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TRANSPORT- COMMUNICATIONS

MONTHLY REVIEW

DECEMBER 1957—No. 128

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INDIAN ROADS CONGRESS, NEW DELHI

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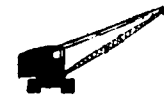


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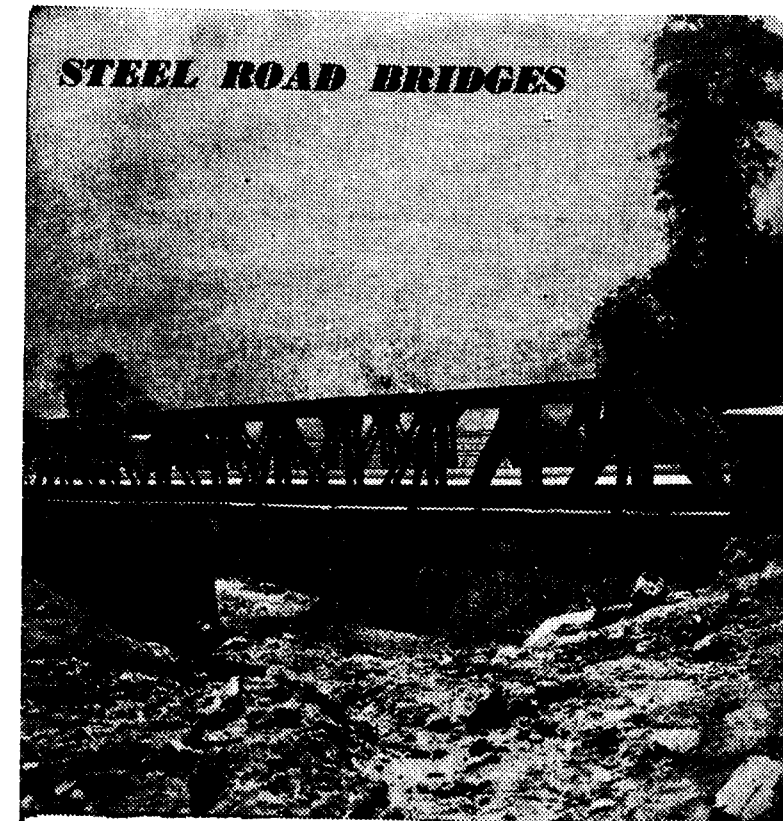
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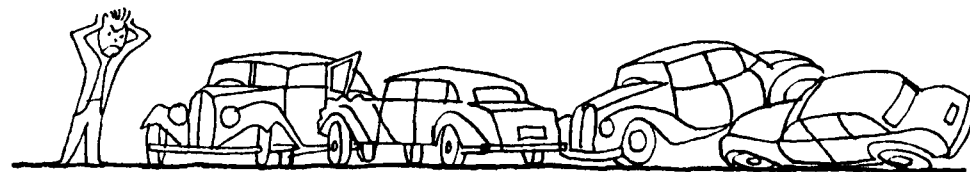


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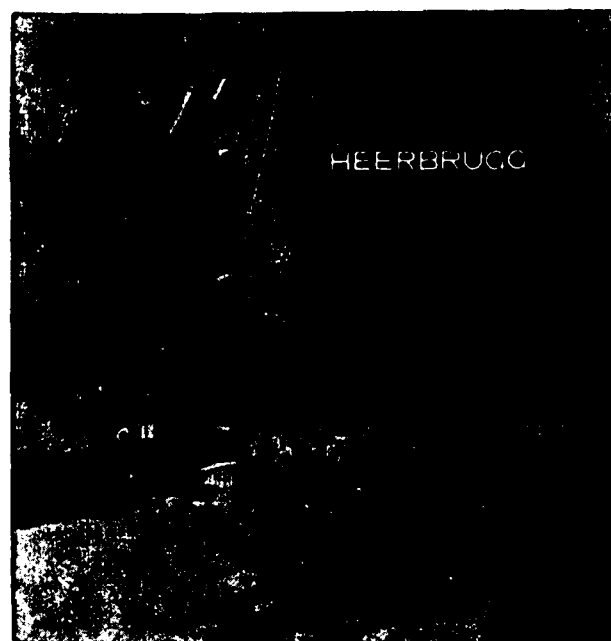
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INDIAN ROADS CONGRESS

TWENTY - SECOND SESSION

NEW DELHI — JANUARY 1958

The Indian Roads Congress will hold the twenty-second Annual Session at New Delhi early from 4th to 8th January 1958. More than three-hundred Highway Engineers from all over India are expected to attend.

On this occasion a Seminar on "Low Cost Roads" will also be organised by the ECAFE. As the Seminar on low cost roads will immediately follow the Indian Roads Congress Session, some foreign delegates attending the Seminar are also expected to participate in the deliberations of the Congress.

The following Papers will come up for discussion during the Session :

<i>Paper No.</i>	<i>Subject</i>	<i>Author</i>
Volume XXII-1		
199	"Construction of a Bridge across Pennar River at Nellore."	J. V. Prasad
Volume XXII-2		
200	"Asphalt Paving Mixtures-Their Design and Composition."	N. H. Taylor
201	"Construction of Prestressed Concrete Super-structure for the Bridge over River Hindan at Ghaziabad."	A. S. Bishnoi & J. S. Mathur
202	"Experimental Soil Stabilized Road Construction in Black Cotton Soil Area."	J. F. Mistry
Volume XXII-3		
203	"Study and Investigation of performance and Failures of Road Pavements in Uttar Pradesh."	H. G. Verma & D. C. Chaturvedi
204	"Scientific Aspects of the Road Traffic Problem."	T. S. Khanna
205	"The Importance of Subgrade Compaction in the Economic Design of Flexible Pavements."	S. R. Mehra & H. L. Uppal

Besides Papers, panel discussion on the use of soil for cheap all-weather road construction which could not be completed last year will continue during the present Session.

A general report prepared from the reports of research work received from the Central Road Research Institute and the State Road Research Laboratories will also be discussed during the Session.

Visits to engineering works of interest in and around Delhi will be arranged for the delegates.

A technical engineering exhibition in which various engineering firms, and Govt. Departments are expected to participate will be arranged at the time of the Session.

PORT-COMMUNICATIONS LY REVIEW

A REVIEW OF
ROAD ENGINEERING, DEVELOPMENT & TRANSPORT

DECEMBER 1957

URBAN HIGHWAY PROBLEMS

ANY one who has experienced the interminably slow crawl on our highways on approaching the towns and cities—both big and small—will realise the seriousness of the traffic problem which confronts the urban areas. Not only are the widths of pavements narrow but, to make the situation worse, there are all kinds of obstructions on the pavements which cause congestion and are veritable bottlenecks for the smooth flow of traffic. The reasons for this state of affairs are not far to seek. There is probably no town or city in India whose population has not shown phenomenal increase during the last decade and which has not experienced a large increase in the volume of traffic. This, unfortunately, happens to be of a mixed pattern consisting of motor vehicles, bullock carts, hand-carts, tongas, rickshaws and bicycles. Added to this are the habits of the people which do not seem to have changed much through the years since the time when the highway served as market place, business centre, recreation and dwelling place, in short the hub of all activities.

The obstruction to traffic is indeed a very serious problem whose implications in terms of money have been assessed in certain countries. Studies carried out in America have indicated that the direct loss on account of waste of petrol, wear and tear of vehicles, accidents and lost time amounts to 2 cents per mile of travel. In the U.K., it was estimated that the minimum loss from a fall of one mile an hour in the speed of travel was about 30 million pounds a year, taking into account only vehicles which travelled for business purposes. If other vehicles were also considered, the figure would be 90 million pounds.

Traffic volumes in India are expected to increase in the near future with progressive industrialization of the country, and the problem of urban highway congestion has therefore, to be solved boldly and on scientific lines. No ready-made formulae can be applied in dealing with the problem but traffic engineering investigations are first required in which various studies are involved, e.g., volume studies, origin and destination studies, cordon counts, speed and delay studies, parking, accidents, etc. These studies serve to provide factual information regarding characteristics of the traffic flow, travel habits of the people, shifting traffic patterns, etc. Based on this information various improvements can be effected both for regulation and increase of traffic flow. These improvements may consist of widening of pavements, improvement of intersections, improvements in directional control, traffic signs, parking facilities, etc.

A close study of the problem, however, shows that there are limits to the extent to which traffic flow can be improved by small-scale improvements, regulation, and restriction. Inevitably a stage is reached when this may lead to an over-all reduction in traffic movement and decline of business. Other ways to improve the situation have, therefore, to be looked to. Construction of by-passes and ring roads around towns and controlled access highways in the case of bigger cities have to be considered. Several by-passes on our highways in important towns are already under construction where the existing links within municipal limits are found unsuitable for development as parts of National Highways for want of the minimum requisite land width (at least 130 ft) required for this purpose.

The scope for improvement of road links in the case of most of the existing towns is limited on account of the difficulty and high cost of acquisition of land and built-up property. But where new by-passes are constructed it is comparatively easy to acquire sufficient land width (150 to 200 ft) at the outset with a view to accommodate the through road and provide for the construction of parallel service roads on either side for local traffic, with limited access to the main highway. The parallel service roads are to be constructed either immediately or in the course of time as development of the area takes place. Provision can then be made for separation of traffic, elimination of cross traffic by providing over-bridges, subways, etc. Besides acquisition of land, other precautions like prevention of encroachments, avoiding leasing of road land, discouraging erection of toll and octroi barriers are necessary. If these precautions are not taken, the same situation is likely to prevail after some time as the by-pass was meant to avoid.

Since the town traffic problem is essentially that of the town, co-operation of the road authority within the town limits is essential. The existing links through towns on National Highways with a population of 20,000 and above are presently the liability of the State Governments or the local bodies. Their help and co-operation are, therefore, required not only in acquiring land and built-up property, wherever required, but also in the matter of adequate provision of parallel service roads for local traffic and precautions for their future control and maintenance. It should not be forgotten that improvement of the condition of the existing road links or construction of suitable by-passes on the National Highways will be to the benefit of not only through traffic but also of the town itself.

Lastly, mention should be made of the urgent need for necessary legislation in respect of right of way and control of access to the highways. In this direction it is heartening to note that steps towards the formulation of comprehensive legislation are under way. The urban transportation problem is as much a legislative and town planning problem as an engineering one. Close co-operation between the various authorities concerned, viz., government departments, municipal administrations and town planning authorities is, therefore, necessary in the interest of a speedy and effective solution of the problem.

Recreation and relaxation are no longer idle luxuries only for those who can afford them; for modern man these amenities are just as necessary as food, water, shelter and power. To the progressive and conscientious civic administrator the provision of these amenities represents not only a challenge but an outstanding opportunity for the display of vision, boldness and determination.

—S. S. Morris.

(From a Paper to the Institution of Park Administration (South Africa).)

UNIQUE ELEVATED ROAD IN BRUSSELS

Cantilever Design with Central Columns

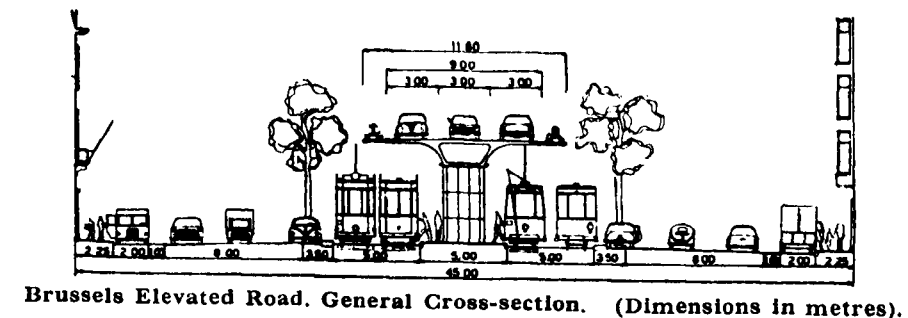
AN unusual elevated road, over half-a-mile (900 m.) long, including the end ramps, has been completed recently in Brussels between the Place de l'Yser and the Place Sainctelette, both of which are important traffic centres.

An underpass would have been impossible here owing to the presence of the river Senne in an underground channel, part of the Charleroi canal, and other subterranean obstacles. In the preliminary design it was proposed to carry an elevated roadway on two rows of columns.

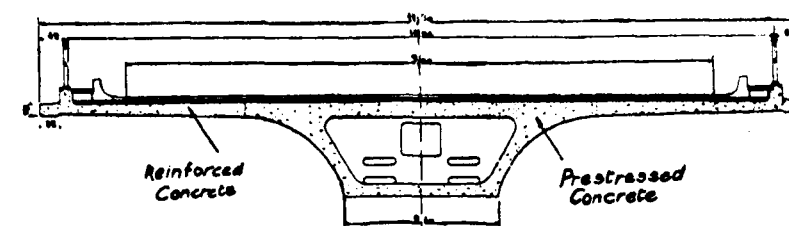
either 79 ft 6 ins (24.14 m.) or 85 ft (25.72 m.) long, cantilevered out from a central hollow beam of prestressed concrete. The headroom beneath the viaduct is 20 ft (6.10 m.) and the ramp at one end has a gradient of 7 per cent (1 in 14.3) while that at the other is inclined at 6 per cent (1 in 16.7).

Foundations

The subsoil at the site consists of some 26 ft (8 m.) of poorly compacted sandy clay, mud and peat, under which is relative-



Brussels Elevated Road. General Cross-section. (Dimensions in metres).



Brussels Elevated Road. Cross-section of Superstructure.

Such a design, however, was considered unsuitable for the particular site and for aesthetic reasons a further scheme was planned using only a central row of columns. This design has been adopted.

The superstructure accommodates three lines of traffic and can carry a uniformly distributed loading of 102 lb per sq. ft. (500 kgm. per sq. m.). The roadway consists of 29 reinforced concrete elements,

very well compacted sand from a depth of 33 ft (10 m.) downwards.

Franki piles with a bearing capacity of 100 tons were used for supporting the columns and the local site conditions, which included a close network of underground pipes, sewers, and channels, rendered pile-driving somewhat tricky and modifications in the piling system had to be introduced in places. At one point the

viaduct supports were founded upon the piles of a canal bridge and anchored thereto with steel connections.

The river Senne was spanned by a large reinforced concrete beam, supporting the columns and resting on Franki piles driven at the sides of the channel.

Superstructure

The overall width of the elevated roadway is approximately 39 ft (11.80 m.) and the width of the carriage-way is approximately 30 ft (9.0 m.). The surfacing is asphaltic concrete and specially designed safety kerbs are provided. These have a concave face and are high enough to deflect a wheel away from the parapet railings. The latter are of a simple, but artistic, design and are constructed of anodised aluminium. They have been tested by driving large American cars against them at speeds ranging from about 25 to 43 m.p.h. (40 to 70 k.p.h.) and angles of impact upto 50 degrees. These tests were conducted in a special yard and it is reported that the railings withstood this treatment quite successfully. It is understood that the roadway is only intended for automobiles.

Each length of the viaduct floor constitutes an independent unit. The prestressed central beams are freely supported on the columns and the cantilever extensions are independently reinforced.

The total prestressing load was 1640 tons and it was transmitted by 8 cables, each of 58 strands, anchored by the Bleton system. The beams rest on a layer of synthetic rubber, half an inch (13 mm.) thick, in which a fine metallic mesh is

incorporated (known as the S.T.U.P. patent material). This seating permits deflections to take place in both longitudinal and transverse directions. In order to prevent relative movements between adjacent beams, however, longitudinal dowels are provided, encased in copper tubes.

Although the superstructure rests upon the columns in a stable manner for all positions of the loading, each element of the platform is connected to the columns by steel members designed to deflect.

For aesthetic reasons the supporting columns for the overhead road have been designed with as slender a bulk as possible. Their cross-section measures about 8 ft by 3½ ft (2.40 by 1.10 m.) and in shape consists of a rectangle with semi-circular ends.

Lighting

Much thought appears to have been devoted to the lighting both of the elevated road and the roadway beneath. It is intended to light the underside of the viaduct in an indirect fashion by rays reflected from curved parts of the superstructure so as to provide diffused lighting free from shadows. The elevated road will be lit by luminous strips incorporated in the safety railings and these will provide a series of lateral beacons defining the carriageway boundaries.

The contractors for this unique elevated roadway were Les Entreprises De Waele-Francois and the job was completed in slightly over a year at a cost 67 million Belgian francs.

(From "Highways and Bridges and Engineering Works," October 16, 1957.)

DEFINITIONS OF HIGHWAY ENGINEERING TERMS

- FLOCCULATION RATIO:** The Void ratio of a soil when it is in the condition of a deflocculated sediment.
- FLOCCULATION LIMIT:** The water content of a soil, when it is in the condition of deflocculated sediment.

ORIGIN AND DESTINATION SURVEY OF TRAFFIC OVER SYDNEY HARBOUR BRIDGE

THE opening of the Circular Quay Overhead Roadway will have a marked effect on the flow and direction of traffic over the Sydney Harbour Bridge to and from and through the City area. So that information could be obtained in advance to assist in determining the most satisfactory arrangements for dealing with the altered movement of traffic, the Department of Main Roads and the Department of Motor Transport conducted a survey of vehicular traffic crossing the Bridge between 7-30 a. m. and 9-30 a. m. on Wednesday, 13th March, 1957.

This survey, known as an Origin and Destination Survey, was made by handing to the drivers of all vehicles except bus drivers a questionnaire card which was to be completed and returned to collectors at the Toll Barrier or returned by post. An illustration of the card is given in Fig. 1

Prior to the survey, publicity was given by press and radio, and banners were displayed on the bridge announcing that a survey would be held. Also, on the morning prior to the survey, between the hours of 7-30 a. m. and 9-30 a. m. a publicity leaflet was handed over to all drivers crossing the bridge. The leaflet explained the purpose of the survey to be held and indicated the questions that drivers would be asked.

A Wednesday was selected as the most suitable day for the survey as it is an "average" day as far as traffic flow on the bridge is concerned. Also, a mid-week day suited the arrangements for advance publicity and the method proposed for collection of the cards.

All cards were serially numbered according to the toll gate from which they were to be issued, e. g., card No. 6.402 was the 402nd card issued from toll gate No. 6. During the survey the serial number of the last card issued at the end of each fifteen-minute period was recorded so that a fifteen-minute traffic count was

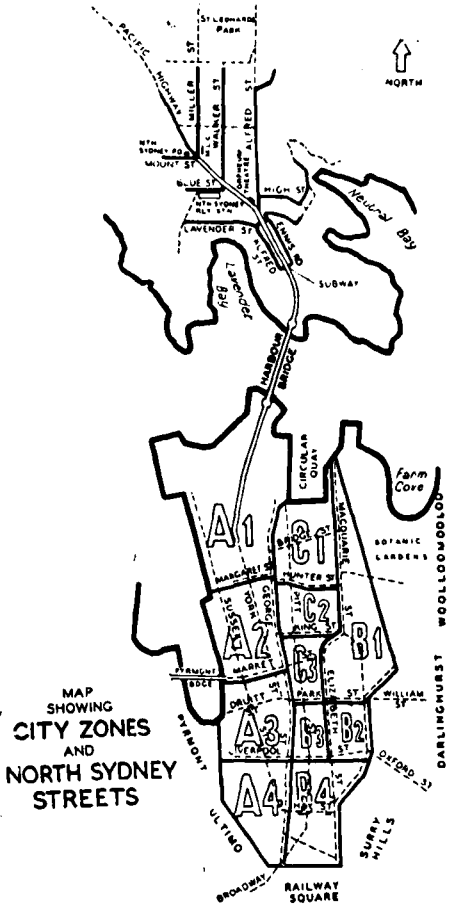
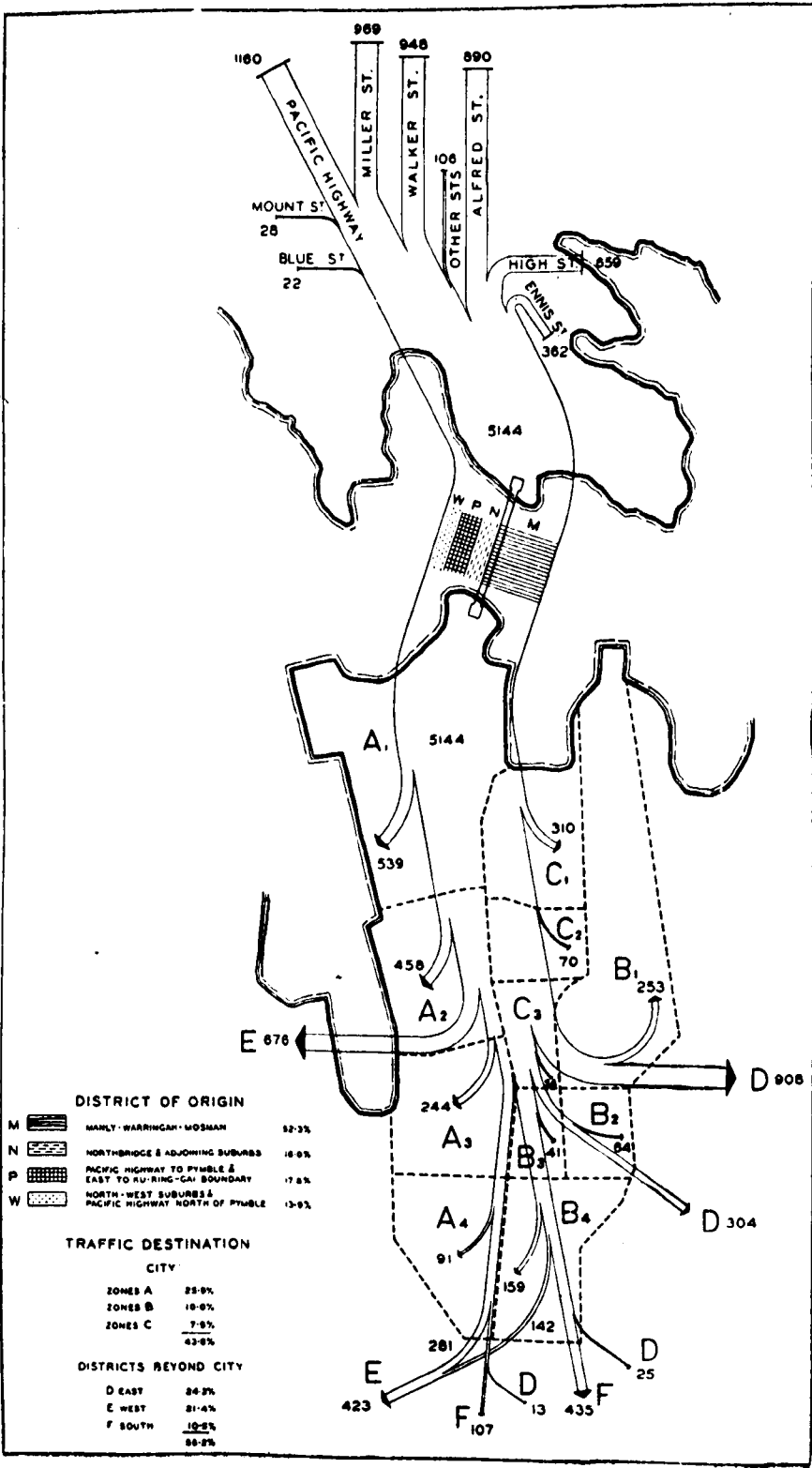


Fig. 1

conducted in conjunction with the survey. The flow of buses was recorded separately by noting their route identification number as they passed through the toll gates.

Cards were distributed for two hours from 7-30 a. m. During that period 11,729 vehicles crossed the bridge—9,394 south-bound to the City, and 2,335 north-bound, including 147 and 140 buses for south and north flow respectively. The peak hour of traffic flow for city vehicles was 7-45 a. m. to 8-45 a. m., when 5,144 vehicles were recorded. The north-bound flow during the same period was 1,147 vehicles.



The total number of cards returned was 8,650 or 75.6 per cent of those issued during the two-hour period. The return from drivers who were issued cards during the peak hour was 84.8 per cent from those south-bound and 52.8 per cent from north-bound drivers.

Considering rates of flow during fifteen-minute periods, the highest rate recorded for south-bound traffic during the peak hour was 84.8 per cent from those south-bound and 52.8 per cent from north-bound drivers.

Considering rates of flow during fifteen-minute periods, the highest rate recorded for south-bound traffic was 5,284 vehicles per hour—which applied during the period 8-0 a. m. to 8-15 a. m. This rate of flow, it may be noted, differs very little from the actual peak hour count of 5,144 vehicles. The highest rate of flow through a toll gate during a fifteen-minute period was recorded at 632 vehicles per hour through each of two gates.

The initial sorting of survey cards returned and the preparation of summary sheets were undertaken by the Department of Motor Transport. Analysis of the returns and the preparation of traffic-flow diagrams were undertaken by the Department of Main Roads. The following are extracts from the data obtained:

South-bound (city) traffic crossing the bridge in the peak hour originated in Northern Suburbs Districts as follows:

	per cent
From the Manly-Warringah-Mosman area	52
From the Cammeray-Northbridge-East Willoughby-East Lindfield area	16
From the Pacific Highway area between Victoria Cross and Pymble, and north-east of Pacific High-	

way between St. Ives and East Lindfield	18
From suburbs north of Pymble and west of Pacific Highway but north of Parramatta River	14

During the same period the city bound traffic reached the bridge approaches proper via principal streets in the North Sydney area as follows:

	Vehicles
From Pacific Highway north of Miller street	1,160
From Miller-street	969
From Walker-street	948
From Alfred-street	890
From Hihg-street	659
From Ennis-road and Mac Dou-gall-street	362
From other streets	156

(See diagram on opposite page)

After crossing the bridge 44 per cent of all peak-hour inward traffic remained within the central City area, and 59 per cent of this volume entered an area west of George street and east of Darling Harbour, Day-street and Sussex-street. Of the remaining 56 per cent of total traffic, 43 per cent travelled through the city to Eastern Suburbs, 38 per cent to Western Suburbs, and 19 per cent to Southern Suburbs. From the information secured by the survey it has been estimated that after crossing the bridge approximately one-third of the traffic south-bound to the city during the morning peak period will use the Quay Overhead Roadway when this is opened later on this year. It has also been possible to determine the amount of traffic which will be diverted from present routes of approach to the bridge to new routes in order to enter bridge lanes appropriate to points of destination across the bridge.

(From "Main Roads," September, 1957.)

"The first duty of a university is to teach wisdom not a trade; character, not technicalities."

(From "The Engineer", Aug. 30, 1957)

TESTING FOR DEFLECTION OF R.C.C. DECK SLAB OF NARMADA BRIDGE AT BROACH

(Contributed)

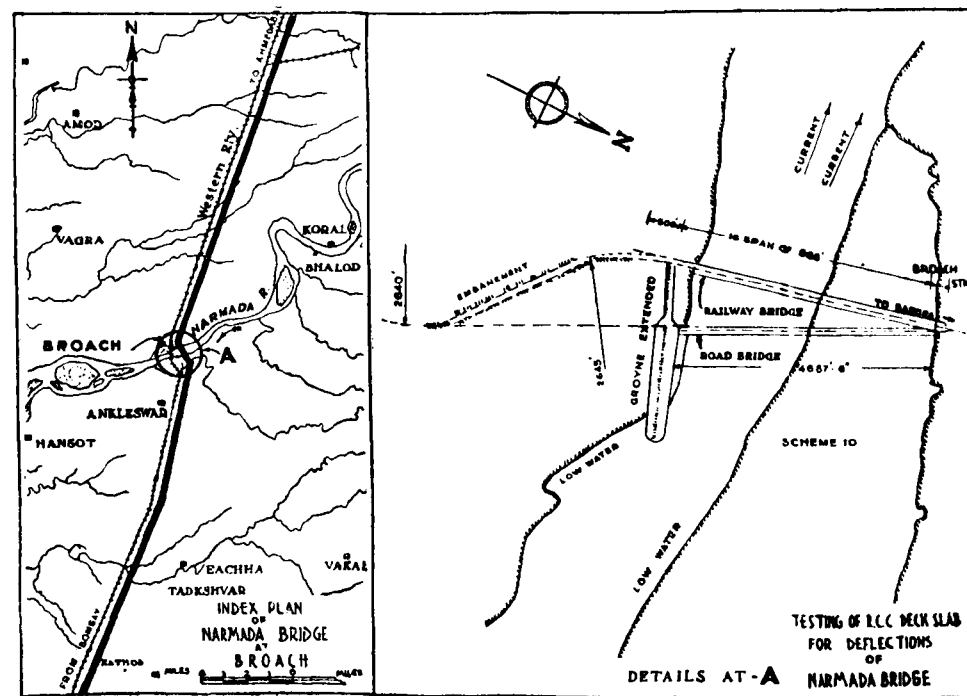
General

THE railway bridge over Narmada river at Broach, now converted into a road bridge, was originally constructed in the year 1881, for carrying a single lane of railway traffic. While constructing this bridge provision was made to accommodate another lane, if necessary. The bridge consists of 25 spans of 187 ft-6 in. centre to centre of piers (183 ft-6 in. centre to centre of bearings). The main girders are of wrought iron, with triple intersection web members. The girders are 18 ft deep and placed 17 ft centre to centre. The main trusses, cross girders, bracings etc., are of wrought iron. Subsequently, in 1935 the Railway constructed a new two-lane bridge just downstream of the old bridge. The old railway bridge of single lane traffic was taken over by the Bombay P.W.D. for using it as a road

bridge. The bridge was then converted into a road bridge with a 15 ft roadway by providing 6 in. thick R.C.C. deck slab with 1½ in. asphalt wearing coat. As the roadway is only 15 ft wide, it forms a single traffic lane and the traffic on this bridge is controlled by signals. As the bridge is very narrow it forms a serious bottleneck on an important National Highway, and hence there was a proposal for providing three relief spans having two traffic lanes for waiting places for opposite traffic. Span Nos. 6, 13, and 19 from Broach side are not provided with a concrete slab but instead with a wooden decking to facilitate the widening to two traffic lanes as relief spans.

Necessity of the Tests

The R.C.C. deck slab, 6 in. thick, is continuous over 12 spans, the supports being



the top W. I. flange ($7\frac{5}{16}$ in. wide) of the cross girders. Unfortunately, this slab has been constructed to a faulty design and no reinforcement at top has been provided in the centre of span of each slab panel. The reinforcement at top is absolutely necessary to take up the negative B. M. resulting in the slab when two adjacent panels of the slab are loaded. The differential temperature effect, the W.I. girders tending to expand much more relatively to the R.C.C. deck slab laid directly on the cross girder flanges, and the negative bending moments due to plying traffic must have accelerated the formation of cracks. Definite cracks in the R.C.C. slab panels were, therefore, anticipated. The asphalt carpet in span No. 7 from Broach side was accordingly stripped off to observe the actual location of these cracks. The location of the cracks as observed in span No. 7 is shown in Fig. 1. The following observations were made :

- (i) All the cracks were located in the sections without any top reinforcement i.e., where sectional steel was minimum.
- (ii) There were one or more cracks in each continuous bay of 12 spans of 5 ft— $2\frac{1}{2}$ in. each.
- (iii) All the cracks were through cracks since they were continuing for full depth as observed from the edges of kerbs on either side.

The R.C.C. decking was, therefore, considered unsafe for vehicular traffic, and all traffic on this bridge was stopped at one time. The National Highway No. 8 being the main arterial road running along the coast North of Bombay with ever increasing traffic, this abrupt stoppage of traffic was a very extreme measure resulting in a major bottleneck to the traffic. It was, therefore, decided to watch the behaviour of R.C.C. decking under a load test so as to determine if the bridge could be opened safely at least for light vehicular traffic.

Span No. 7 from Broach side was selected for the test. This span has R.C.C. slab in 3 units of continuous spans. The first unit consists of 11 continuous spans,

the second 13 continuous spans, and the last unit again of 11 continuous spans each of 5 ft— $2\frac{1}{2}$ in. centre to centre as shown in Fig. 2.

Arrangement for Testing

Platform

The observation platform was an independent scaffolding from the ground for the full width of about 18 feet of the decking and about 90 ft in length covering the whole area of the slab under observation. The centering consisted of large diameter bamboo posts with closely spaced bamboos to form the top platform.

Dial Gauges

Deflections in the deck slab under test load were measured by means of dial gauges which read to a least count upto 0.0001 in. The general arrangement of fixing these gauges is shown in Fig. 3.

Test Load

The test load was applied by means of a loaded truck. In this way the load was spread throughout but moving from place to place on the bridge, and observations for deflection were made for each load position. The loaded truck was made to traverse the centre line of the roadway with the rear axle stopping successively on pre-marked equally spaced divisions on the bridge decking, and deflection readings were observed and recorded for the corresponding truck positions.

Slab Panels tested. In the first unit there are eleven continuous spans each of 5 ft— $2\frac{1}{2}$ in. centre to centre of wrought iron cross girders and as the test load moved from one end of the unit to the other its effect could be observed, if so desired, simultaneously in all the spans of the unit for any particular position of the test load ; however such observations in all the panels for any one set of test were not necessary as the effect would be prominent only in the panel below the test load, gradually diminishing in further panels, the effect becoming very negligible in panels beyond 4th panel from load position, e.g., the deflection in slab panel No. 5 or 6 when test load was in slab panel No. 1 or 2 would be negligible. Also, as only a limited number of dial gauges were avail-

able at the time of the test, it was decided to observe deflection in only 4 consecutive slab panels in each set of test. Three slabs lengths were tested as under: (please refer to Fig. 2.)

1st Test:—This was done in the slab length between cross girders 4 to 8 of the first unit of eleven continuous spans. In this length, as will be seen from Fig. 2, panels between cross-girders Nos. 5 and 6, 6 and 7 are cracked while between cross-girders Nos. 4 and 5, 7 and 8 are uncracked. In the cracked panels 5-6, and 6-7, two dial gauges one on either side of the crack were put in order to record the correct differential deflection between the two abutting vertical faces in the crack. In the uncracked panels, the dial gauges were fixed symmetrically below centre line of the panels. D_1, D_2 etc...refer to the position of dial gauges.

2nd Test:—In this test the slab length between cross girders 7 to 11 was tested. In this slab length there were no visible cracks in the deck slab, A_1, A_2 etc., refer to the position of dial gauges.

3rd Test:—In this test the slab length between cross girders 9 to 13 of unit No. 2 was tested. In this test, slab panel between cross-girders 10-11, and 11-12 were cracked, while between 9-10 and 12-13 was uncracked. M_1, M_2 etc...refer to dial gauges positions.

Deflection Readings

The loaded truck of known weight was moved slowly from one end of the continuous unit under test to the other end. The rear axle was stopped at predetermined places on the deck slab and deflection readings were recorded simultaneously on the dial gauges.

A graph showing deflections observed for dial gauge in position A_3 for various positions of moving truck load is given in Fig. 4. This is a typical graph drawn for one of the dial gauges in the second slab panel tested between cross girders 7 to 11. On the same graph is interposed another set of curves which shows deflections anticipated at A_3 in the panel between the cross girders 7 to 11 assuming it

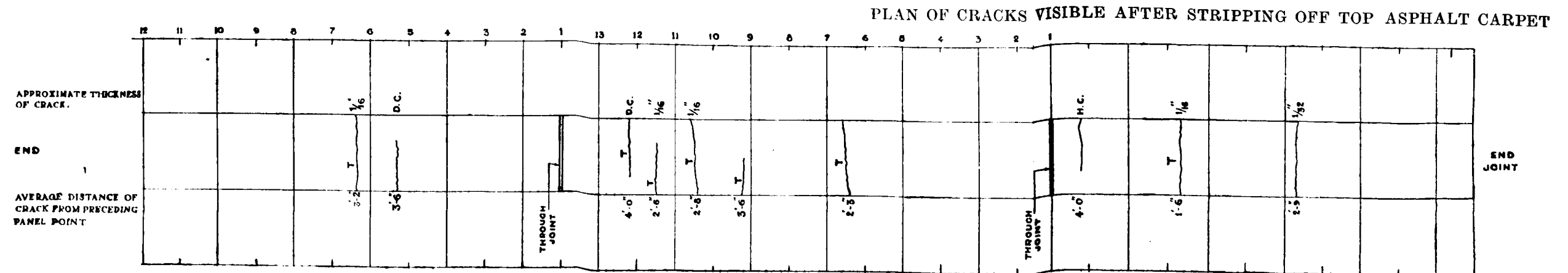
to be continuous on 4 spans and simply supported on cross girders Nos. 7 and 11. The value of E assumed is $E = 3 \times 10^6$ lb per sq. in. Fig. 5 shows a similar graph for dial gauge in position D_3 .

Observations—The following observations were made from the deflection readings obtained:

- The deflections of cracked panels were about 80 per cent more than the deflection of uncracked panels.
- There was no appreciable relative deflection between two abutting faces of the crack i.e., almost full shears were transmitted.
- Nearly full B.M. was transmitted as could be seen from upward deflection of panels on the other side of cracked panels as compared to those of bay without any crack.
- Cracks did not widen out (as measured with 0.002 inch least count) as their plaster patch did not crack under load nor did filler gauges show any widening out.
- Cracked panels did not return to zero deflection.
- Uncracked panels generally returned to zero deflection.

Conclusions

Near failure conditions will arise when the cracks will lose substantial capacity to transmit shear and bending moments. At present, transmission of shear is nearly 100 per cent and transmission of bending moments is also nearly perfect. The load actually coming on the axle was about 8 tons as against $1\frac{1}{2}$ tons now proposed for the light traffic to ply on the bridge. The bridge structure has been observed to vibrate quite heavily even with the passage of a bullock cart, and it is therefore necessary as a measure of precaution, to permit only light traffic over this bridge with a speed restriction of 10 M.P.H. even though the slab has been tested for a higher axle load.



R.C.C. SLAB WITH 11 CONTINUOUS SPAN R.C.C. SLAB WITH 13 CONTINUOUS SPAN R.C.C. SLAB WITH 11 CONTINUOUS SPAN

Fig. 1

ABBREVIATIONS:

T— THROUGH CRACKS
D. C.— DISTANCE CRACKS 1/32 in. APPROX.
H. C.— HAIR CRACKS
DISTANCE BETWEEN TWO ADJACENT CROSS GIRDERS IS 5 ft-2 1/2 in. C. TO C.

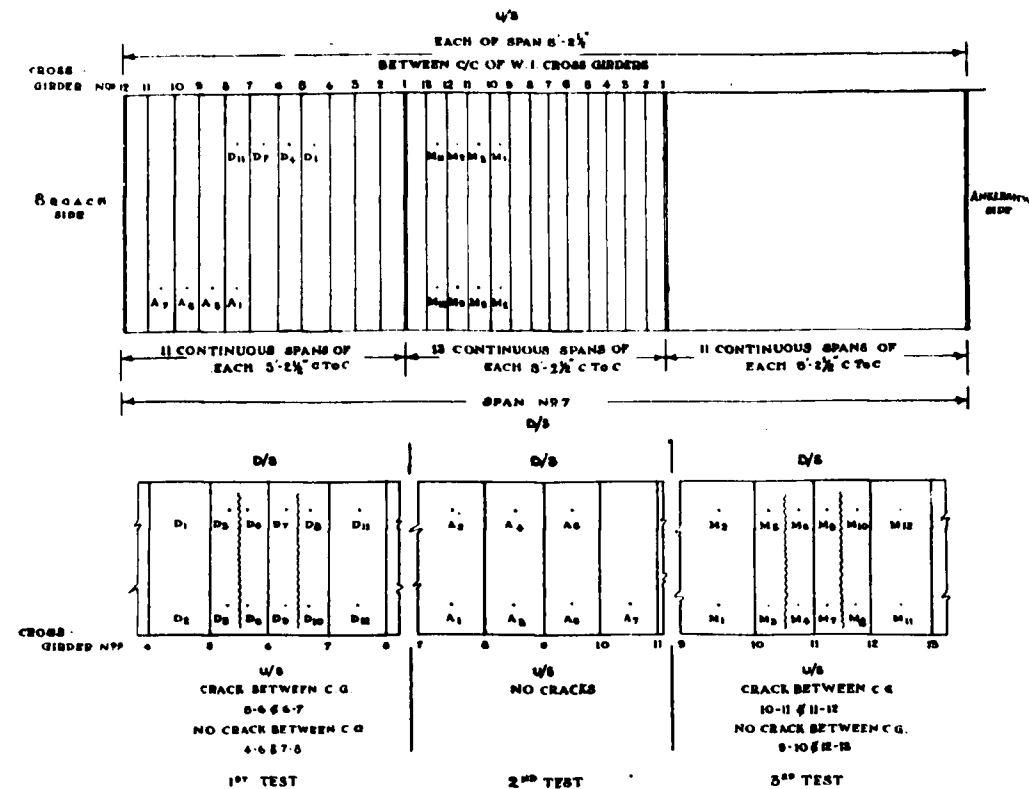


Fig. 2

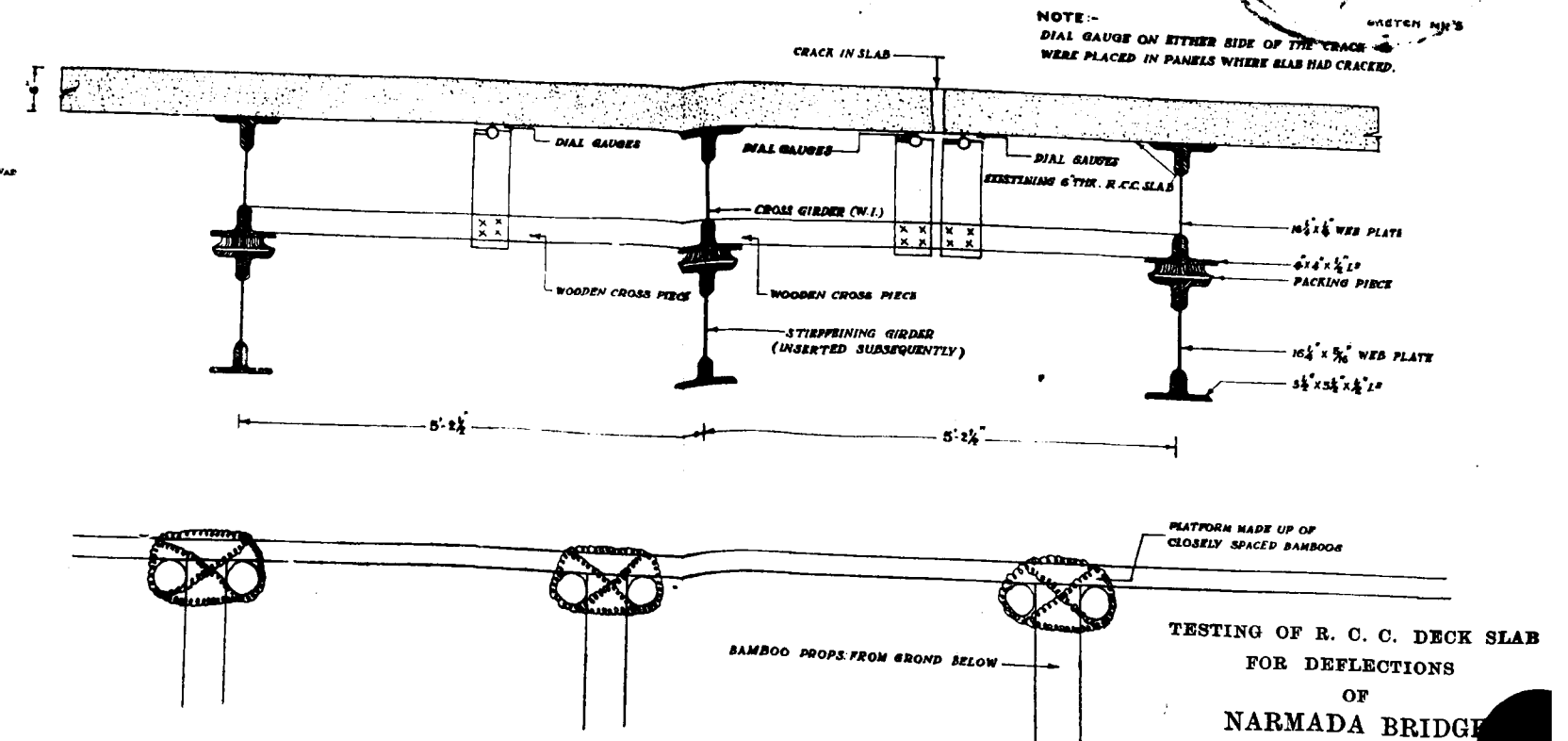


Fig. 3

GRAVEL BASE ROADS IN NORTHERN RHODESIA

Design, Construction and Maintenance

By

G. RAWLINGS PAPE, B.ENG., M.I.C.E., M.I.H.E., M.I.W.E.

IT is only in degree that the problems facing the highway engineer in Northern Rhodesia differ from those of his confreres in other parts of the world, and the successful technique of designing and constructing roads using gravel instead of pitched, broken stone bases has been built up in this territory through exchange of knowledge and by experience and the rigid application of the scientific method.

There are several systems in general use for classifying road subgrade and base materials, and the U. S. Public Roads Administration (1945) System has been adopted by the Public Works Department, Northern Rhodesia. This classification (Table 1) is based on sieve analysis of percentages passing the No. 10, No. 40 and No. 200 sieves and on the liquid limit and plasticity index of the fraction passing the No. 40 sieve.

The roads of Northern Rhodesia which have been improved to the standard of two-lane bituminous surfaced highways are designated Class I, and this classification includes roads which, while of two-lane width, have a central bituminous surface only 10 ft wide. The present policy is not to construct any more 10-ft wide bituminous surfaces because they are dangerous and expensive to maintain and subsequently to widen. The initial cost of the 10-ft strip is over 60 per cent of a 20-ft wide surface, the rate of depreciation is greater, and the cost of widening high; with rapidly increasing traffic counts they are not an economic proposition. Future improvements of roads from gravel to bitumen standard will provide 20-ft carriageway width when traffic is estimated to reach 50 vehicles per hour, increasing to 22 ft for 200 vehicles per hour, and 24 ft for higher concentrations.

When planning the improvement of roads to gravel standard, designated

Class II, horizontal and vertical adjustments are made to bring the road on to its final alignment so that subsequent improvement to Class I can be achieved by adding nothing more than the gravel base course and bitumen surfacing. The major earthworks are, therefore, constructed at this stage and a gravel sub-base laid. The geometric standards for major roads, recently revised and now under discussion by the Federal Roads Advisory Committee, are based on design speeds of 60 to 70 m.p.h. in open country reducing to 30 to 40 m.p.h. in hilly country. They provide a minimum formation width of 32 ft within a reservation which is recommended to be not less than 180 ft wide to allow for future development of dual carriageways, service roads, cycle tracks and intersections.

Horizontally, minimum radii reduce from 1,637 ft (3 deg. - 30 min.) for a 70 m.p.h. design speed to 239 ft (24 deg.) for a design speed of 30 m.p.h. Maximum gradients of 1 in 15 are aimed at except in difficult terrain where 1 in 10 has been accepted for short distances. Vertical summit curves range between 15,600 ft radius for 60 m.p.h. and 2,800 ft radius for 30 m.p.h., while sag curves of from 4,000 ft to 1750 ft minimum radii will be provided for similar design speeds. Non-passing sight distances of 200 ft at 30 m.p.h. to 600 ft at 60 m.p.h. and passing sight distances of 600 ft at 30 m.p.h. to 2,300 ft at 60 m.p.h. are proposed. The geometric standards now to be adopted for branch roads and minor district roads, not necessarily on their final alignment, is a formation width of 24 ft to 26 ft wide and a single lane carriageway of 12 ft with the minimum requirement of grades and curves suitably reduced.

The C.B.R. design method is applied in conjunction with the Atterberg indices and based on 90 to 92 per cent of the

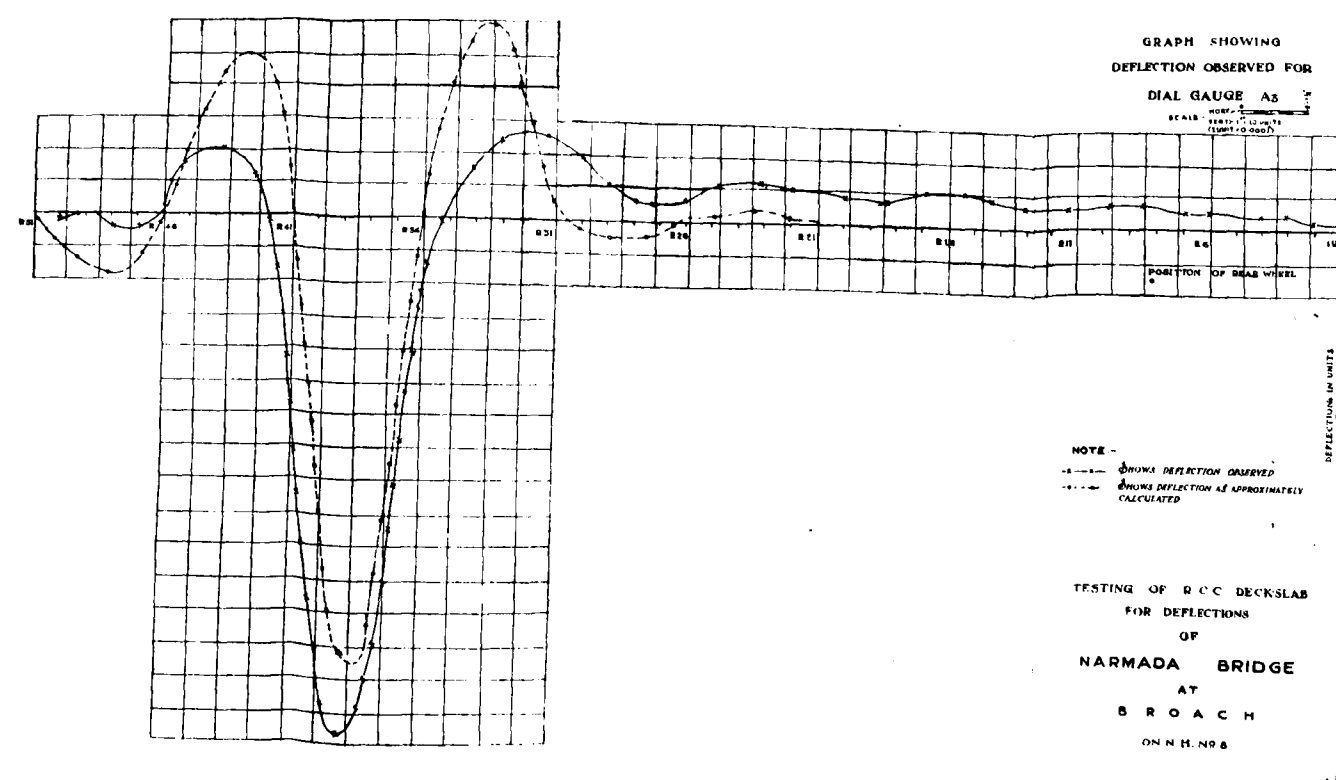


Fig. 4

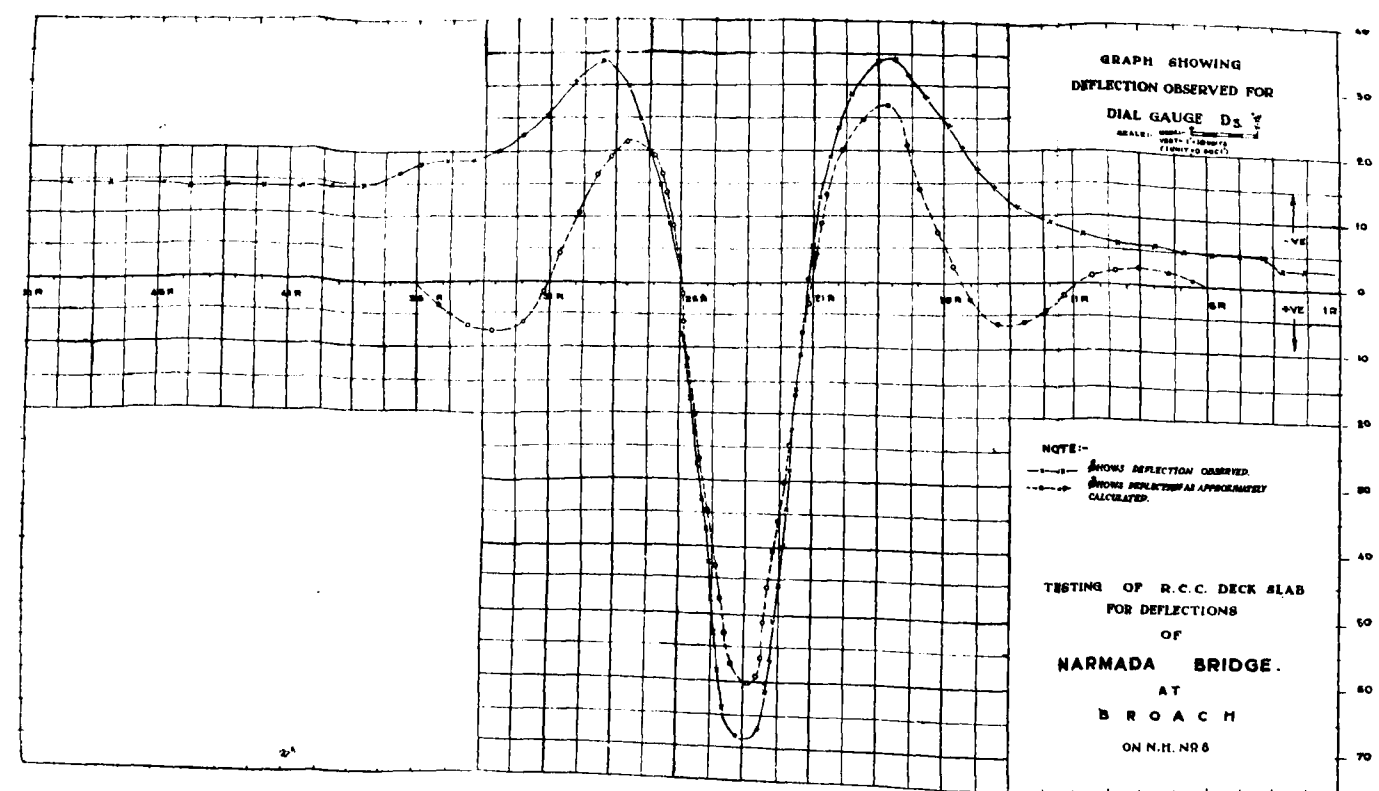


Fig. 5

WIDENING OLD NARROW BRIDGES

By

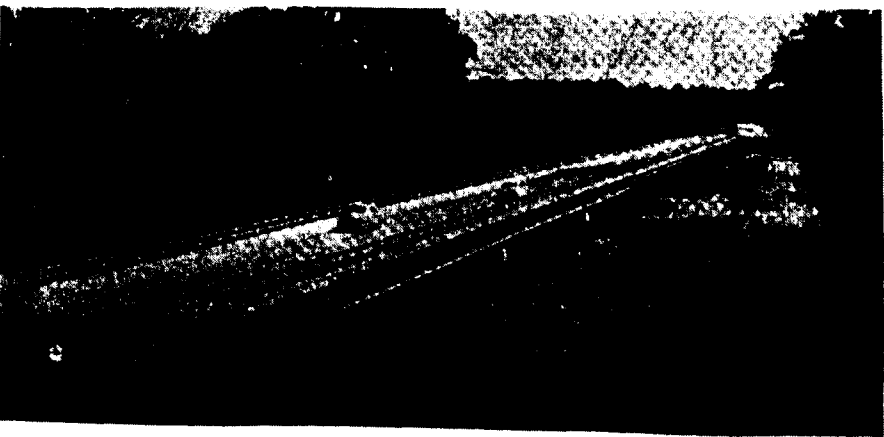
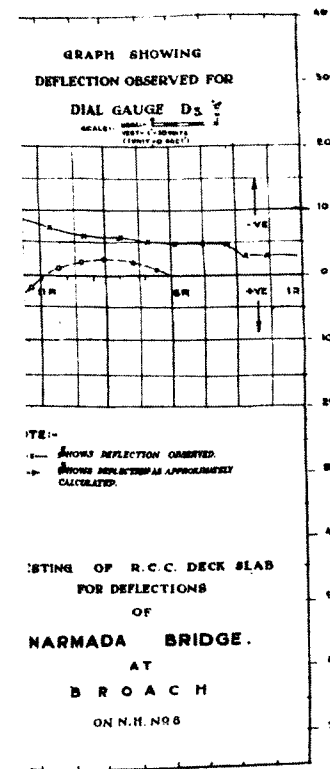
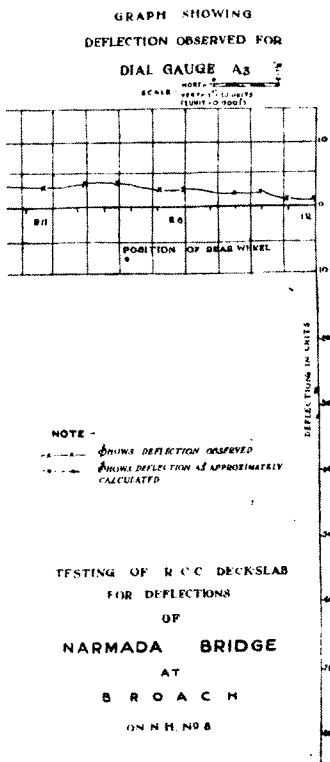
R. R. BARTELSMEYER

Chief Highway Engineer of Illinois, Springfield

A comprehensive programme of bridge widening is in progress in Illinois, as an important step in increasing the safety and traffic capacity of the state highway system.

widths were increased from 9 to 10 ft and then 11 ft and now 12 ft, these old bridges became dangerous bottlenecks in the travelled way. Widening of the pavements necessitated widening of the structures. Many of the old structures are deteriorated to such an extent that rehabilitation would be uneconomical. But a considerable number are found to be sound in both substructure and superstructure, especially in the conventional type of reinforced concrete slabs and reinforced concrete deck girders.

Practically all of the bridges which were constructed in the 1920's under the two State Bond Issue Acts were built with roadways which ranged in width from 20 to 24 ft between side rails. A 6-in. curb on each side cut another foot from the roadway. As pavement lane



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Table 1
Classification of Highway subgrade Materials (U.S. Highway Engineers)

General classification	Granular material (35 per cent or less passing No. 200 sieve*)						Silt-clay materials (more than 35 per cent passing No. 200 sieve*)				
Group classification	A-1		A-3	A-2				A-4	A-5	A-6	A-7 A-7-5 A-7-6
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7				
Sieve analysis, per- centage passing:											
No. 10 sieve* ...	50 max.		51 min.								
No. 40 sieve* ...	30 max.	50 max.	10 max.	35 max.	35 max.	35 max.	35 max.	36 min.	36 min.	36 min.	36 min.
No. 200 sieve* ...	15 max.	25 max.									
Characteristics of fraction passing:											
No. 40 sieve* ...											
Liquid Limit (per cent) ...			No	40 max.	41 min.	40 max.	41 min.	40 max.	41 min.	40 max.	41 min.
Plasticity index (per cent) ...			plasti- city	10 max.	10 max.	11 min.	11 min.	10 max.	10 max.	11 min.	11 min.
Group index <i>b</i> ...	6 max.			0			4 max.	8 max.	12 max.	16 max.	20 max.
Usual types of sig- nificant constitu- ent materials ...	0		0								
	Stone fragments gravel and sand		Fine sand	Silty or clayey gravel and sand				Silty soils		Clayey soils	
General rating as subgrade ...	Excellent to good						Fair to poor				

Classification procedure: With required test data available, proceed from left to right on above chart and correct group will be found by process of elimination. The first group from the left into which the test data will fit is the correct classification.

a Plasticity index of A-7-5 sub-group is equal to or less than liquid limit minus 30. Plasticity index of A-7-6 sub-group is greater than liquid limit minus 30.

b The formula for the group index is as follows: (1)

Group index = 0.2a + 0.005a.c. + 0.01b.d. (1)
where a = that portion of percentage of sub-grade soil passing No. 200 sieve* greater than 35 and not exceeding 75, expressed as a positive whole number (0 to 40).

b = that portion of percentage of sub-grade soil passing No. 200 sieve* greater than 15 and not exceeding 55, expressed as a positive whole number (0 to 40).

c = that portion of the numerical liquid limit greater than 40 and not exceeding 60 per cent expressed as a positive whole number (0 to 20).

d = that portion of the numerical plasticity index greater than 10 and not exceeding 30 per cent expressed as a positive whole number (0 to 20).

Group index should be shown in parentheses after group symbol as:
A-2-6(3), A-4(5), A-6(12),
A-7-5(17) etc.

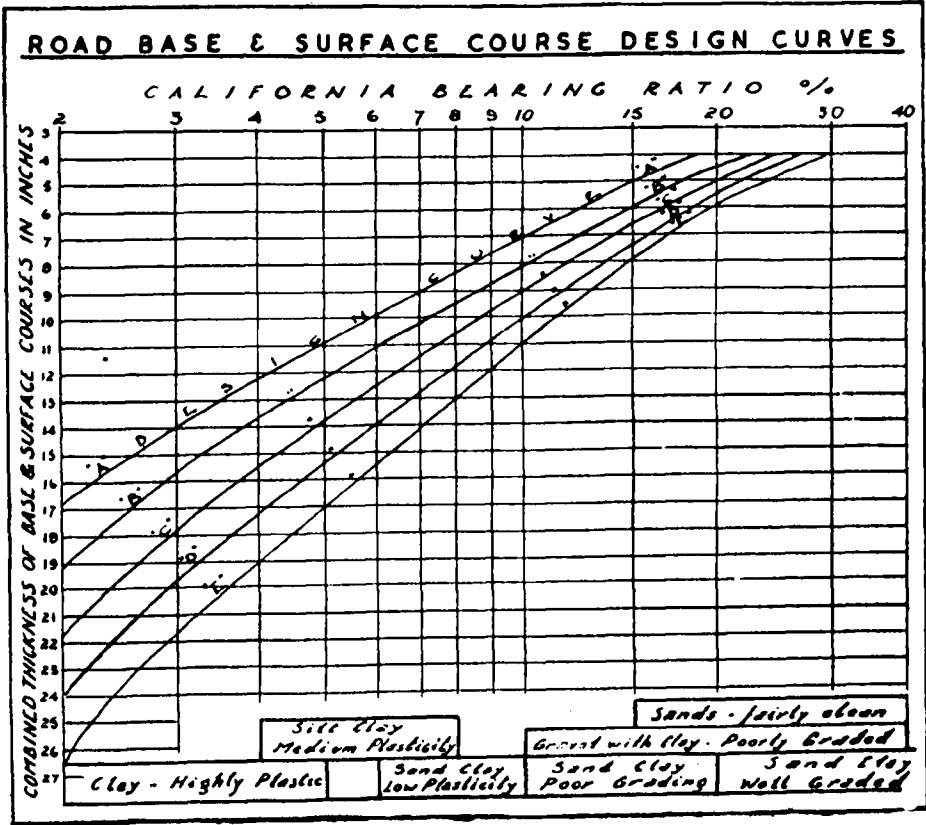
*Sieve sizes are American, approximate British equivalents are as follows:

United States A.S.T.M. E.11/26	Great Britain B.S. 410
10	8
40	36
200	200

C.B.R. obtained at modified A.A.S.H.O. compaction. The design curves used are a combination of the Wyoming method and the Porter curves prepared by the department's consulting engineers (see diagram). Curves C and D correspond approximately to the Porter curves for 7,000 lb and 9,000 lb wheel loads and are

normally used, but curve E, which matches the Porter 12,000 lb wheel load is taken in special cases where the intensity of traffic is likely to be very high.

The standards demanded for sub-base and base course materials are shown in Table 2 and, where suitable gravels for



DETAILS FOR DETERMINING DESIGN CURVE TO BE USED		
MOISTURE CONDITIONS:		ASSIGNED VALUE
Arid or High Table Land not subject to standing water		2
Ground subject to occasional standing water during storms		4
" " saturation but No Frost		7
" " rainfall greater than 50 in. per annum		10
TRAFFIC CONDITIONS:		
Traffic of	0 to 50 vehicles per day	0
" "	51 to 100 "	1
" "	101 to 200 "	2
" "	201 to 300 "	3
" "	301 to 400 "	4
" "	401 to 700 "	5
" "	701 to 1000 "	6
" "	1001 to 1500 "	8
" "	over 1500 "	10
SUM OF ASSIGNED VALUES		DESIGN CURVE TO BE USED
From 0 to 8		Curve A
" 9 to 13		" B
" 14 to 18		" C
" 19 to 24		" D

Table 2
Standards for Imported Gravels and Soils

Test	Base Gravel A	Base Gravel B	Sub-base Gravel	Running Coarse Gravel	Sub-base Soil	Fill Material
Grading	Per cent passing	Per cent passing	Per cent passing	Grading similar to sub-base		Cover thick-ness deter-mined on in-place C.B.R. and soil con-constants
Sieve No. 1 in. to 1½ in. ...	100	100	100			
½ in. ...	70-100	70-100	70-100			
¾ in. ...	50-80	50-100	50-100			
3/16 in. ...	35-65	35-85	35-85			
7 ...	25-50	25-70	25-70		100	
36 ...	15-30	15-45	15-45		35-70	
52 ...	13-27	13-41	13-41		30-60	
100 ...	9-22	9-34	9-34		20-40	
200 ...	5-15	5-25	5-25		10-25	
Maximum P.I. ...	8	6	17	10-17	8	
Minimum moulding C.B.R. ...	80	80	50	Not applicable	50	
Minimum C.B.R. in place. ...	50	50	20	Not applicable	20	

Gravel requirements for the stabilisation :
Grading similar to B.
Maximum P.I. depends on per cent passing 200 mesh.
Minimum Moulding C.B.R. before stabilisation 50.
" " " after " 180.
Maximum P.I. after stabilisation 6.

base courses cannot be found within 4 to 5 miles of the site, local gravels are stabilised by the addition of lime. The great increase in strength attained through the pozzolana effect of the lime on most soils and gravels found in Northern Rhodesia has led to extensive use of this method of stabilisation, and over 180 miles of main roads have already been constructed with such base courses. As a measure of the increase of strength which is achieved, it is usual to require that a moulded C.B.R. of 50 shall be increased by lime stabilisation to at least 180.

The types of soils and gravels usually found near at hand for road construction in Northern Rhodesia are A2-4, which can usually be made stable in base courses by mechanical compaction alone, and A2-6 which requires lime stabilisation in addition to mechanical compaction. (See Table 1.) A1-b type gravels are also found and can be used successfully without lime stabilisation in most cases. The A1-b, A2-4, A2-6 and related soils are usually the decomposition products of granites, limestones, quartzites, dolomites, sandstones and basalts; there are also some extensive laterite deposits. It is

fortunate that the distribution of such soils is so widely spread over the territory, but their absence in the Kalahari sand areas of Barotseland and parts of the Southern Province has posed a difficult problem in building satisfactory low-cost roads in these provinces, and research on this is in hand. Two other types of soils present difficulty in subgrade design. The first is the highly plastic clay found in low-lying swampy dambos, types A6 and occasionally, A7, and the second type of difficult soil is in group A4 which, when non-plastic, shows deceptive stability until encountered under poor drainage conditions.

Construction has, in all except a few cases, involved major realignments and improvement of line and grade up to the accepted geometrical standards and has been fully mechanised. Subgrades, sub-bases and base courses are all compacted to controlled field densities by means of sheepfoot, pneumatic-tyred and steel-tyred rollers, selected according to the type of soil encountered. After the material has been brought to within 1 per cent of the modified A.A.S.H.O. optimum moisture content using water sprinklers,

disc harrows and ploughs, the section is shaped by heavy construction graders to correct cross-section and compacted by sheepfoot rollers towed by pneumatic-tyred tractors. The road base is then again shaped by grader to correct cross-section, grade line and again compacted by pneumatic-tyred and steel-tyred rollers until a smooth and uniform surface is obtained ready for the prime coat of tar.

When the gravel found within economic hauling distance is of the soil type A2-6, with a liquid limit of more than 35 and plasticity index of more than about 11, stabilisation of the base course by the addition of from 3 to 4 per cent hydrated lime is employed. Measured quantities of the lime are set out along the road, spread uniformly over the surface of the base course material, and intimately mixed with it at correct moisture content by disc harrows and mouldboard ploughs. In this way, the plasticity index of the base course is reduced to less than 8 and the moulded C.B.R. at Modified A.A.S. H.O. compaction is increased to at least 180 on specimens left three days to cure and then soaked for four days in water under a 10-lb weight.

Crude tar or tar prime from Wankie Collieries is used for priming the base course and is applied at temperatures of 180 deg. F. for crude tar or 120 deg. F. for prime at a rate of 0.16 to 0.20 galls. per sq. yd. The prime is allowed to dry over several days and if necessary traffic can be run over it for long periods before surfacing begins. On the majority of Class I roads a double bitumen seal specification has been used, normally a 80/100 penetration bitumen binder applied at the rate of 0.18 gallon per sq. yd. in the first seal and 0.23 to 0.25 galls. per sq. yd. in the final seal; occasionally bitumen emulsion and M.C. 5 cutback bitumen are substituted in cold weather. The road stones usually available in Northern Rhodesia are limestone, quartz, dolomite and occasionally granite. A Treton value not greater than 35 with a crushing value of not more than 20 is aimed at. A coarse textured finish is favoured with $\frac{3}{4}$ in. + $\frac{1}{2}$ in. stone at 60 to 70 sq. yd. per cu. yd. dressing the first seal coat and $\frac{1}{2}$ in. + $\frac{1}{4}$ in. stone at 105 to 110 sq. yd. per cu. yd. covering the final seal coat.

In the other direction of finding a higher but not too costly surfacing specification for traffic intensities of over 450 vehicles per hour (3,000 vehicles a day) the 'Cape Seal' has been introduced. The specification for this method of applying a pre-mixed stone chip surface is briefly to complete the prime coat and first seal coat as in the double seal specification, and then to apply the second seal coat at the reduced rate of 0.16 gallon per sq. yd. (in place of 0.23 - 0.25 gallon per sq. yd.) and follow it with a final dressing of pre-mixed chippings spread at the rate of 164 sq. yd. per cu. yd. The pre-mix material is prepared in a paddle mixer using a 6 to 6½ per cent by weight 180/200 penetration bitumen cutback with 1¼ to 1½ per cent by weight diesel oil and one part- $\frac{1}{4}$ in. + $\frac{1}{8}$ in. stone chips to two parts stone crusher dust to make up the 100 per cent.

Gravel is lost from the road surface under the action of traffic at a rate which has been assessed as high as 1 in. in thickness each year. The gravel sub-base courses have been laid from 4 in. to 8 in. thick and, therefore, a re-gravelling programme will soon be necessary on gravel roads built in 1953, and account of this is being taken in framing future maintenance programmes.

Pneumatic tyred tractors with side cutting mowing equipment are being introduced as a further stage in mechanical maintenance with the aim of substantially reducing the size of the African labour force employed. Also, as roads are raised to Class II and Class I standards, side drains will be formed of shallow-saucer cross-section so that they can be cleared and graded mechanically with the same object in view.

Minor defects and wear in bituminous surfaces are remedied by patching, but re-sealing eventually becomes necessary and is an essential maintenance operation to preserve and renew the surfaces of Class I roads. At intervals of from five to seven years, depending on traffic intensities, a seal coat must be sprayed with a blinding of stone chippings. So far it has not been necessary to institute any large programme of this kind in

(Continued on page 36)

HERE AND THERE

1. PRECAST ARCH BRIDGES IN SPAIN

● In the fifteenth volume of the Memoirs of the International Association for Bridge and Structural Engineering, Sr. C. Fernandez Casado describes the methods now being used by the Spanish Ministry of Public Works for the construction of bridges using precast arches. Precast construction is used because of the reduction in the scaffolding, which is particularly important in the case of a bridge over a deep valley; other advantages include a reduction of the time the bed of a river need be obstructed by staging, quicker construction, and smaller foundations because of the reduction in dead weight of the superstructure due to the higher quality of the concrete and consequently the smaller sizes of members.

The first bridge (photo) built in this manner is over a canal at the Cubillas dam in Granada. This is a three-pinned arch with solid spandrels and a road slab acting compositely to resist the longitudinal stresses. The spandrels are continued on to the embankments to form walls retaining the filling. The bridge has a span of about 150 ft. Precast arches and transverse beams form the first part of the structure on which the spandrels were cast, and this construction was used to support centering for the slab. The arches were cast in halves and erected by means of a mast and temporarily supported on a central timber tower. On the same site an aqueduct with eight spans of 66 ft was built in a similar manner.



Photo 1.—Bridge at Cubillas, Spain, with Span of 150 ft

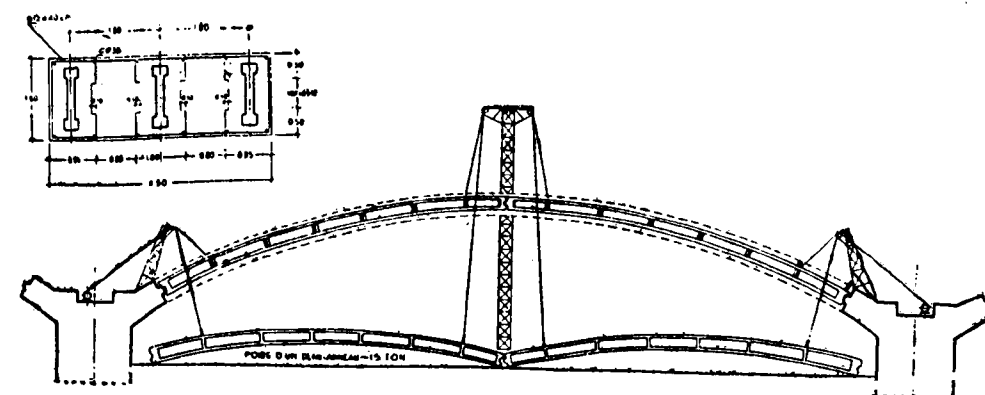


Fig. 1. Erection of Bridge at Merida

4. PRESTRESSED SUSPENSION BRIDGES

● ACCORDING to Daniel C. Vandepitte, of the University of Ghent (Belgium), the concept of the suspension bridge with unreinforced concrete stiffening beams that are prestressed by the main cables is derived in an entirely natural way from the conventional prestressed concrete bridge or from the self-anchored suspension bridge. The longest spans existing in prestressed concrete are about 375 ft long, and these involve girders that are very deep at the supports. Designers often have to increase depth of beams beyond the value which live-load moments require to provide enough eccentricity for the prestressing cable. The prestressed concrete suspension bridge concept abandons the requirement that the cable be placed in the girder concrete. In this application

the prestressing element is almost entirely outside the concrete except at and near the end bearing anchorages.

As compared with ordinary steel suspension bridges, the prestressed concrete suspension bridge has the drawback of requiring false work, heavier cables and towers and larger pier foundations. However, it has the advantages of having a cheaper deck, of needing no costly anchorages, of requiring very little maintenance, and of possessing much more rigidity; and provided the spans are not too long, the prestressed concrete suspension bridge costs less than its steel counterpart.

(From "Engineering News-Record"—August 8, 1957.)

5. CATTLE TAKE OVER FROM MACHINES

● NEARLY 1000 head of cattle are being used in the Fadhli area of the Western Aden Protectorate, on the Arabian Sea, to construct an emergency deflector dam urgently needed to irrigate fields in the Jol area. The age-old method had to be adopted when, owing to heavy and repea-

ted floods, machines were unable to put up the deflector. The cattle pull rudimentary slip scrapers to pile up earth into an embankment that will be the dam.

(From "Engineering News-Record"—August 9, 1957.)

6. TURKEY ROAD PROGRAMME REQUIRES 134 MILLION DOLLARS

● TURKEY will spend (U.S.) 134 million dollars for national highways in 1957, twelve times the amount of the 1948 budget when the United States inaugurated its aid to the road programme.

Since 1948, according to the International Road Federation, United States assistance has amounted to 40.3 million dollars. In the same period, Turkish expenditures for national highways have amounted to 420 million dollars, including construction, maintenance and administration.

The highway network now aggregates 24,550 kilometres. All-weather roads in Turkey have increased to 19,000 kilo-

metres, of which 5,350 kilometres are new roads built to modern standards in the past nine years. Of these, 3,380 kilometres are bituminous-surfaced or paved. A total of 21,700 kilometres is maintained.

At the beginning of the programme in 1948, all-weather main roads totalled 9,093 kilometres, of which only 930 kilometres had bituminous or other high-type surface. Civilian motor cars, trucks, and buses on the roads in 1956 numbered 71,247, compared with 18,597 in 1948.

(From "World Construction," June, 1957.)

CURRENT LITERATURE

ABSTRACTS

PERFORMANCE OF BITUMINOUS SURFACING—Bulletin 154 of the Highway Research Board, Washington, D.C.

THIS bulletin contains two papers presented at the 35th Annual meeting of the Highway Research Board, January 17-20, 1956.

The paper "Field and Laboratory Investigations on Hot Mix Asphalt Concrete" was prepared by John W. Shupe and Delos C. Taylor of the Department of Applied Mechanics, Kansas State College. This report presents a comparison of experimental road test sections of asphaltic concrete for three years of service. This investigation is a part of a co-operative study of the State Highway Commission of Kansas and the Applied Mechanics Department of Kansas State College.

The paper "Service Record Study of Bituminous Concrete and Sand Asphalt Pavements in North Carolina," was presented by A. Duke Morgan of the North Carolina State Highway and Public Works Commission. It is the second performance report on observations of several test sections of high-type bituminous concrete.

URBAN ARTERIAL PLANNING—Bulletin No. 153 of the Highway Research Board, Washington, D. C.

THE three papers of this bulletin were presented at the 1956 Annual meeting of the HRB as part of a session on urban traffic planning problems and methods.

The first, on "Directional Analysis of Vehicle Travel Desire," uses the Detroit Metropolitan Area traffic study as a basis for describing trip desire chart construction and applications.

The second, entitled "Directional Contour Maps of Travel Desire," uses the Dallas Country (Tex.) origin-destination survey of 1950-51 to project travel desire data to 1980 and depict it graphically. Directional maps of both the contour and block types, and their applications to specific uses, are described.

The third paper describes the "Comprehensive Arterial Highway Plan for the Cleveland Metropolitan Area," from both the analysis and planning approaches.

SECTOR ANALYSIS FOR CONCRETE PAVEMENT LOAD STRESSES Bengt F. Friberg,—(Proc. Paper 1153). Journal of the Highway Division, Proceedings of the American Society of Civil Engineers.

THIS paper is an outline of Sector Analysis, an approximation method of elastic analysis for slabs subjected to tire-imprint loads and resting on yielding subgrades. The method is used for a wide range of loaded-area dimensions, and for slabs of limited dimensions, such as highway and airport pavements.

The principles and procedures are described, and Sector Analysis is applied to stress and deflection determination in slabs of conventional highway dimensions subjected to single-wheel loadings for which comparative test observations are available. Stresses computed by Sector Analysis are in line with test observations. Application to common highway axle loadings is illustrated and compared with test road observations.

Sector Analysis is shown to provide a simple and sufficiently accurate design tool for the complex load and stress conditions of limited-dimension pavement slabs.

REPORT ON INVESTIGATION OF SCOUR AT BRIDGES CAUSED BY FLOODS OF 1955—Lyle K. Moulton and Craig Belcher, Connecticut State Highway Department and Bernard E. Butler, Tippetts, Abbott, McCarthy and Stratton. Presented at the 36th Annual meeting, Jan. 7-11-57, Washington, D.C.

FOLLOWING the August 1955 flood, three teams of foundations engineers were dispatched to study scour at the 75 state-owned or state-maintained bridges that were damaged or destroyed. They made careful measurements of maximum and average depths of scour and obtained other data relative to maximum high water, mode of failure, debris, and channel characteristics. The results of these studies and the factors influencing the various modes of failure are presented and discussed.

At many of the bridges studied the foundations were unharmed and the failures were only in the pier or abutment walls of superstructures. At other bridges where failure was caused by scour, that scour was greatly increased by "secondary scour" which occurred after collapse of the structure, so the original scour picture is not clear. However, at 18 bridges the original scour could be measured accurately and the maximum height of water was known; data from these 18 bridges was carefully analysed and a formula was found that would fit these data. This formula relates the average depth of scour

to the difference between the sediment load in the approach flow and the transport capacity under the bridge. Examples of the application of the scour formula are included.

SUMMARY—De L'institut Technique, Du Batiment Et Des Travaux Publics, Revue Mensuelle, Juillet Aout 1957, Nos. 115-116.

THE old metallic Voulte viaduct, destroyed in 1944, has been replaced by 5 identical spans of 200 ft between the centre lines of piers. Each span consists of prestressed concrete portal frames 185 ft long between hinges, with a rise of 33 ft. The 18 ft wide bridge deck is of three cell tubular section. 26 ft independent girders supported on legs ensure the continuity of the bridge deck on piers and abutments.

The process of construction from one side to the other side of the river included essentially:

The preliminary and symmetrical construction of the legs of a pile;

The carrying out of the crossing units by successive cantilevered voussoirs built up symmetrically with regard to the centre line of a span, by means of semi-sliding forms supported by foot-bridges suspended to a Bailey Bridge.

A method of prestressing by means of bundles of wires tensioned by helical deviation has been imagined and specially developed for this viaduct.

O and M.

"My husband can't find a thing. He promised to make me an early morning cup of tea, and then he couldn't find the tea. And all the time it was there in an empty cocoa tin marked matches."

SELECTED RECENT LITERATURE IN ENGINEERING JOURNALS

X. BRIDGES AND OTHER STRUCTURES

1. **Friction losses in Prestressing under Site Conditions**; B. K. CHATERJEE, *Civil Engineering*, Vol. 51, No. 601, July 1956, pp. 765-767.
2. **Design of the Floor of a Regulator on medium soil**; K. M. AGGARWAL, *Civil Engineering*, Vol. 51, No. 601, July 1956, p. 768.
3. **The Use of Wire Models to solve the Continuous Vierendeel Girder**; G. HONDROS and D. A. KRICKBY, *Civil Engineering*, Vol. 52, No. 607, January 1957, pp. 51-54, Part I.
4. **A Practical Method of Analysing Structures Using Large Models**; KIM FUNG TSE, *Civil Engineering*, Vol. 51, No. 606, December 1956, (Part I), Vol. 52, No. 607, January 1957, pp. 67-70, Part II.
5. **Long-Span Prestressed Concrete Bridges — Structures Built by Freyssinet System**; M. GUYON'S PAPER, *The Surveyor*, Vol. CXVI, No. 3381, February 8, 1957, pp. 130-132.
6. **Recent Prestressed Concrete Construction in Belgium**; Prof. D. VANDEPITTE, *Roads & Road Construction*, Vol. 35, No. 410, February 1957, pp. 49-52.
7. **A Twin Tube Tunnel under Baltimore Harbour**; *Roads & Road Construction*, Vol. 35, No. 410, February 1957, pp. 47-48.
8. **Prestressed Concrete Bridge Across the River Sone at Chopan**; B. S. MATHUR, *The Indian Concrete Journal*, Vol. 31, No. 2, February 1957, pp. 41-47.
9. **Kaljani Bridge at Alipur Duar, West Bengal**; *The Indian Concrete Journal*, Vol. 31, No. 2, February 1957, pp. 54-55 and 64.
10. **The Aerodynamic Stability of Suspension Bridges under Wind Loading**; DR. A. HIRAI and DR. A. HOYDEN, *Der Bauingenieur*, Vol. 31, No. 11, November 1956, pp. 402-408 (In German).
11. **The Theoretical and Photoelastic Investigation of a Tunnel Tube that is Loaded in its Longitudinal Direction by Sinking Disturbed Zones**; GERHARD SONTAG, *Der Bauingenieur*, Vol. 31, No. 11, November 1956, pp. 408-412 (In German).
12. **Precast Prestressed Beam Bridges**; DR. HERMANN BAY, *Der Bauingenieur*, Vol. 31, No. 11, November 1956, pp. 412-420 (In German).
13. **A New Design Method for Articulated Honeycomb Works, Represented for example by Vierendeel Trusses**; HUBART BECK, *Der Bauingenieur*, Vol. 31, No. 12, December 1956, pp. 436-443 (In German).
14. **Contribution to the Design of Prestressed Concrete Construction**; DR. KONRAD SATTLER, *Der Bauingenieur*, Vol. 31, No. 12, December 1956, pp. 444-457 (In German).
15. **A Light Metal Road Bridge**; H. HAMPEL, *Der Bauingenieur*, Vol. 33, No. 1, January 1957, pp. 17-22 (In German).
16. **The Walt Whitman Suspension Bridge in Philadelphia**; K. H. SEEGBERS, *Der Bauingenieur*, Vol. 32, No. 1, January 1957, pp. 22-24 (In German).
17. **The Poisson's Ratio for Concretes and its Measurement**; A. GHLEMUTZ, *Der Bauingenieur*, Vol. 32, No. 1, January 1957, pp. 28-30 (In German).
18. **A Consideration of the Stress analysis of Ring Structures**; R. C. COATES, *Civil Engineering and Public Works Review*, Vol. 50, No. 594, December 1955, pp. 1359-1361.

19. **Stress Distribution in Bisymmetrical Girders under Combined Bending and Torsion**; J. S. TERRINGLIN, *Civil Engineering and Public Works Review*, Vol. 50, No. 594, December 1955, pp. 1365-1367.
20. **The Analysis of Frames with Non-Prismatic Members—The Column-Analogy Method**; E. S. E. LYLE, *Concrete and Constructional Engineering*, Vol. LI, No. 12, December 1956, pp. 563-566.
21. **Design Based on Loads Causing Failure**; *Concrete and Constructional Engineering*, Vol. LI, No. 12, December 1956, pp. 575-581.
22. **Analysis of Bow String Arches**; F.H. TURNER, *Concrete and Constructional Engineering*, Vol. LII, No. 2, February 1957, pp. 61-72.
23. **Vaults Curved in Two Directions**; S. SIVASWAMI, *Concrete & Constructional Engineering*, Vol. LII, No. 2, February 1957, pp. 83-89.
24. **Edge-Beams of Slabs Spanning in Two Directions**; *Concrete and Constructional Engineering*, Vol. LII, No. 2, February 1957, p. 92.
25. **Strength of a Concrete Slab Prestressed in Two Directions**; SCONDELIS, K. S. PISTER and T. Y. LIN, *Journal of the American Concrete Institute*, Vol. 28, No. 3, September 1956, pp. 241-256.
26. **Theory of Stresses Induced in Reinforced Concrete by Applied Two-Dimensional Stress**; BRUCE H. FALCONER, *Journal of the American Concrete Institute*, Vol. 28, No. 3, September 1956, pp. 287-293.
27. **Analysis of Inelastic Bending Stress in Concrete Beams**; JAMES M. PRENTIS, *Journal of the American Concrete Institute*, Vol. 28, No. 3, September 1956, pp. 309-317.
28. **Ultimate Flexural Analysis Based on Stress-Strain Curves of Cylinders**; G. M. SMITH and L. E. YOUNG, *Journal of the American Concrete Institute*, Vol. 28, No. 6, December, 1956, pp. 597-609.
29. **Truss Analysis by Stiffness Considerations**; HAROLD C. MARTIN, *Proceedings of the American Society of Civil Engineers*, Vol. 82, October 1956, Paper No. 1070, E. M. 4, pp. 1-20.
30. **Minimum-Weight Design of a Portal Frame**; WILLIAM PRAGER, *Proceedings of the American Society of Civil Engineers*, Vol. 82, October 1952, Paper No. 1073, pp. 1-10.
31. **Forth of Firth Road Crossing**; *The Engineer*, Vol. 203, No. 5273, February 15, 1957, pp. 257-259.
32. **Diagram for Design of Reinforced Concrete for Modulus Ratio, $n=10$** ; DR. MAX HERZOG, *Schweizerische Bauzeitung*, Vol. 75, No. 7, February 16, 1957, pp. 93-95 (In German).
33. **The Anchorage in Tunnel Construction Replaced with Leitherto Common Built-in place Method**; L. V. RABEEWICZ, *Schweizerische Bauzeitung*, Vol. 75, No. 9, March 2, 1957, pp. 123-131 (In German).
34. **Strain Gauge Measurement of Steel Stress in P. C. Constructions**; G. MITTELMANN, *Civil Engineering*, Vol. 53, No. 608, February 1957, pp. 167-170.
35. **The Use of Wire Models to Solve the Continuous Vierendeel Girder**; G. HINDROS & D. A. KIRBY, *Civil Engineering*, Vol. 52, No. 608, February 1957, pp. 171-172, Part II.
36. **A Note on the Suspension Bridge Theory**; R. HEILIG, *Des Stahlbau*, Vol. 26, No. 2, February 1957, pp. 50-52. (In German)
37. **Calculation of Thrust in Two Hinged Portals with Variable Moments**; W. WRIGHT, *Civil Engineering*, Vol. 51, No. 603, September 1956, pp. 988-990.
38. **A Photoelastic Investigation of Prestressed Concrete Anchorages**; S. P. CHRISTODOULIDES, *Civil Engineering*, Vol. 51, No. 603, September 1956, pp. 994-997.

RECENT ADDITIONS TO THE LIBRARY OF THE INDIAN ROADS CONGRESS

1. **Traffic Problems, with Particular Relation to South Wales**; Christopher T. Brunner, Institution of Highway Engineers, 55, Romney Street, Westminster, S. W. 1.
2. **Reconnaissance for Uranium-Bearing Carbonaceous Rocks in California and Adjacent Parts of Oregon and Nevada**, Geological Survey Circular No. 313, (1954); George W. Moore & James G. Stephens, Geological Survey U. S. Department of Interior, Washington, 25 D.C.
3. **Publications Fourteenth Volume 1954 (International Association for Bridge and Structural Engineering)** Verlag Leemann, Zurich, (Switzerland).
4. **Further Papers on the Wisconsin Loess of South-Western Iowa**; Engineering Report No. 22, (1953-54), D.T. Davidson and Associates, Iowa State College, Ames, Iowa, U.S.A.
5. **Deleterious Constituents of Indiana Gravels**; HRB Bulletin No. 94 (1954), Publication No. 342, Highway Research Board, 2101, Constitution Avenue, Washington, 25, D.C.
6. **Some Problems involved in Destructive and Non-Destructive Testing of Concrete—Symposium on Mix Design and Quality Control Concrete**, London 20, 11-13 May 1954; R. Jones and P.J.F. Wright, Cement and Concrete Association, 52, Grosvenor Gardens, London, S.W. 1.
7. **Concrete Curing Methods—Two (Reprints from Proceedings of the Thirty-Third Annual Meeting of Highway Research Board, January 1954)**; Reprint No. 11, December 1954, Phillip L. Melville, Virginia Council of Highway Investigation and Research, Charlottesville Virginia, U.S.A.
8. **The Technical Report—(Its Preparation, Processing and Use in Industry and Government)**, 1954; Edited by B.H. Weil, Reinhold Publishing Corporation, New York, U.S.A.
9. **Construction of Concrete Roads** (1946); Cement and Concrete Association, 52, Grosvenor Gardens, London, S.W. 1.
10. **Mechanical Analysis of Soils Engineering, Report No. 21 (1954-55)**; D.T. Davidson and Associates, Iowa State College, Ames, Iowa, U.S.A.
11. **Highway-User Taxation**; Highway Research Board Bulletin No. 92 (1954), Highway Research Board, 2101, Constitution Avenue, Washington, 25, D.C.
12. **Soil Density and Stability**; Highway Research Board Bulletin No. 93 (1954), Highway Research Board 2101, Constitution Avenue, Washington, 25, D.C.
13. **Synthetic Methods for Interruption Tests on Circuit Breakers**; H. Bertil Thoren No. 87, (1955), Transactions, Royal Institute of Technology Stockholm, Sweden.
14. **"Statistical Methods in Concrete Research"** (Reprint from Magazine of Concrete Research 1954, Vol. 5, No. 15, March, pp. 139-149), P. J. F. Wright, Cement and Concrete Association, 52, Grosvenor Gardens, London, S.W. 1.
15. **Annual Report (Technical) 1950**; Volume I, Publication No. 50, Edited by S. L. Malhotra, Central Board of Irrigation and Power, New Delhi.

BUDGETS AND ADMINISTRATION REPORTS

ORISSA STATE BUDGET 1957-58

The following extracts relating to civil works have been taken from Orissa State budget for the year 1957-58.

Heads	Actuals 1955-56	Revised Estimate 1956-57	Budget Estimate 1957-58
(In lakhs of rupees)			
Revenue			
Rents	6.80	6.06	8.06
Ferry Receipts	0.20	0.15	0.15
Tolls on roads	0.72	0.60	0.71
Recoveries of expenditure	*3.11	1.84	3.47
Transfer from Central Road Development Accounts	7.67	13.44	13.13
Grants from Government of India for the Development of State Roads of Economic or Inter-State Importance.	3.75	11.61	28.66
Miscellaneous	5.70	2.53	5.53
Khondmals Road Fund			
(1) Plough Tax	0.01	0.07	0.07
(2) Miscellaneous Receipts	0.07	0.02	0.03
Deduct—Refunds	-0.70	-0.15	-0.05
Total	27.33	36.17	59.76
Expenditure			
Original Works	26.84	30.87	99.32
Repairs	100.01	103.81	107.42
Grants-in-aid	0.06	0.09	0.09
Suspense	91.27	73.00	70.00
Lump addition for regrant of lapses	...	...	2.50
Lump deduction for probable savings	...	-2.50	-4.61
Development Schemes	3.66	0.82	...
Recoveries for reduction of expenditure	-119.40	-61.00	-70.00
Establishment, Tools & Plant	38.12	46.02	65.51
	140.56	191.11	270.23

*Includes Electrical also.

Heads	Actuals 1955-56	Revised Estimate 1956-57	Budget Estimate 1957-58
(In lakhs of rupees)			
Capital Account of Civil Works outside the Revenue Account			
Buildings	45.47	74.27	88.65
Communications	76.60	109.20	83.00
Establishment and tools and Plant Charges	...	19.06	19.83
Expenditure in connection with New Capital			
Construction Work	48.70	51.31	46.35
Establishment	1.89	1.39	1.55
Tools & Plant	...	1.55	1.00
Suspense-Debits	55.04	26.24	13.25
Total	227.70	283.02	253.63

Revenue from Roads

Receipts under the Indian Motor Vehicles Acts	15.79	2.93	3.02
Receipts under the State Motor Vehicles Taxation Act	24.65	40.00	54.68
Taxes on Sale of Motor Spirit and lubricants	28.35	...	30.00
Refunds	-0.24	-0.22	-0.21
Total	67.55	42.71	87.49

ORISSA STATE BUDGET FOR 1957-58

(A brief review with reference to Civil Works)

THE total revenue of the State is estimated at Rs 2189.48 lakhs for the year 1957-58 as against Rs 1878.61 (revised estimate) for 1956-57 and Rs 1611.37 lakhs (actual) for 1955-56. The corresponding expenditure figures are Rs 2507.03 lakhs for 1957-58 (Budget Estimate) and Rs 2532.50 lakhs for 1956-57 (Revised Estimate) and Rs 2319.50 lakhs for 1955-56 (Actual).

1957-58 while the revised estimates for 1956-57 and actuals for 1955-56 amounts to Rs 191.11 lakhs and Rs 140.56 lakhs respectively. In terms of total State Revenue the expenditure amounts to 12.3 per cent in 1957-58, 10.2 per cent in 1956-57 and 8.7 per cent in 1955-56.

The revenue expenditure on civil works outside the revenue accounts was estimated at Rs 253.63 lakhs for the year 1957-58 while the revised provision for the previous year amounted to Rs 283.02 lakhs.

The revenue expenditure on civil works is estimated to be Rs 270.23 lakhs for

LIST OF APPROVED WORKS ON NATIONAL HIGHWAYS

S. No.	Job No.	Name of Work	Amount Rs lakhs
BIHAR			
1.	1800 BR 31	Construction of north approach road to Mokameh bridge up to north high bank of the river on N. H. No. 31 and clay topping over the horizontal surface of sand embankment	28.91
JAMMU AND KASHMIR			
2.	1799 JK 1-A	Flood damages to Tawi bridge at Jammu.	3.00 Pending scruting
3.		Two Works each costing less than 2 lakhs.	2.33
ORISSA			
4.	T.A. No. 97 RS 6	Construction of 3 minor bridges over Ana Haldibabal and Thilmil Nallaha on N. H. No. 6 between Gourpalli and Badarma ghat at 34/1, 37/6 and 39/1 miles respectively.	1.34

(Continued from page 24)

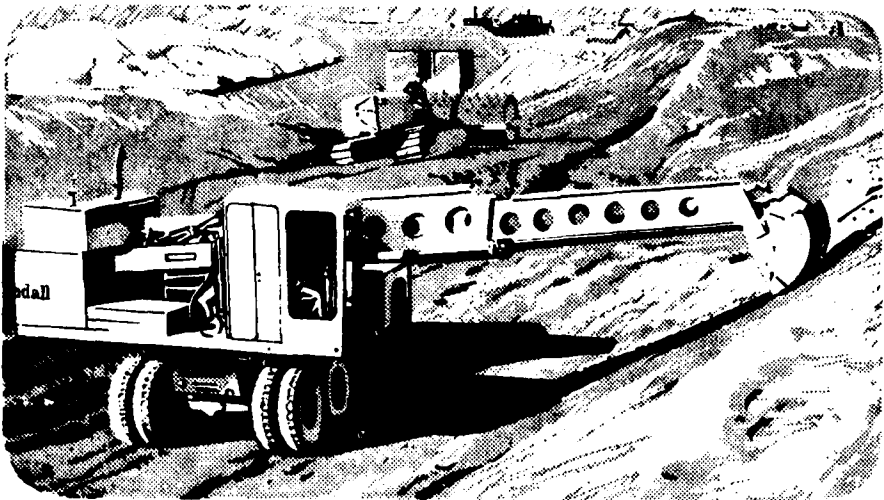
Northern Rhodesia, but the time is not far distant when the annual re-sealing programme will rise to as much as perhaps 80 miles. Experimental work using both hot bitumen and bituminous emulsion has been undertaken by departmental teams and also in one instance by contract.

The present average cost, including depreciation of plant and administrative overheads, of maintaining Class I and

Class II roads in the territory is a little less than 150 pounds per mile per annum, but this does not make any allowance for re-gravelling or re-sealing. It is estimated that when the full impact of re-gravelling and re-sealing programmes have to be met the cost may rise to 250 pounds per mile per annum for Class I roads and to not much less for Class II roads.

(Adap'ed from "The Surveyor" - May 4, 1957.)

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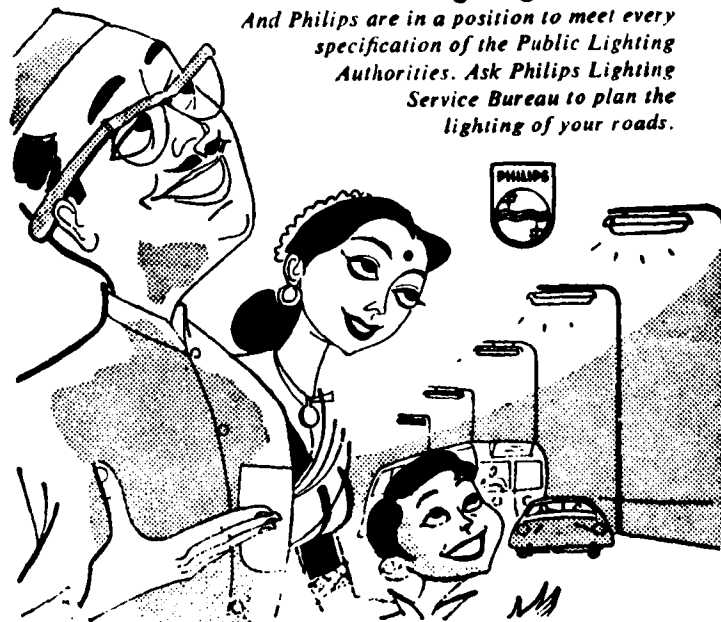
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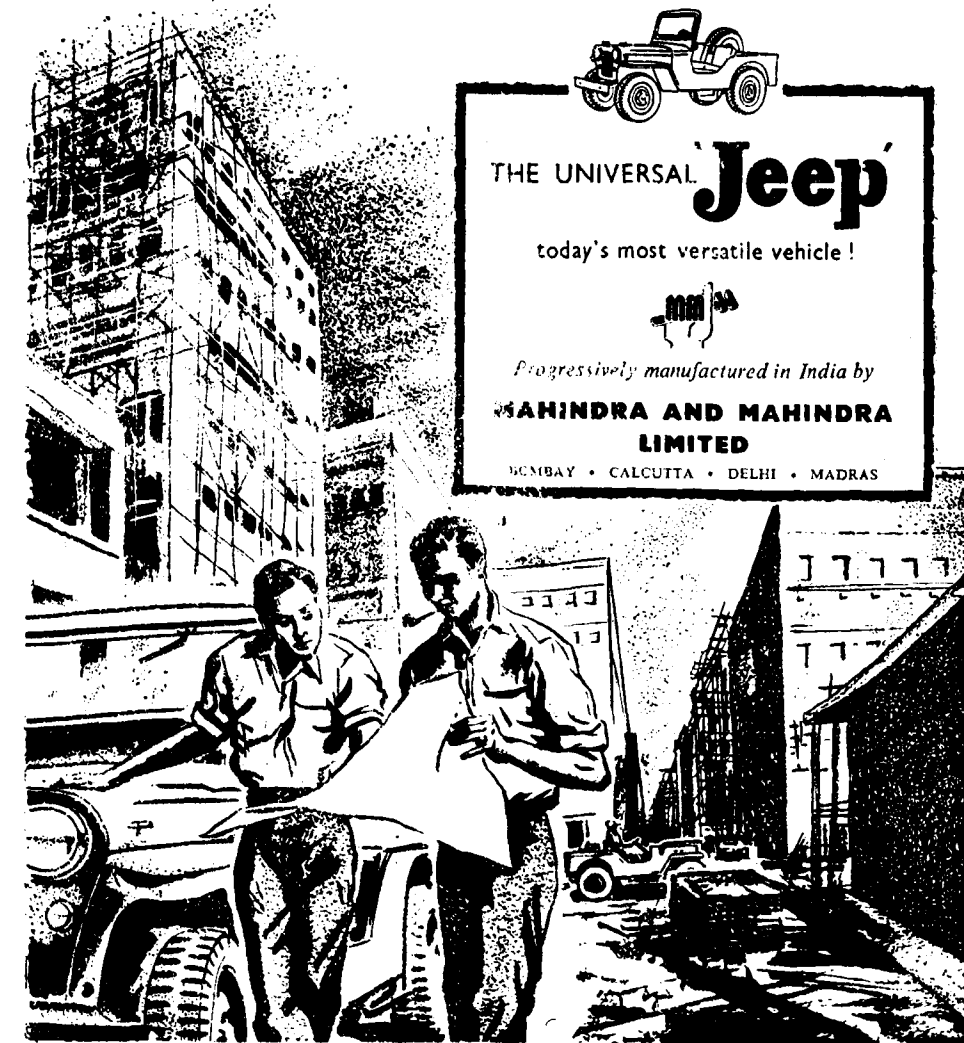
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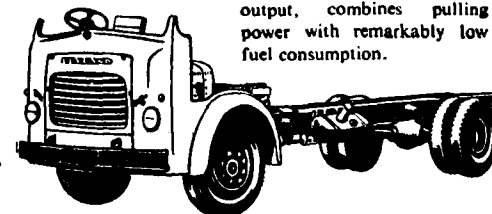


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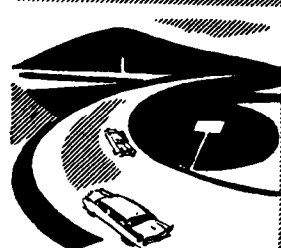
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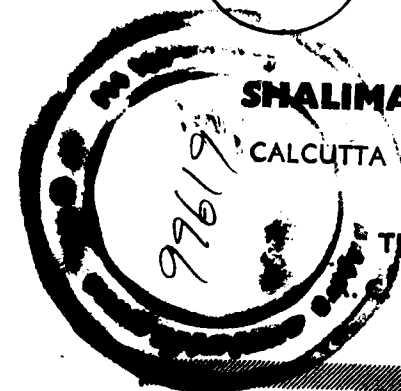
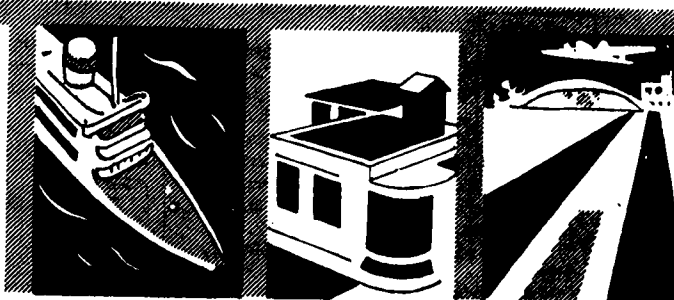
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