure of West Bengal for the year 1958-59 are estimated at Rs 6,886 lakhs and Rs 7,269 lakhs respectively indicating a deficit of Rs 383 lakhs. The revised estimates for 1957-58 revenue and expenditure are Rs 6,998 lakhs and Rs 7,264 lakhs respectively leading to a deficit of Rs 266 lakhs for that year.

The budget estimate of expenditure on civil works to be met from revenue for

1958-59 forms 5.1 per cent of the revenue for that year as against the corresponding figures of 5.5 per cent arrived at from the revised budget for the previous year (1957-58).

The provision for capital expenditure on civil works outside the revenue account in the current year is Rs 607.34 lakhs, out of which Rs 280.00 lakhs have been allotted for development of State roads under the Second Five-Year Plan.

(Continued from page 51)

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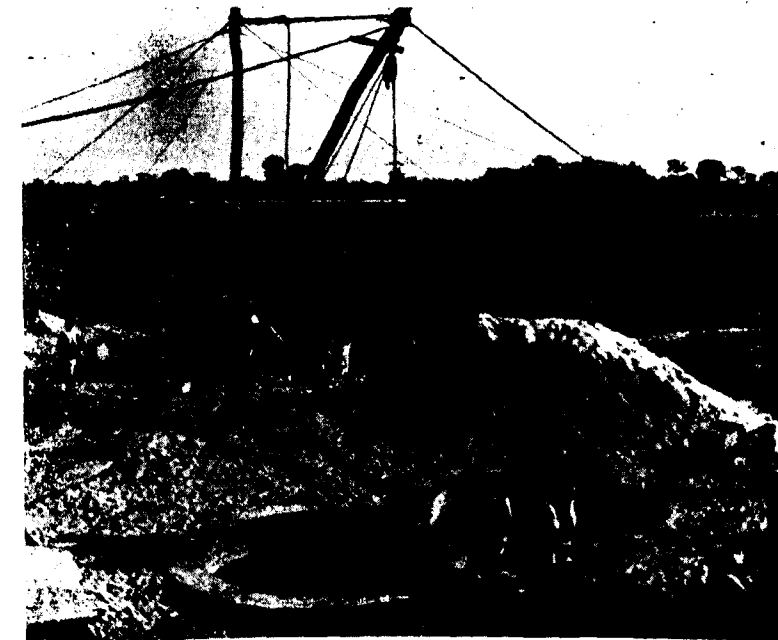
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VERDICT OF HISTORY

Civilization is a movement and not a condition, a voyage and not a harbour.

—ARNOLD TOYNBEE



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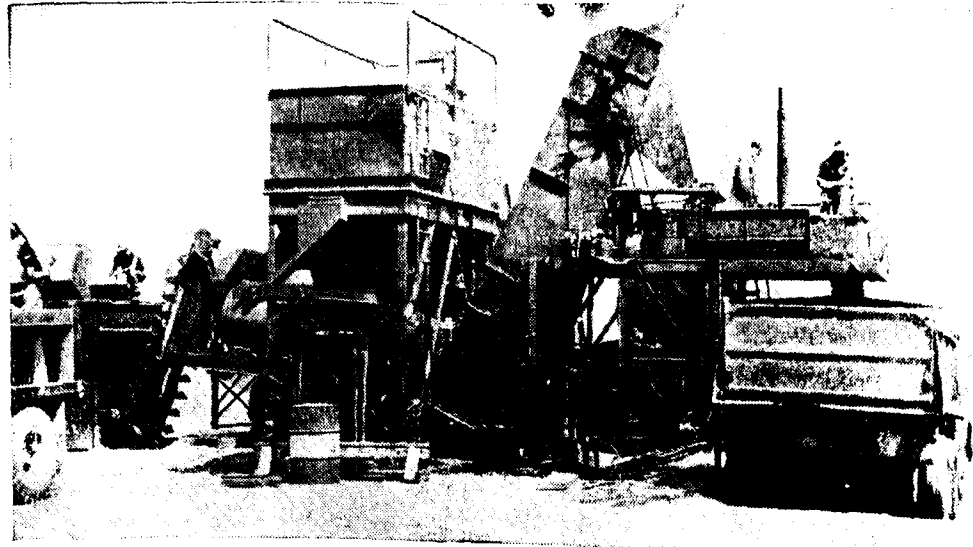
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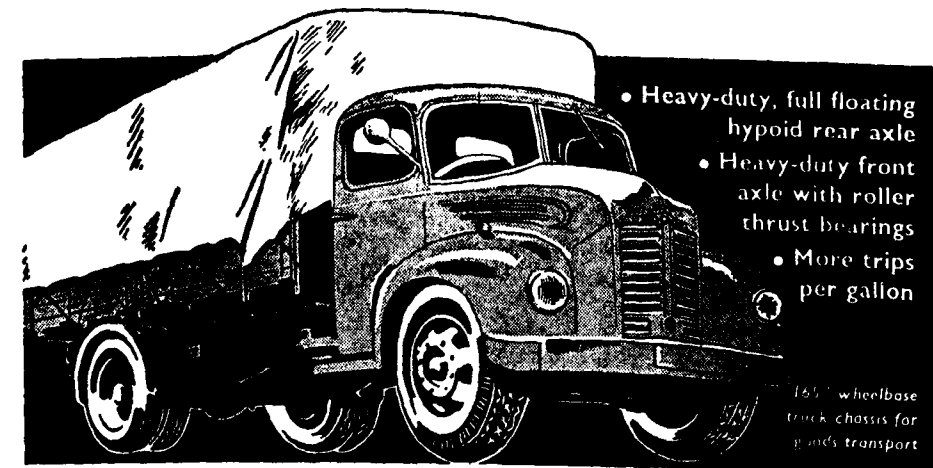
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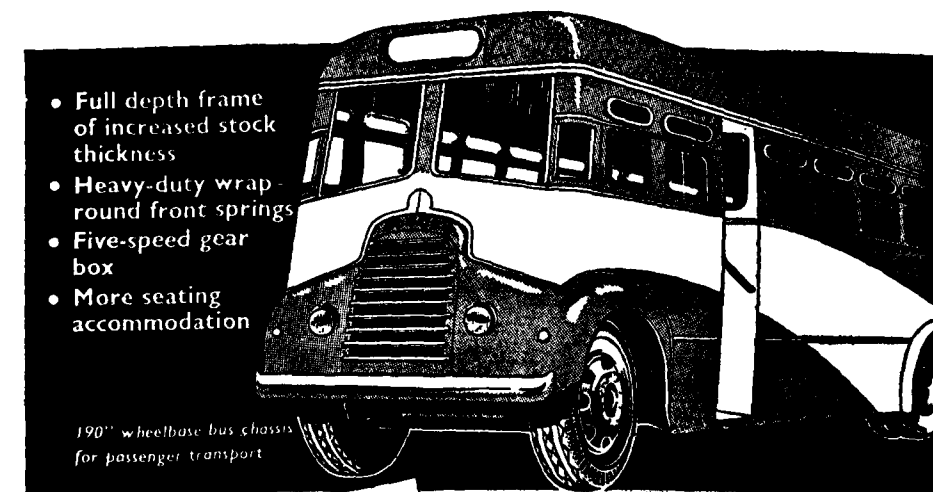
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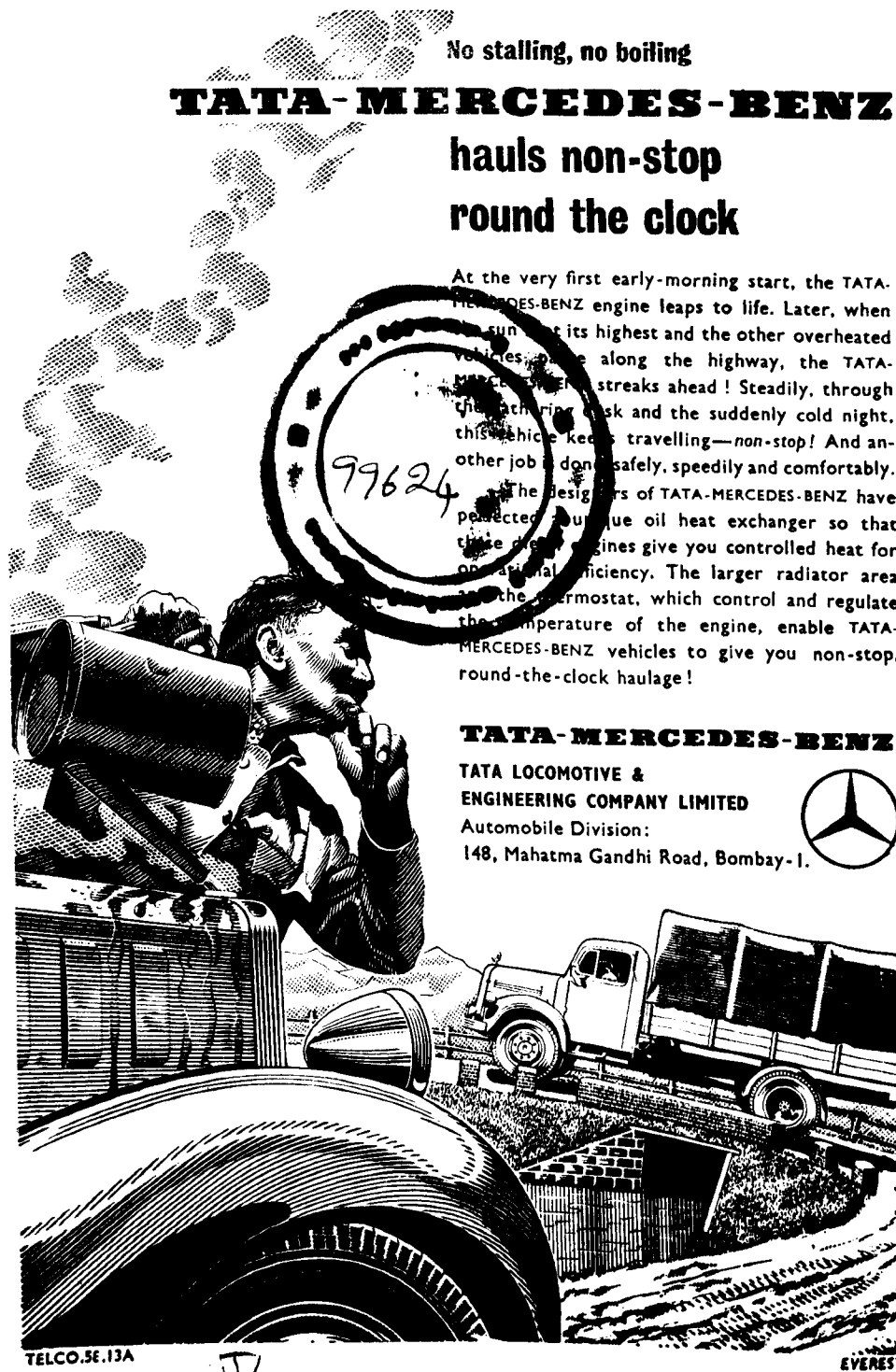
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