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TRANSPORT-COMMUNICATIONS

MONTHLY REVIEW

OCTOBER 1958—No. 138

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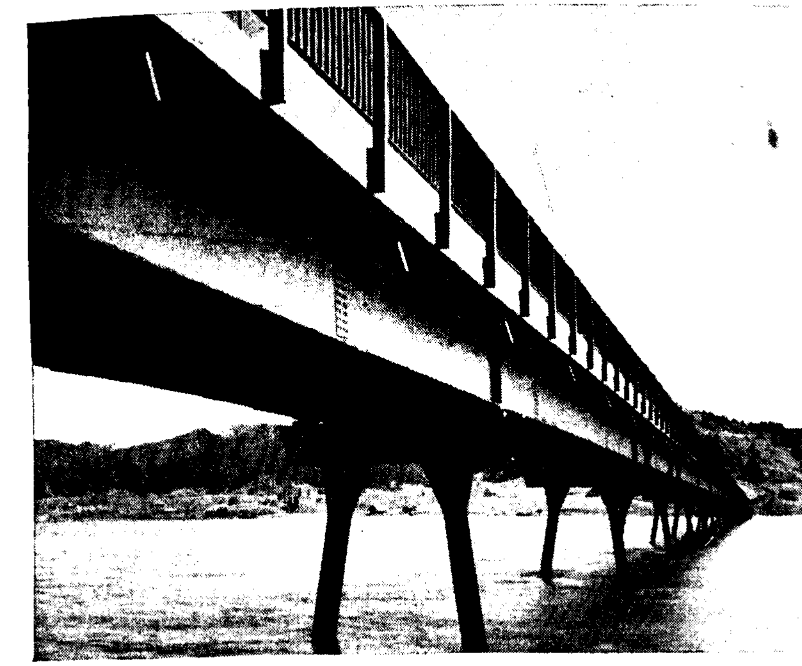

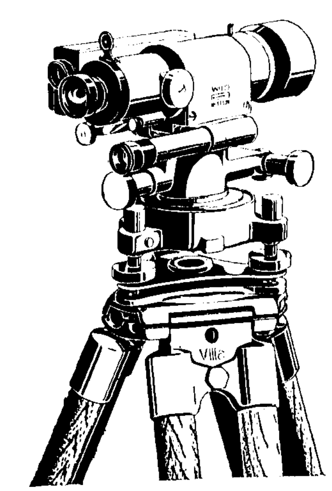

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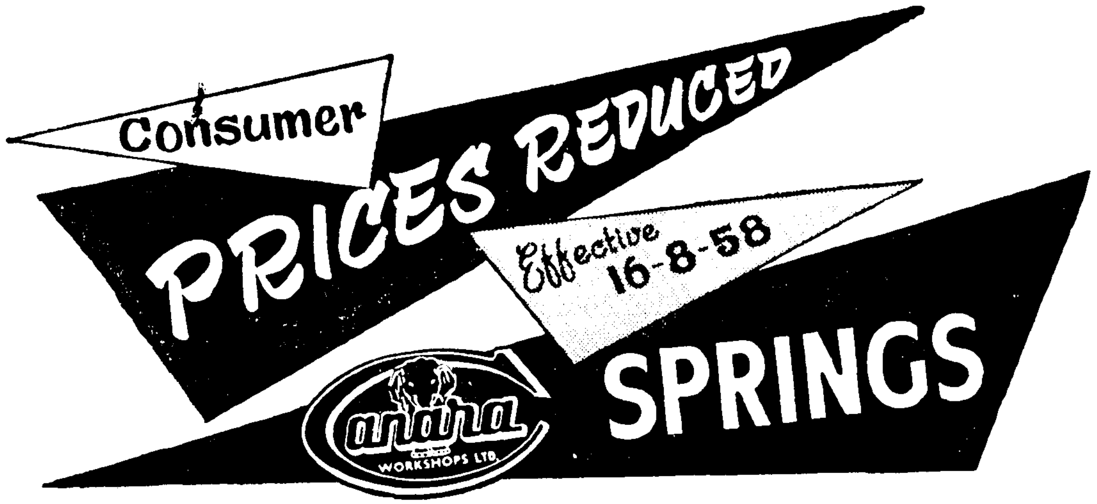

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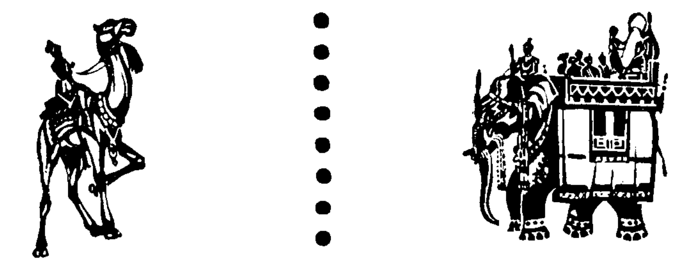

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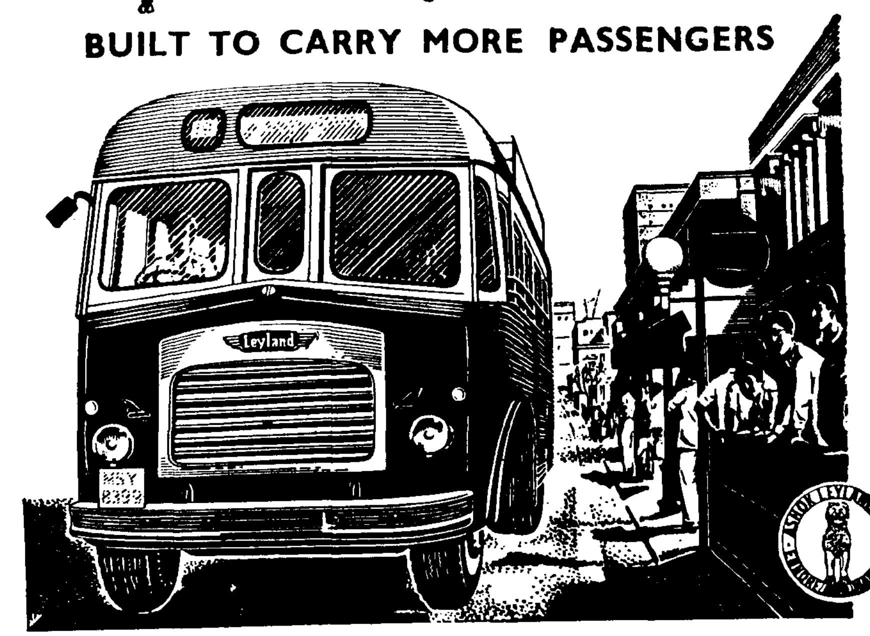

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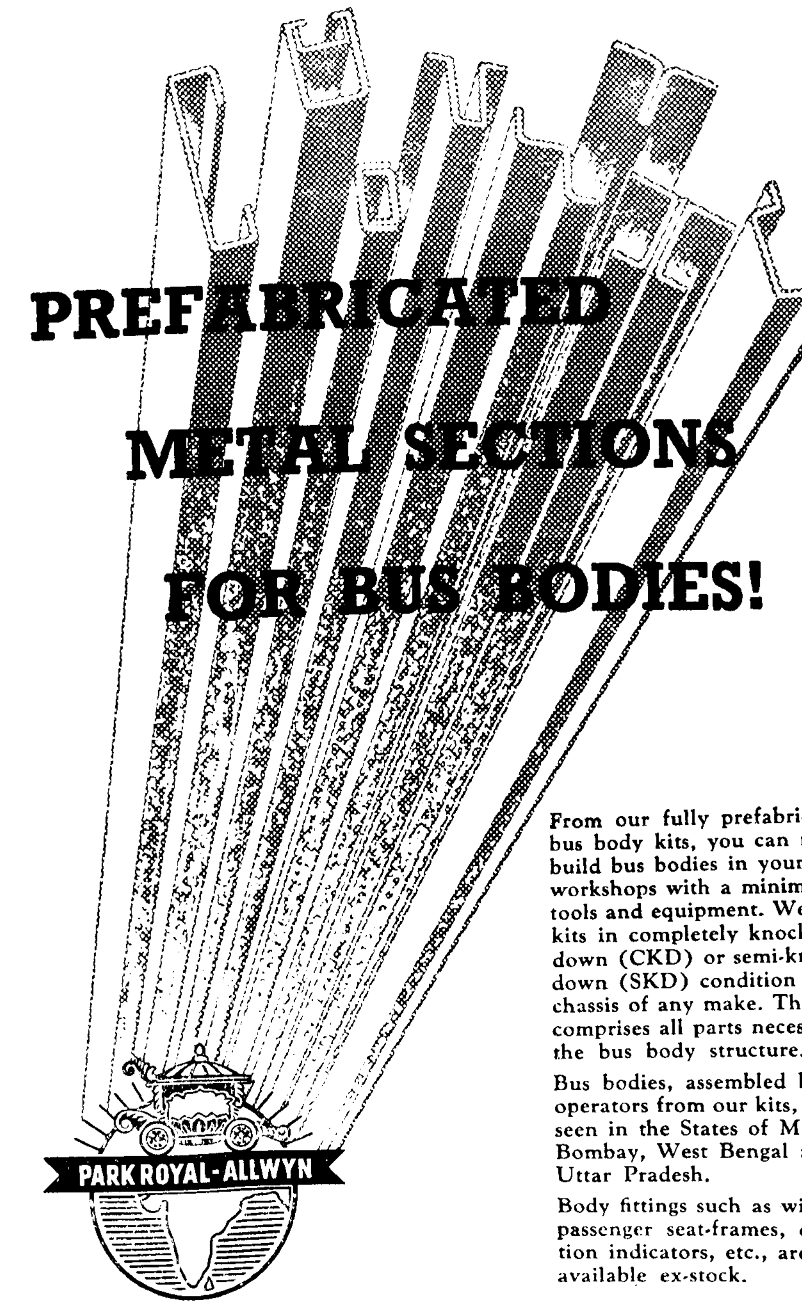

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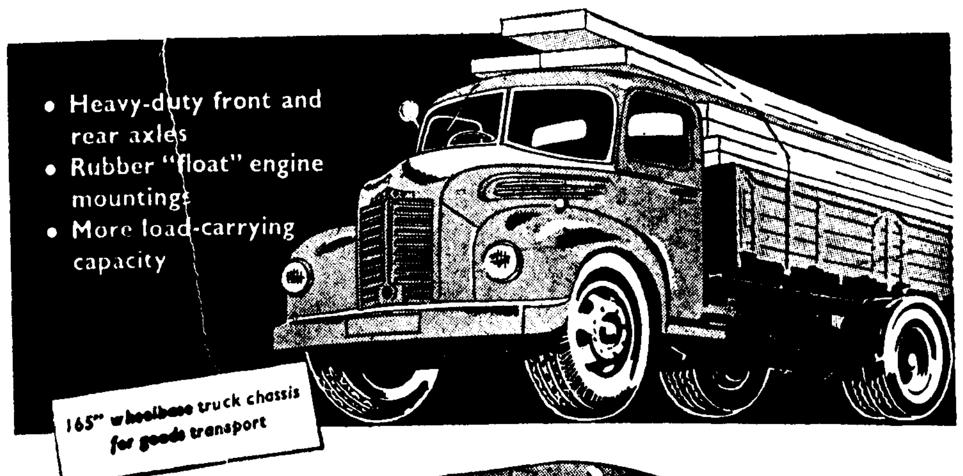

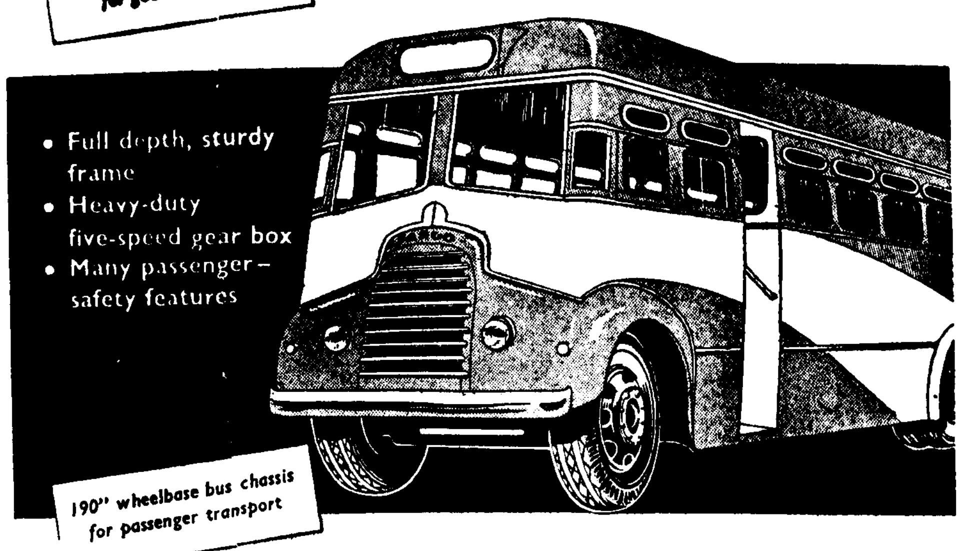

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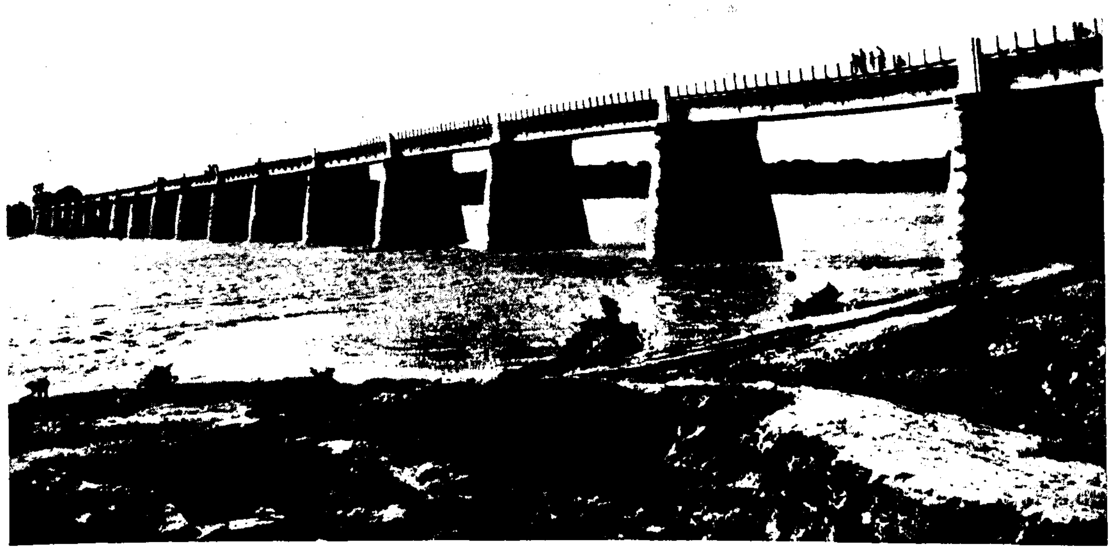

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MONTHLY REVIEW

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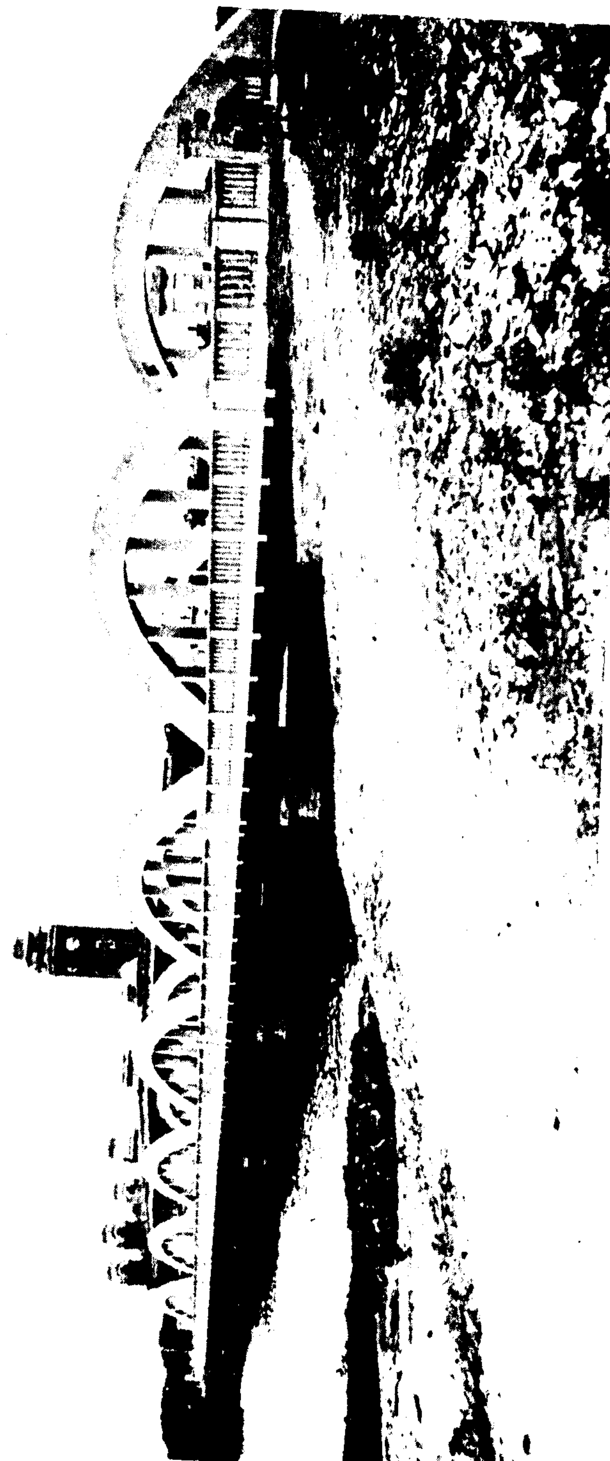


NAPIER BRIDGE, MADRAS, BUILT IN 1941-43. CONSISTS OF 6 SPANS OF 74 FT WITH 32 FT WIDE CARRIAGEWAY AND 8 FT WIDE CLEAR CANTILEVER FOOTPATHS ON EITHER SIDE.

TRANSPORT-COMMUNICATIONS MONTHLY REVIEW

A REVIEW OF
ROAD ENGINEERING, DEVELOPMENT & TRANSPORT

OCTOBER 1958

HIGHWAY RESEARCH IN U.S.A.

A.A.S.H.O. ROAD TEST

By

N. Mohan Rao*

Central Road Research Institute

Introduction

A very striking development in the field of highway research in the U.S.A. is the big boost being given to it by large scale undertakings of field experimentation. The most important of these and the largest highway research project ever undertaken is the AASHO Road test, located at Ottawa, Illinois, about 80 miles southwest of Chicago. This giant project, sponsored by the American Association of State Highway Officials and being administered by the Highway Research Board is estimated to cost about 22 million dollars, a sum financed on a nationwide basis.

The test road consists of 836 separate sections of pavements (of different thicknesses) and 16 test bridge spans, construction of which is almost complete. Test traffic ranging in axle loads from 2,000 to 48,000 lb will operate on these pavements for two years commencing from sometime in October this year. Data regarding stresses, strains, curvatures and deflections, etc. will be measured and recorded by precision instrumentation.

This huge experiment has been planned with specific objectives; objectives so wide in scope that the findings will materially influence our knowledge of highway transportation. The most important features of this test are :

1. The planning and design of the experiment embodying "the principles of scientific experiment design that make possible the isolation of experimental error, the elimination of systematic bias, generalization at least within the immediate area of the project and the consequent ability to make statements of significance—principles involving randomisation in the layout of experimental units and randomisation of other processes whenever economically practicable, limited actual replication of test units and

* The writer is on a visit to U.S.A. as a nominee of the Government of India, for training in the field of Highway Transportation, under the Technical Co-operation Aid Programme of the United States Govt.

the use of factorial design to strengthen the analysis."

2. Use of a million dollars worth of precision instruments to measure and record the structural behaviour of the pavements in terms of stresses, strains, deflections and curvatures, etc.

The project has on its staff some of the expert engineers and scientists of the United States, working under the guidance of a 34 member National Advisory Committee drawn from different technical organizations, both government and private. Technical panels made up of specialists in the fields of statistics, instrumentation, materials and construction, soils, bridges, maintenance, vehicles and public information are formed for consultation on specific problems in the planning, design and execution of the project.

An attempt has been made in the following pages to describe some aspects of this project briefly, in order to stimulate interest among Indian engineers in this phase of work.

Objectives of the Experiment

The specific objectives of this experiment are :

1. To determine the significant relationships between the number of repetitions of specified axle loads of different magnitude and arrangement and the performance of different thicknesses of uniformly designed and constructed asphaltic concrete, plain portland cement concrete and reinforced portland cement concrete surfaces on different thicknesses of bases and sub-bases when on a basement soil of known characteristics.

2. To determine the significant effects of specified vehicle axle loads and gross vehicle loads when applied at known frequency on bridges of known design and characteristics. The bridges include Steel I beam design, conventional reinforced concrete design and prestressed concrete design.

3. To make special studies dealing with such subjects as paved shoulders, base types, pavement fatigue, tire size and pressures, and heavy military vehicles, and to correlate the findings of these special studies with the results of the basic research.

4. To provide a record of the type and extent of effort and materials required to keep each of the test sections or portions thereof in a satisfactory condition until discontinued for test purposes.

5. To develop instrumentation, test procedures, data, charts, graphs and formulas, which will reflect the capabilities of the various test sections and which will be helpful in future highway design, in the evaluation of the load carrying capabilities of existing highways and in determining the most promising areas for further highway research.

Design of Experiment

The experiment is designed using the principles of randomisation, replication and complete factorial, in order to establish 'significant relationships' between the independent variables under study; these being, (1) axle load, (2) axle spacing, (3) number of load applications, (4) surfacing type (asphalt or concrete), (5) concrete reinforcement (plain or reinforced), (6) thickness of surface course, (7) thickness of base course and (8) thickness of sub-base.

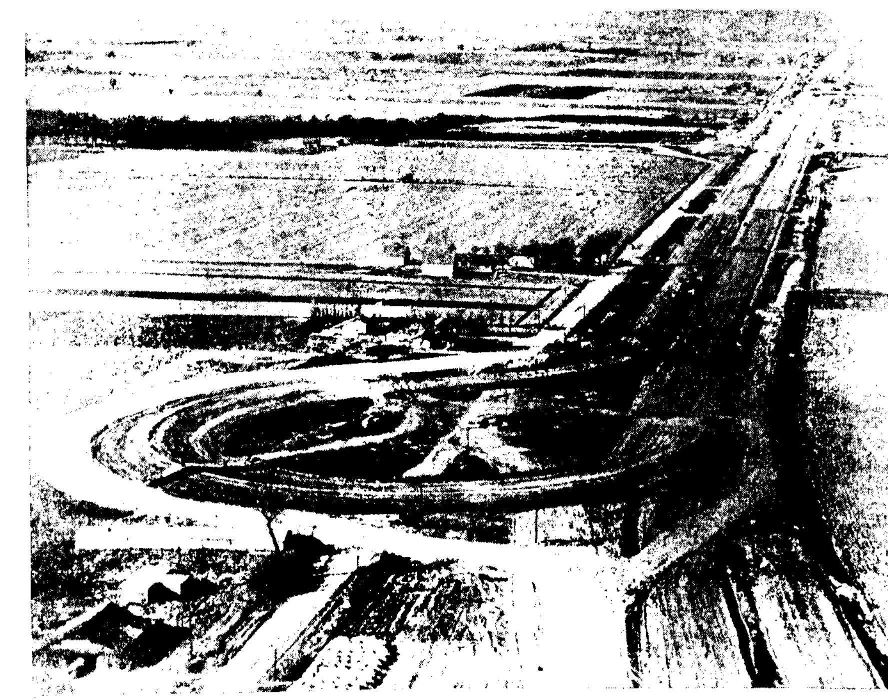
This list will show that not all the important variables affecting the structural behaviour of pavements are included in this test. Some of these are sub-grade type, quality of base and sub-base material, climatic conditions etc. Benefiting by the findings of the present experiment, it should be possible to design future tests introducing new variables such as sub-grade type etc., while keeping some of the present variables constant.

Great control was exercised in processing and compacting the embankment material at optimum moisture to attain maximum uniformity in support strength of the sub-grade throughout the length, thus assuring that sub-grade properties do not enter the list of variables. The embankments were constructed a minimum of 3 ft high from a fine grained clay soil

available locally, "a soil typical of wide areas of the country". The experimental sections were built on the central 24 ft of the embankment.

Using a complete factorial design, 836 separate sections of pavement were constructed in six test loops. Each test loop has two tangents with turn-arounds on either end. Traffic will run on five test loops (A, B, C, D, E) of which four have courses of the road crust in all the loops for flexible pavement sections of the main factorial group. Similarly, rigid pavement sections consist of various thicknesses of pavements, both plain and reinforced, built on different thicknesses of sub-base.

In addition to the main experimental stretches constructed on the tangents of the loops, some experimental sections



A bird's eye view of one of the test loops during construction.

two tangents 6800 feet long and one has 4400 ft tangents. The sixth loop was constructed to permit auxiliary studies on pavements not subjected to traffic. Figure 1 shows the layout of Test road loop E over which vehicles of single axle loads 2000 lb, 6000 lb operate. This is the test loop consisting of thin sections for light traffic. Fig. 2 shows the layout of Test Road loop D constructed for operating vehicles with single axle loads of 30,000 lb and tandem axle loads of 48,000 lb. In this loop the thickness of section varies from 11 in. to 31 in. Table I gives details of variations in the thickness of different

were built on the turn-arounds where the only variables are the quality of binder and type of asphalt mix.

The experiments on test bridges have been designed to collect data on the behaviour of short-span bridges under load repetition and dynamic loading. Sixteen test bridge spans were constructed in groups of four on straight tangents outside the pavement test sections in the two loops to be subjected to heavy traffic. These are simple 50 ft spans consisting of three beams and a concrete slab. In eight of these the beams are steel sections, in four

Table I

DESIGN DETAILS OF THE FLEXIBLE PAVEMENT SECTIONS OF THE MAIN FACTORIAL GROUP

Sr. No.	Loop	Axle-Loads	Variation in thickness: Surface	Base	Sub-base	Number of Sections required for Complete Factorial Design	Number of Replications	Total Number of Sections	Range of Variation in total Thickness
1.	E	2,000 lbs-Single 6,000 lbs-Single	Nil 1″ 2″ 3″	Nil 3″ 6″	Nil 4″	24	10	34	Nil to 13″
2.	A	12,000 lbs-Single 24,000 lbs-Tandem	2″ 3″ 4″	Nil 3″ 6″	Nil 4″ 8″	27	3	30	2″ to 18″
3.	B	18,000 lbs-Single 32,000 lbs-Tandem	3″ 4″ 5″	Nil 3″ 6″	4″ 8″ 12″	27	3	30	7″ to 23″
4.	C	22,400 lbs-Single 40,000 lbs-Tandem	3″ 4″ 5″	3″ 6″ 9″	4″ 8″ 12″	27	3	30	10″ to 26″
5.	D	lbs-Single lbs-Tandem	4″ 5″ 6″	3″ 6″ 9″	8″ 12″ 16″	27	3	30	15″ to 31″

they are conventional reinforced concrete and in four they are prestressed concrete.

The test traffic will consist of trucks and tractor-semi-trailer combinations. The traffic will run for 18 hours a day, 6 days in a week for 2 years commencing from this October.

The 24 ft wide pavement is divided into two lanes one for single axle traffic and the other for tandem axles. The vehicles will run at 30 m.p.h. in a "controlled pattern of transverse position stimulating the transverse position pattern found by the Bureau of Public Roads to exist in normal trucks operation on high type highways throughout the U.S.A." The traffic will be so regulated as to allow load repetitions at intervals of one minute on all the loops.

Measurements

A number of measurements will be made during the test which will not only help in evaluating the serviceability condition of the pavement but will also aid in arriving at the relationship existing between the pavement behaviour, expressed in terms of stresses, strains, deflections, curvatures, etc., and the design features of the experimental stretches. These measurements will involve processing of hundreds of millions of bits of data. Most of this processing will be done automatically with the help of IBM machines and digital computers. The principal measurements that will be made are as follows:

1. Curvature of the asphaltic concrete surfacing of flexible pavement under full speed traffic.
2. Deflection at the surface and at sub-surface interfaces between pavement layers under full speed traffic.
3. Deflections at very slow speeds at the surface of flexible pavement.
4. Deflections and strains at the corners of rigid pavement slabs.
5. Strain distribution under static loads in certain concrete slabs.
6. Sub-surface pressures at slab sub-base interface in certain concrete slabs.
7. Sub-surface pressures in selected flexible pavements.
8. Longitudinal profile of the surface in the wheel paths.
9. Transverse profile of the surface.
10. Permanent (as opposed to transient) deformation at the sub-surface levels in flexible pavements.
11. Temperature above, on, and under the surface throughout the project.
12. Strains and deflections—dynamic and static—in test bridges.
13. Dynamic wheel load—the load actually applied by a wheel as it passes a point where other measurements are being made.
14. Depth of frost penetration.
15. Total upward and downward deflection occurring at the corners of selected concrete slabs during an interval (usually one day).
16. Automatic scheduling and recording of transverse vehicle placement history.
17. Precipitation, humidity, wind and air temperature.

Instrumentation

As was mentioned earlier, a million dollars worth of instrumentation is being used to make the above measurements and record them. It is beyond the scope of this article to describe in detail the design features and working principles of all these instruments. However, a few of the devices being employed for measuring curvatures, deflections, etc., are very briefly described below.

Curvature strips are made of epoxy impregnated fiberglass strips with resistance wire strain gauges fixed on the top and bottom. The design and fabrication of curvature strips involved many important problems such as (1) providing good mechanical and water-proofing protection for basic strip, (2) selection of water-proof cable for input and output signals, which could stand temperatures up to 400° F., (3) encapsulating of the strip with strain gauges in the plastic resins, (4) formulation of plastic resins, minimizing air bubbles, (5) calibration of the curvature strips, etc. In all cases curvature strips will be placed directly under $1\frac{1}{2}$ in. surface course and will be attached to pavement with roofing nails.

Linear variable differential transformers (L. V. D. T.) are being used on this project for measuring transient deflections to a sensitivity of 1/1000 of an in., both in rigid and flexible pavements. The linear variable differential transformer is an electro-mechanical transducer which produces an electrical output proportional to the displacement of a separate movable core. In this instrument, there are three coils equally spaced on a cylindrical coil form. A rod shaped magnetic core, positioned axially inside the coils assembly provides a path for magnetic flux linking the coils. Any movement of the core relative to the coils induces differential voltage output from the transformer which has been found to vary linearly with change in core position. This principle is utilized in measuring transient deflections of pavements. Suitable attachments are designed and fabricated by the staff of the project to make either the moveable core or the outer cylindrical coil form to move with the deflecting pavement so that as the deflection occurs a differential voltage output is induced which is measured and translated in terms of deflection.

Flexible pavement deflections under slow moving traffic are measured with Benkelman Beam. Benkelman Beam is a simple device for measuring deflection of a pavement midway between the dual tires of a slowly moving vehicle. This instrument is being widely used in the

United States and Canada to find answers to such problems as (1) structural adequacy of pavements of different design and age, (2) validity of design methods, (3) permissible deflections in different types of pavements etc. Fig. 3 shows the essential features of this device. The probe arm shown in the figure has to be inserted between the dual tires. Any vertical movement in the probe arm, as a result of pavement deflection, is indicated by a sensitive dial gauge as shown in the figure. On the AASHO project, an automatic mechanical Benkelman Beam is fabricated, which reads eleven surface deflections every 25 ft as the vehicle moves down the road at 3 m.p.h. Some of the other intricate apparatuses designed and fabricated on this test project are the longitudinal profilometer to plot a profile in terms of slope of the road and the transverse profilometer to trace the transverse profiles at different sections of the road. For recording all the above measurements intricate electronic instrumets are being employed.

Pavement Evaluation

Data on longitudinal and transverse profiles of surfaces, on cracking and faulting, will be employed for evaluating the pavement performance in relation to the eight principal variables being studied in this test. Using mathematical techniques an index called the 'Performance Index' will be derived from the above data, the validity of which will be established by checking this value with the average rating given to the pavement by a panel of experts, based on visual examination. Similar methods are proposed for defining the serviceability condition of the pavements at any stage of the experiment, by an index called 'Condition Index'.

Conclusion

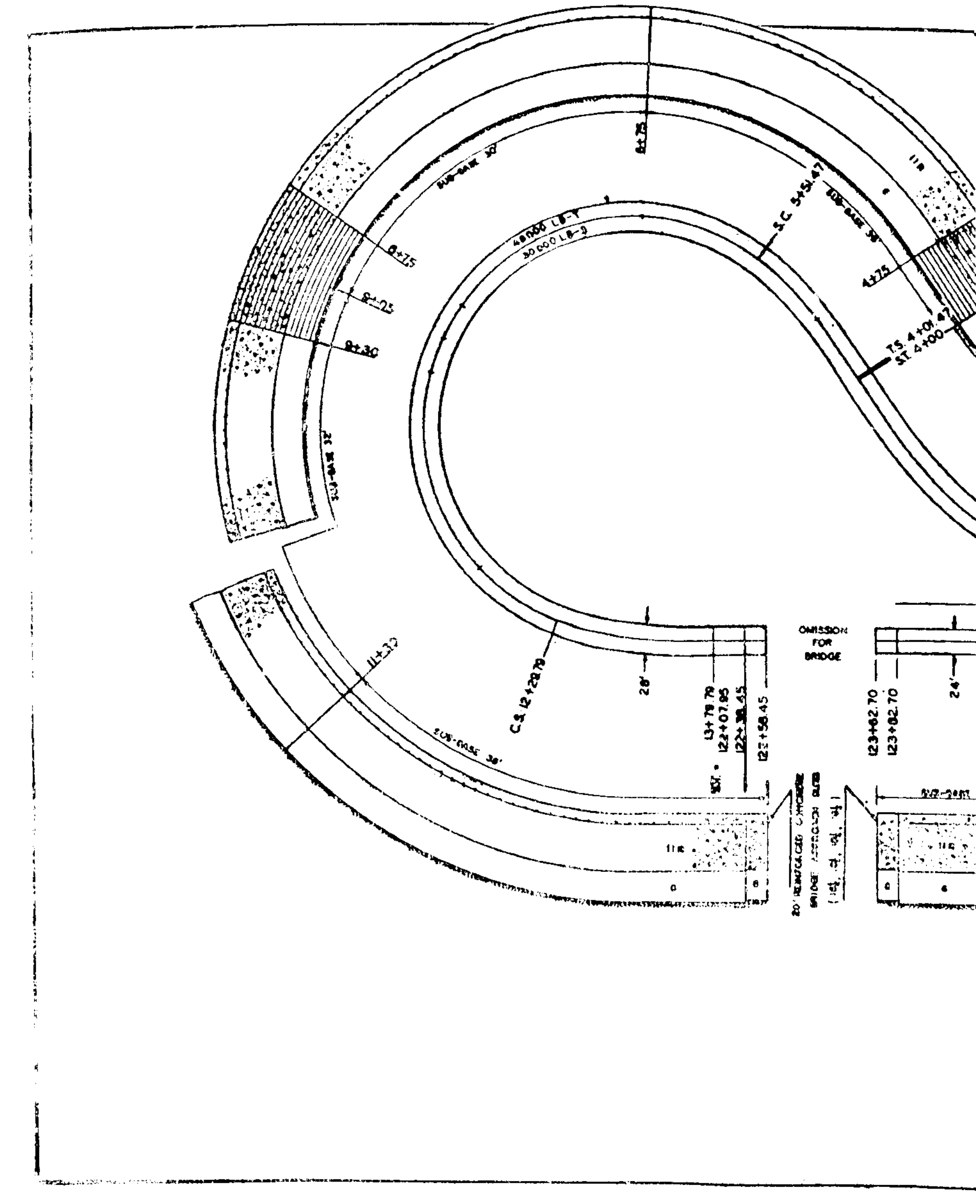
AASHO Road Test is a big enterprise of the highway engineers of the U. S. A. The findings are bound to influence decisively some aspects of highway transportation. Planned and designed as this project is, on systematic and scientific lines, there is no doubt that the goal set for it by the project director, Mr. McKendrick, Jr., in the following words, will be attained. "This is the goal of the AASHO Road test, sound, logical and unassailable facts and figures; data which will be meaningful and helpful to all highway administrators and engineers. This will be the data which will fulfil the specific objectives of the project and be useful to others in accomplishing their aims in the overall effort to provide better and safer highways for a growing and progressive nation."

However, it should be realized that, in spite of the massiveness of the project, it is only a first step, a beginning in rationalizing methods of highway design and many more tests of this nature are necessary in the future to find answers to all the problems of highway and bridge design.

Acknowledgments

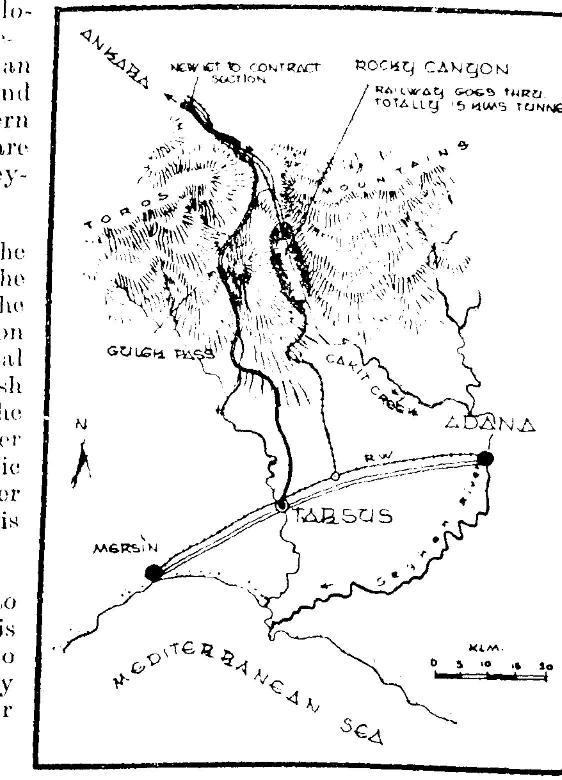
The writer acknowledges with gratitude, all the facilities and help given during his study tour of the project, by Mr. W. B. McKendrick, Jr., Project Director of the AASHO Road Test with whose kind permission this article is being published. Acknowledgements are also due to Mr. W. J. Schmidt, Chief of Public Information for making available all the relevant information. The writer is particularly indebted to Messrs. A. C. Benkelmen, F. H. Scrivner, H. C. Huckins, J. F. Shook, and Dr. P. E. Irick and their staff, for the very valuable and instructive discussions he had with them, and also to Messrs Fred Finn and W. E. Tesko, Observers on this project for the Asphalt Institute and the Portland Cement Association respectively.

The writer acknowledges that he had taken material for this article liberally from the reports of the Project Director, Mr. W. B. McKendrick, Jr., and Mr. W. N. Carey, Jr., Chief Engineer for Research, presented at the annual meeting, of the American Society of Civil Engineers, held at Chicago during February 1958.



BOLD REALIGNMENT WILL UNKINK TURKEY'S NO. 1 HIGHWAY

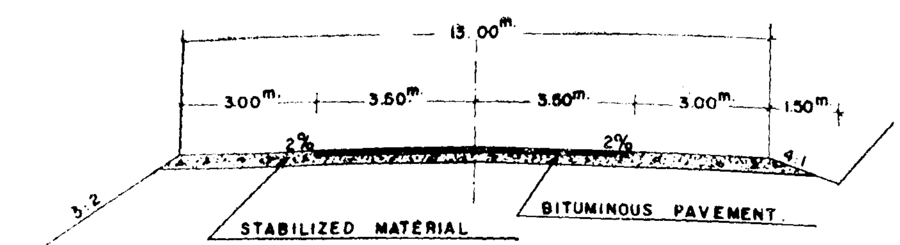
THE greater part of Turkey's 450-kilometer Istanbul-Ankara-Tarsus route-the nation's No. 1. state highway and an international one has been relocated and reconstructed in compliance with modern high standards. The remaining parts are either under construction or being surveyed and designed.



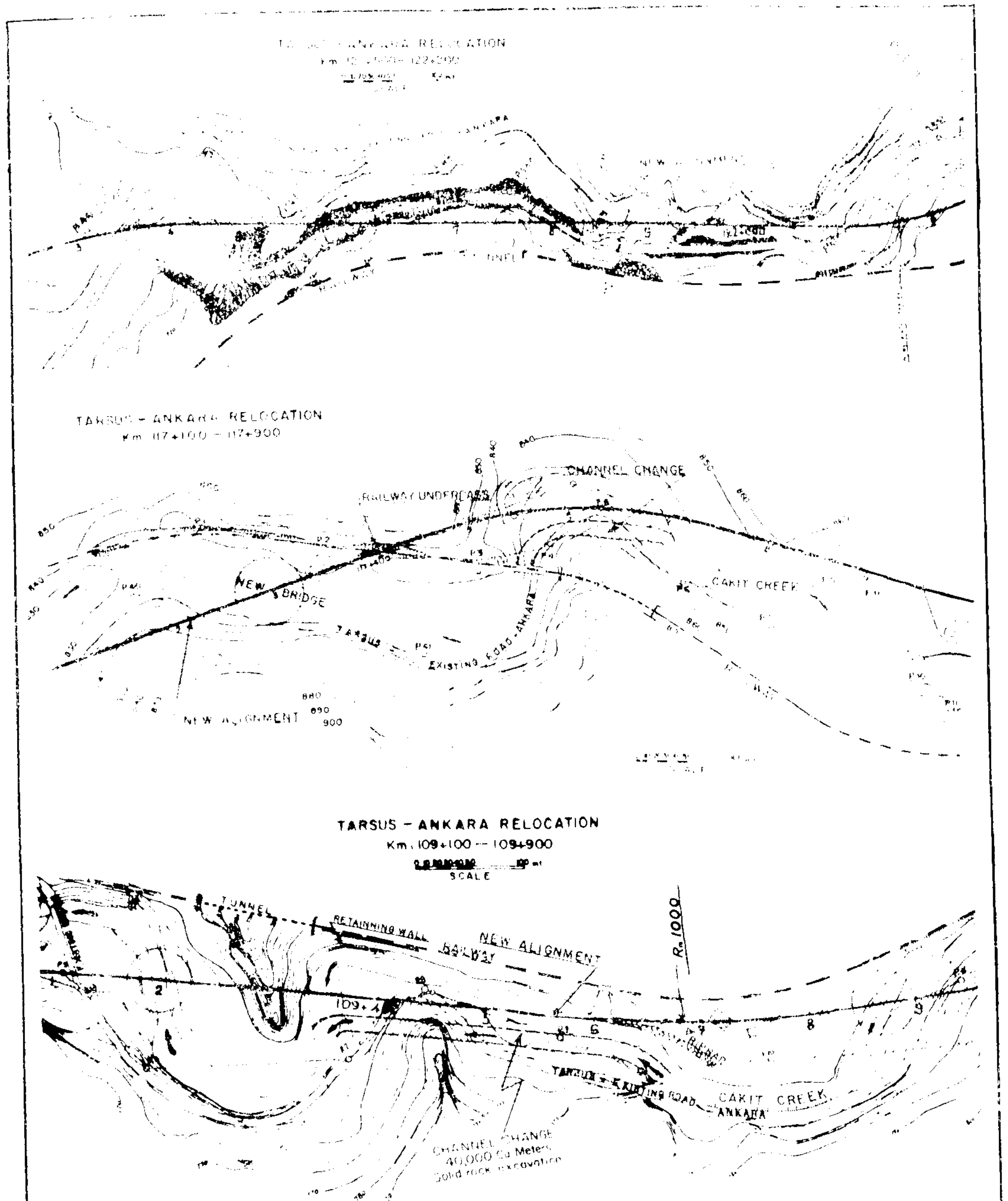
One of the most rugged parts of the above route is a 40-km segment which the Toros Mountains Range, parallel to the Mediterranean Sea. A 13-km portion here was recently let to contract. Total cost is estimated at 14 million Turkish pounds (1.00 dollar = 2.80 T.P.). The project entails the highest per kilometer cost as well as the highest geometric standards for its kind of terrain, ever designed in Turkey. Construction is scheduled to be finished in 1959.

It has been found more economical to use the highest possible standards for this part of No. 1 state highway, which is to carry the greater portion of the heavy traffic for the new big Mersin Harbour now under construction.

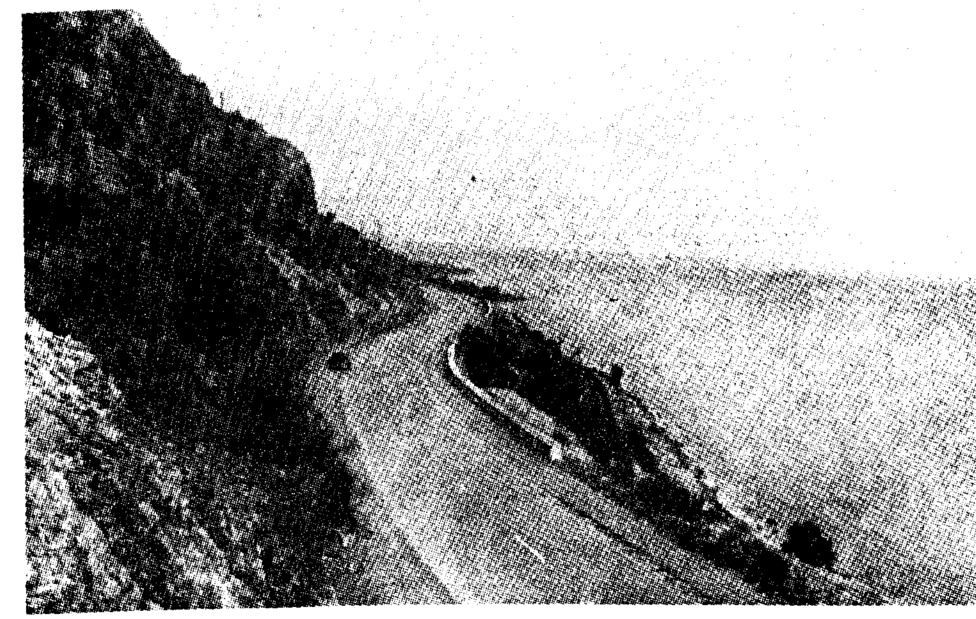
For this reason (see plan and profile sketch) the new alignment, following the same creek with the present winding narrow road and railway, crosses the old creek bed 27 times. A total of 14 bridges each about 30 meter average span have had to be provided; the other crossings were eliminated by channel changes. Solid rock excavation totalling 60,000 cubic meters was resorted to for the two channel changes at klms 109 + 500 and 117 + 500, as a design means of eliminating four additional bridges.



CROSS — SECTION



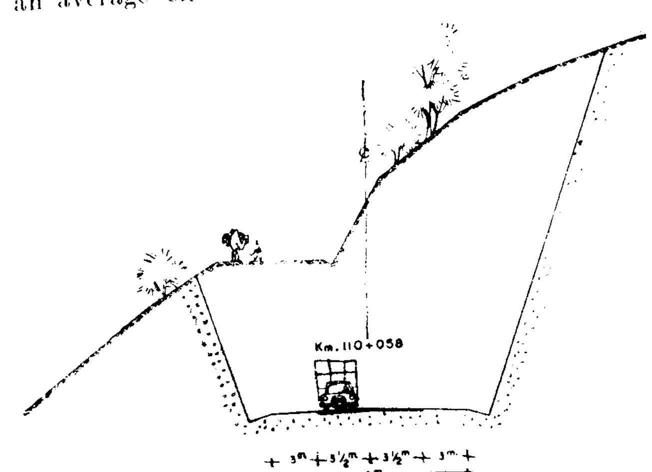
• Examples of plan sheets showing old road and new location in relation to the mountainous topography.



Roadway cross section for Istanbul-Ankara-Tarsus road.

A 58 degree skew railway under pass at klm 117 + 400 has been found the most suitable solution although the railway goes through cut at this place. Between klm at stations 121 + 500 and 122 + 684 where the existing road winds up on very steep grade with nine switchbacks, the new alignment goes along the top of a rocky gorge on 5 per cent gradient. In this short interval, four skewed bridges with a total of 200-meter span and with an average elevation of 20 meters high enabled us to use a 350 meter radius horizontal curve without being forced to run through a long tunnel or blind curves.

This is the project's sharpest curve. Three of the other horizontal curves range from 500 to 700 meters radius; and the rest from 1,000 to 2,000 meters. Where the horizontal standards allow safe stopping, sight distance for at least 110 kilometers per hour have been provided.



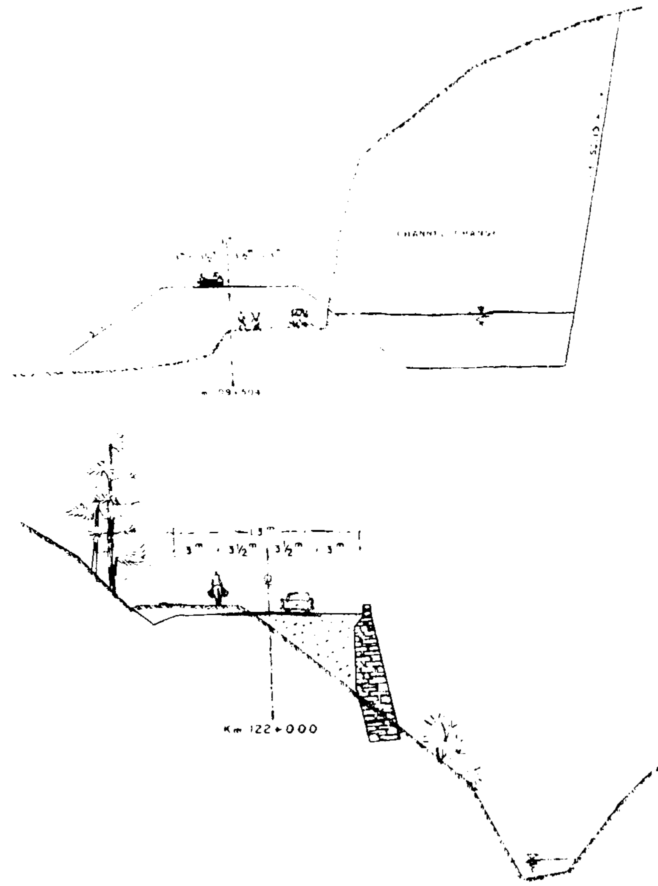
Cross section of the new road in relation to old—showing the various situations involved in the realignment.

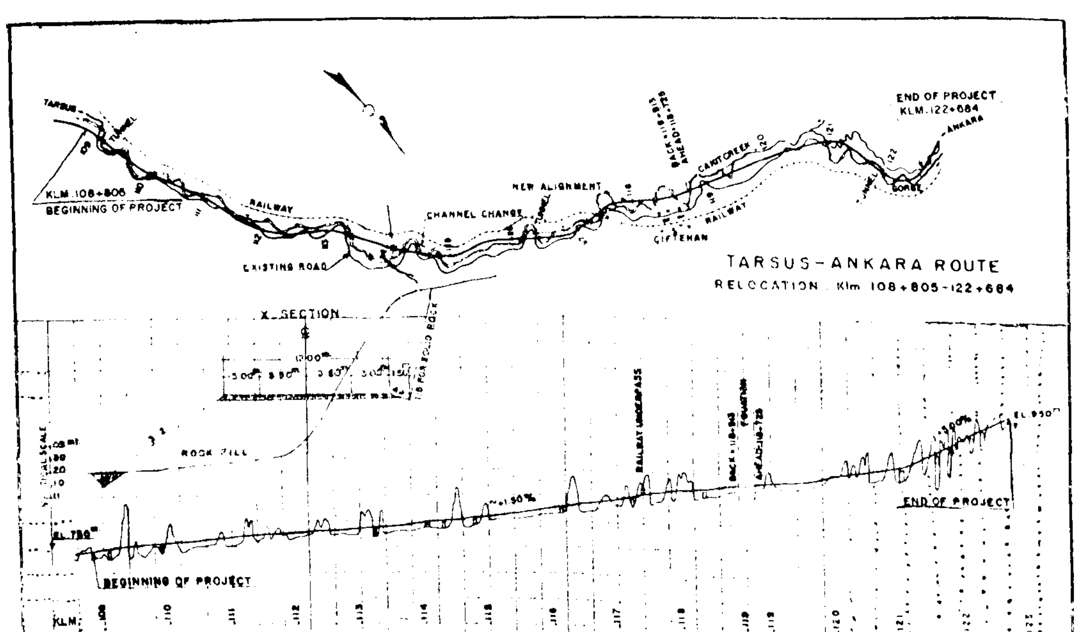
Because of the high geometric standards the new alignment runs through several cuts deeper than 30 meters, making the total excavation about 1,000,000 cubic meters in the 13 kilometers of distance; 90 per cent solid rock. The construction cost of the project hence is for rock excavation and bridges.

By not following only the present winding creek-side road, but instead by re-aligning, we have made it easier to handle the current traffic, one of the densest in Turkey.

Beyond this section of the road, about 100 kilometers of relocation remains to be done toward the harbour. Only 20 km of it runs through rugged terrain. Survey and design are under way.

This existing narrow winding road passes through the famous historical old Gulek Pass. Since the Cakit Creek cuts the Toros Range through a deep rocky canyon for 15-km distance, old Gulek Pass has been a historic one. It was used by the armies of Alexander the Great and Persian King Dara. If the relocation here is chosen through this old pass, about 15 km of alignment on 5 per cent sustained reverse grade will be necessary for traffic going down to the harbour. This obviously will increase the operational cost of the heavy traffic. On the other hand to relocate through the deep rocky canyon at water level on a steady down gradient is extremely expensive. These two alternates are being surveyed and designs developed to determine the ultimate line.





Comparison of old road with relocation from beginning to end.
(*From "World Construction", July, 1958.*)

ECONOMICS OF CONCRETE BRIDGE DECK CONSTRUCTION

INVESTIGATIONS OF INTEREST TO ENGINEERS AND CONTRACTORS

A series of large-scale investigations into prestressed concrete bridge beam erection and construction have been initiated by Concrete Ltd at their Hounslow works. Training methods derived from method studies to be carried out in conjunction with the work studies will most certainly be employed to train erection crews working on motorway fly-over Bridges and other types of bridges, large numbers of which will be built in the near future.

Discussing the economics of bridge deck construction, Mr. K. M. Wood, B.A., Chairman and Joint Managing Director of Concrete Ltd, reports that in a number of instances precast prestressed concrete bridges have proved to be more expensive than orthodox insitu concrete bridges. Furthermore, there have been a few failures in the cross stressing of precast bridges. The main reasons for both of these apparent failures are believed to be:

1. The use of designs which necessitate employment of unnecessarily intricate and unnecessarily expensive on-site operations;

2. The use of designs which call for operations which can be safely carried out under laboratory conditions, but which are too difficult to enable sound constructional work to be produced by normal site personnel: and

3. Lack of experience by contractors carrying out the various operations in question. This not only makes it difficult to prepare accurate cost estimates, it also means that experienced men are not available for the work and that site operations are unnecessarily costly.

Big Economics from Operator Training

The fact that lack of experience can indeed lead to very steep cost increases is illustrated by the following fact, which is based upon the very considerable manufacturing and site-work experience of Concrete Ltd. The time required to handle prestressing wire and prestressing equipment can be reduced to one-third or less, a reduction of over 66 per cent, if the operators are given proper training and the opportunity of becoming experienced at their work.

To solve the problems associated with the three points listed, says Mr. Woods, it is necessary to study a representative selection of typical site processes called for by current precast prestressed concrete bridge deck designs, the aim being to separate the comparatively simple and inexpensive processes from those which are very difficult to carry out at a reasonable cost. The latter processes then require study in order to develop more suitable processes and to render these possible by design changes. Alternatively, they require the development of suitable operator training methods.

In addition to this, it is necessary to carry out detailed work study in order to break down the processes studied into sub-operations which can be used directly for provision of accurate cost information on all site processes. This cost data would render possible accurate cost comparisons between alternative methods of precast prestressed concrete bridging.

Two more requirements have to be met. Firstly, the operating teams and supervisory staff responsible for on-site processes should be properly trained, and training experience gained by firms such as Concrete Ltd should be passed on to consulting engineers and contractors engaged upon precast prestressed concrete bridge schemes. Secondly, more attention should be paid to the problem of designing for economical production and erection.

Major Factors

There are seven major factors which require careful consideration by consulting engineers and contractors. These are as follows:

1. Pre-tensioning will always be cheaper than post-tensioning, provided that the precast prestressed bridge beam unit in question is not too large or too heavy to permit handling and transportation as an undivided unit. Furthermore, pretensioning is more simple than post-tensioning and defective workmanship is less likely to occur.

2. The design of a pre-tensioned bridge beam unit is limited by the maximum manufacturing, handling and transportation capacity of manufacturers specialising in this type of work. For example, the present limits of beam capacity at the Hounslow factory of Concrete Ltd. corresponds to a maximum unit weight of 20 tons and a maximum stressing force of 600 tons.

3. The cost of shuttering for a pre-tensioned beam can be a major item. For example, for a complete bridge beam, excluding mould costs, the typical-ex-works selling price of, say, 16 s. per cu. ft. would have to be increased by 3 d. to 10 s. per cu. ft. mould cost, depending upon the complexity of the design. For economical production in a large factory it is normally necessary to employ moulds designed to produce from 300 cu. ft. to 500 cu. ft. at one casting, and these are not likely to cost less than 1 pound per cu. ft. Three important conclusions follow from this:

(a) In large schemes, with abundant repetition work, the mould cost is negligible, unless an abnormally high rate of delivery is required.

(b) In small schemes mould costs are likely to be excessive, unless standard sections are used.

(c) It is economically desirable to avoid changes in internal section along the length of a beam. Changes of section complicate mould design, increase costs and, in general, make the use of standard moulds impossible. It is generally better to carry out local strengthening by stirruping.

Ratio of Steel to Concrete

4. The price of prestressed concrete depends upon the ratio of steel to concrete as well as mould costs and degree of repetition work. For example, an inverted Tee-beam has a higher steel to concrete ratio than a box or I-section beam, and it will be more expensive on this count alone. The point to note is that both plant capacity and labour hours necessary for manufacture will vary with the proportion of steel to concrete.

5. Mild steel ancillary reinforcement, such as stirrups, is always necessary, but the exact amounts required are always difficult to determine. Many designs, however, call for excessive amounts of ancillary reinforcement, particularly in the central two-thirds of a beam.

6. It is particularly difficult to obtain dimensional accuracy in prestressed concrete, because of the tendency of moulds to move during wire extension (pretensioning). The British standard draft code on the structural use of prestressed concrete in buildings recognises this fact, stating: "It should be noted that insistence on closer tolerances than are really necessary may give rise to considerable difficulties in manufacture." The main point to remember is that, in general, close tolerances can be obtained where they are fundamentally necessary.

7. With the longer bridge beams, it is important that the prestressing wires be curved downwards. This is best achieved by deflecting a limited number of wires from the top to near the bottom of the section. Although deflecting presents few difficulties, it can be assumed that the cost is between 1 pound and 5 pound for each point in the beam at which downward deflection is carried out, depending upon the size of the beam. Generally speaking, it is best to restrict downward deflection to four points on the longer beams and to two points on the shorter beams.

(From "Highways and Bridges and Engineering Works", July 16, 1958).

SOIL STABILIZATION WITH BITUMINOUS MATERIALS

By

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Introduction

RECENT decades have seen lot of developments in the methods of road construction. By far, one of the most important has been the introduction of methods by which the soil found on the site of a proposed road is used in the construction of the road base, thereby, in many cases, saving the cost of transportation of stone. For this purpose, the soil must be strengthened and made resistant to the effects of moisture and temperature variation, which would otherwise cause the soil to lose its supporting power. This can be achieved by treating the soil in a number of ways and the process is known as "Soil Stabilization", i.e. the method of strengthening the soil and stabilizing it against the detrimental effect of weathering.

Soil stabilization can be defined as any method of treating soil to make it less affected by water or to increase its load-bearing capacity usually by the use of admixture.

The word 'Stabilization' in connection with road work has been used rather loosely, but fortunately it conveys a definite idea. A stabilized fill, subgrade road surface or road base is one that will stay put and stabilization is the process which makes it that way.

Stabilization of soils can be achieved by one of the following methods:—

(1) The dilution procedure (Mechanical Stabilization) in which poor soils are diluted with granular aggregates until the deleterious properties of the poor soil are reduced if not eliminated.

(2) Treatment with chemicals so that the soil will maintain a suitable moisture content under fluctuating climatic conditions and thereby ensuring its stability.

(3) The addition of hydraulic setting materials by which the soil is cemented into a more or less completely stabilized mass: and,

(4) The addition of water-proofing materials such as bituminous binders by which it is attempted to render the soil more or less impervious to water and thus retain its originally designed properties.

A Review of the General Principles of Bituminous Stabilization

A study of the literature pertaining to Soil Stabilization in general reveals many notable contributions of the use of bituminous materials in soil stabilization. This is logical because Bitumen has long been used as a binder and water-proofing agent in highway construction.

Benson and Becker identify two procedures for bituminous Soil Stabilization. The first is based on the establishment of a definite soil-water-bitumen system. This method utilises an intermediate moisture content known as "Fluff point" and produces a system consisting of soil-water aggregations which are in turn coated with films of bitumen. The writers point out the following advantages of this procedure over those based on the theory of intimate mix:—

(i) Relatively small bitumen contents required

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(ii) A minimum of mixer work and time required

(iii) The more complete utilization of soils " in sites " due to the greater range of soils which may be successfully treated.

The second method discussed by Benson and Becker is that of utilizing supplementary mixture. Their findings on the use of heavy metallic salts lead them to the conclusion that such salts affect soils only slightly at the concentration used (3% and less) and that the use of such salts is economically prohibitive. They continue by saying that the use of Portland cement and lime in conjunction with Bituminous Stabilization has beneficial effects and is economically feasible.

Endersby's contribution to the science of soil stabilization with bitumen is really noteworthy. He was one of the first who really grappled with the problem in a scientific way. In " Fundamental Research in Bituminous Soil Stabilization ", he strikes at the root of the definition. " The term ' bituminous soil stabilization ' is often used to cover anything from a clay bound soil lightly treated with oil, to an oil bound sand." Oil, according to him, is itself a cohesive and a lubricant, as is water, and its introduction into the soil will change the mechanical characteristics to some extent/degree. If the oil becomes the dominant cohesive, the mix is no longer a true soil stabilization in the scientific sense, but is rather a soil mix.

Endersby concludes that it is possible to improve soil stabilization with liquid oils several fold over normal previous practice by attending to the following items :—

(1) Proper relation between oil and water content ;

(2) The significance of phase mixing ;

(3) Proper curing ;

(4) Improvement and (or) proper selection of stabilizer ;

(5) Proper selection of stabilizer content.

Winterkorn and Eckert make the statement that the success of bituminous soil stabilization is a function of the general character of the bituminous material employed. In their very comprehensive article, they discuss the classification of bituminous materials by a series of tests as well as the evaluation of the effect of various exchange ions on a series of soils mixed with different bitumens.

Preece, while not primarily concerned with bituminous stabilization of soils, gives a very interesting discussion of atomic and molecular structures as applied to soils. He continues with a description of the lattice structures of the various clay minerals, ionic exchange, preferential absorption and surface energies. His discussion of these subjects as well as the electro-kinetics is very interesting and pertinent to any study of soil stabilization.

The recently held Seminar on Low Cost Roads under the auspices of the ECAFE revealed that bituminous Soil Stabilization has been tried in most of the countries of the ECAFE region e.g. Japan, Malaya, Taiwan and India. In USSR, such roads have been in service for more than 15 years. The use of bituminous soil stabilization is quite common in all the Republics of USSR. Binder percentages used vary from 2 (for sandy loams and sands) to 15 for loamy clay and clayey soils. The latter is, however, not justified as these soils require very high binder content leading to prohibitive costs.

Soils

In suitable climatic conditions a variety of soils may be stabilized with bituminous materials but as with most other forms of stabilization the upper limit of clay content in soils that can be dealt with is to some extent determined by the inability of existing plant to pulverise very clayey soils and mix stabilizers into them. Good results are obtained when reasonably well graded soils are used, and the Highway Research Board of America suggests the limits given in the following list :—

Maximum size of material	approx. one third the campacted thickness

Passing 3/16" B. S. Sieve	— 50 per cent
No. 36 B. S. Sieve	— 35/100 per cent
No. 200 B. S. Sieve	— 10/50 ,, ,,
LIQUID LIMIT	— 40 per cent
PLASTIC INDEX	— 18 ,, ,,

With sand, however, the problem is easier since excess water may be squeezed out by rolling provided excessive quantities of bitumen are not added. The " wet-sand-mix " process was widely employed in Britain during the II World War for airfield construction.

Bituminous Materials

I. Use of Emulsions

It was found as early as in mid-thirties that a small amount of bitumen in the form of a properly manufactured emulsion, when mixed with clay bearing soils, and allowed to dry, entirely changed the former characteristics of the materials. Soils, otherwise unstable, were found to become stable in the presence of water to the extent that they could safely be used as a pavement foundation, where normally they would have been discarded in favour of imported aggregates.

A careful study of the phenomena disclosed that the minute bitumen particles dispersed in the emulsion, were intermingled with the soil colloids during the mixing process, and that when the water evaporated these particles were pulled out into thin bituminous films which by coating the soil grain surfaces, caused them to become water repellant. In other words, soil colloids which had a cementing value, due to the presence of an adsorbed film of water, were caused to retain, instead, an adsorbed coating of bitumen which resisted water infiltration. Bitumen, it was found, becomes almost a part of the soil itself, to such an extent that only a small portion of it can be recovered with the usual solvents. As research continued, it became apparent that the amount of bitumen required by this process was critical. Too small an amount did not render the soil sufficiently water resistant and too great an amount lubricated the soil so that it began to lose its natural stability. Tests were, therefore, devised for measuring the efficiency of the treatment: one which measured the resistance to capillary absorption of water, and the other which measured the resistance to plastic flow within the treated material after it had absorbed as much water, as it could. These tests called " Capillary absorption test " and " Stability test " proved both simple and dependable and are still used for the control of most of the bituminous stabilization work.

In designing mixtures, an amount of emulsion is selected which in the tests shows the greatest benefit in furnishing both water-proofness and stability. This amount is kept within the minimum required for water resistance and the maximum allowed before loss of stability occurs. This range is broad enough and as such the field operations are not too sensitive.

Mixtures can be very satisfactorily designed by using the tests for capillary absorption and stability. The amount of emulsion required is about directly proportional to the amount of fines present in the soil and as such it is sometimes economical to impart gravel, sand or crusher run rock to the existing soil. This practice not only reduces the amount of emulsion used but also imparts further stability to the mix.

The type of emulsion used in soil stabilization is very important. In the initial stages the emulsion used consisted of bitumen suspended in soap solution and was too unstable to mix with fine material without coagulation. The quick " breaking" type of emulsion, while perfectly satisfactory for penetration macadam, was not stable enough to resist breakdown when mixed. The emulsion used in stabilization must be one which is stable enough to withstand any degree of mixing with finest of aggregates, some of which contain even electrolytes. The bitumen in emulsion must be present in particles of microscopic and sub-microscopic size. Without the fineness, the bitumen particles would be too widely dispersed throughout the mixture to be of material benefit as only a portion of the soil colloids would be coated. Emulsion must also have the property of allowing unrestricted loss of moisture from the mixture after it is laid, as otherwise the work would be greatly delayed in setting.

II. Use of Cutbacks

There are two theories regarding the action of bituminous cutbacks and road oils in water-proofing the soil. One is the "plug" theory which holds that the capillaries are simply plugged with bodies of oil, preventing the water from either entering or leaving. The other is "the intimate *mix*" theory under which the individual particles are supposed to be coated with oil. Neither can be considered as covering the whole ground though the 'Plug' theory on a simple statistical basis, must be nearer the truth. The mineral surface area of soils and particularly in clays is so enormous that no amount of oil ordinarily used can be expected to coat it completely.

The action of oil is not a simple plugging of capillaries. *A definite soil system* exists, which changes its nature with the *degree and method of mixing*; and so far as water-proofing is concerned, the process passes through an *optimum phase during* the progress of mixing. This was first studied by Benson and Becker.

It is hardly possible to mix oil with dry soil satisfactorily unless of course the binder content is increased. A water film 'lubricates' the oil and promotes its spread. It is a *very cumbersome process* to determine the proper water content. *Various expedients have been devised* to cope with this. Klinger uses an "exudation point" based on the combined oil and water content which the soil will tolerate when compacted. Benson uses a "fluff point" based on the fact that as water is added, the soil reaches and passes through a condition in which it becomes loose and "fluffy" with a moist appearance. When this condition is passed, it becomes cohesive and muddy. Benson regards it as desirable to wet the soil a number of hours before mixing with oil, in order to give the water time to infiltrate soil cells and break them down to a satisfactory fineness for mixing.

Type of mixer employed has a very important bearing on the outcome; there are vital differences in the phase aspect of different mixers. This is interesting in view of the fact that mixer type and mixing time are the most loosely specified points in many proposed routine control methods.

Viscosity of stabilizer must also be taken into account. *Liquid cutbacks* vary as to viscosity, curing properties and chemical *nature*. *Very high viscosity* is of course undesirable as making the oil too difficult to *mix*. According to Endersby, grades over MC 2 should not be used.

III. Use of adhesion promoting Agents

Oils which can easily force water away are rare. They adhere to stone either because they reached the surface first or because the water got evaporated. An effective alteration (treatment) of the oil noticeably alters the physical nature of the mix. Oil disperses more quickly into the soil and the treated mix tolerates more total fluid content. Treated mix cures more rapidly too.

Construction Methods

Typical Particle size Distribution of soils for Bituminous Stabilization

(Highway Research Board of America)

B.S. Sieve	Percentage passing $1\frac{1}{2}''$ max. size	$1''$ max. size	$\frac{3}{4}''$ max. size
$1\frac{1}{2}''$	100	...	...
$1''$	80-100	100	...
$\frac{3}{4}''$	65-85	80-100	100
$\frac{3}{16}''$	40-65	60-75	80-100
No. 7	25-50	40-60	60-80
No. 36	15-30	20-35	30-50
No. 100	10-20	13-23	20-35
No. 200	8-15	10-16	13-30

The general construction technique is similar to the one employed in stabilization with cement and the same plant

may often be used. The methods briefly are:

Mix-in-place
Travelling plant
Stationary plant

In Britain and the U.S.A., the mix-in-place method is the one most widely used, although travelling plant has been used frequently on large jobs, particularly in the U.S.A. During the war most of the plant used for mix-in-place in the U.K. was agricultural equipment. Modern mixing apparatus has now become available. The mix-in-place method appears to have been commonly used in many other countries.

A variety of specialized mechanical plant is manufactured in the U. S. A. for soil stabilization. No new principles have been evolved in the last decade, although some improvements have been effected in mechanical details. There is'nt very much soil stabilization done in the UK with bituminous materials. The wet sand mix method is commonly used. It can be brought under the purview of stabilization but there is conflict in the minds of engineers whether wet sand mix can be called stabilization.

As the optimum moisture content for stability is usually somewhat below that for compaction and as good mixing is generally considered to be most easily obtained at fairly high moisture contents, it is often found necessary, except with sands, to allow a period for the mix to dry between the mixing process and compaction. Thickness is built in 2" layers. In the mix-in-place process, it is usual to add bitumen in several passes of the tank sprayer, each layer being partially mixed in before the next pass, so as to avoid saturating the soil.

Stabilized foundation courses are not designed to carry traffic without surface protection. Some form of wearing course is therefore absolutely essential. They are usually designed for resistance to capillary water, and not to surface water. They can be designed for submersion if necessary but a more carefully controlled mixture is necessarily used to control more closely the amount and size of voids. It is always preferable and more economical, therefore, to design pavements to resist capillary water and to seal the surface against ingress of water. A penetrating prime coat is applied to the surface of the stabilized base as soon as it has become thoroughly dry and hard: this treatment forms an enriched layer on the surface of the stabilized material providing protection against water infiltration. A very economical thin surface treatment for light traffic roads can be constructed by the use of a high viscosity quick-breaking emulsion which, when covered with stone chips, forms a resistant and non-skid wearing course. Premix chipping carpets can also be laid quite satisfactorily.

The construction techniques employed when use of emulsion is made are different from those when cutbacks/tar are used. The amount of water present in the emulsion itself has to be taken into account. Obviously, therefore, the amount of water to be used is reduced. The amount of water required largely depends on the mixing force of the mixer: greater the force less the quantity of water used. As it is the loss of water from the mixture which pulls bitumen out into the form of a coating for the soil particles, it is essential that the stabilized mixes should be effectively dried. Drying can be greatly hampered by the water which might be sucked from the wet sub-grade. One method to counter this is to spread a thin layer of stabilized mixture on the sub-grade first and allow it several hours to harden and dry. On this can be spread the rest of the mixture, with the assurance that the dried material is already stabilized to the point of acting as a water cut-off at the bottom. This method cannot always be used, particularly in places where rains may occur any time: as such, construction is usually carried out by the trench method and it would provide a fine reservoir for water in case of rain.

Laboratory testing techniques

Testing procedure used in bituminous stabilization may be divided into three groups according to their function, viz., compaction, stability and water-proofing tests.

Standard Proctor test is used for compaction. When calculating results, the weights of both bitumen and water must be substracted from that of the compacted sample to obtain the dry density. The point corresponding to the peak of the curve relating to dry density and moisture content is referred to as the optimum moisture content. Alternatively, the percentage of bituminous material may be added to this to give an optimum total fluids content.

The three most widely known tests employed to evaluate the stability of a soil-bitumen mixture are the modified Hubbard-Field test, the Cone Penetrometer Test, and the Florida Bearing Value test, the latter test is used only for sands. The C.B.R. test can be effectively used for bitumen treated soils.

Modified Hubbard-Field Test is the most widely used stability test in the U.S.A Specimens of the soil bitumen mixture, 2" in diameter and 2" high, are prepared in the moulding assembly under a static load of 600 lbs. After standing the specimens in water to a depth of 1" for 7 days their swelling is measured and the specimens are tested in assembly by measuring the load required to force the plunger into the specimen at a rate of 1" per minute. The soaked strength should not be less than 400 lbs. and the water absorption should not exceed 2%.

The Cone Penetrometer test, though not standardised, is quite commonly used. This involves the measurement of the resistance offered by the soil-bitumen mixture to the penetration of a right angled cone.

The capillary water absorption test (C.W.A.) was devised at the Road Research Laboratory, Harmondsworth for testing the efficiency of water-proofing stabilizers and is a development of the method standardized by the Institute of Petroleum.

Another very interesting test developed by Andrews and Noble in Kansas (U.S.A.) is the measurement of Contact Angles. For bitumen to spread, it must advance along the soil surface. The degree of spreading or wetting is indicated by a determination of the contact angle between the solid and liquid phase. It appears logical that the magnitude of the contact angle between a given soil and bitumen could be used as a measure of the suitability of the materials for bituminous stabilization.

In the contact angle studies, small drops of bitumen were placed on the end of carefully prepared soil briquettes and an actual size photograph taken. The developed plate was placed in a slide projector and the necessary measurement made on the projected image.

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TRAFFIC FLOW AT ROUNDABOUTS

A REVIEW OF THEORY AND PRACTICE

By

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(Concluded from September T.C.M.R.)

IT is apparent from the data given in the preceding articles on this subject, that the working, or design, capacities given by 75 per cent of Clayton's maximum figures correspond roughly to 60-70 per cent of the maxima given by Wardrop's formula and that actual observed flows show reasonable correlation with the theoretical results so obtained.

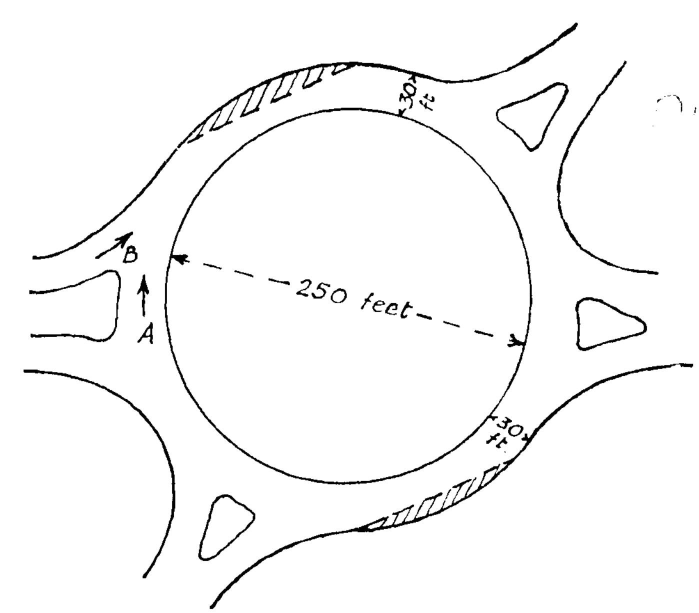

Fig. 1

Certain local circumstances, however, may sometimes exert an influence which requires special consideration. A specific example may serve as an illustration: Counts taken on one segment of the roundabout shown in outline in fig. 1 show that in round figures, a flow of 1,200 vehicles per hour from direction A can weave with 300 per hour from direction B without causing the formation of queues. As a result of the liberal curvature of the central island this weaving occurs at fairly fast speeds, but the full width of the circulating road is not utilised since traffic does not follow the reverse curve on the outer perimeter. The effective width is only two lanes and the theoretical capacity of this segment should not be based on a weaving width of 30 ft. It should be added that concentric curvature of the outer kerb line is now regarded as obsolete and this roundabout was constructed 20 years ago.

If the actual weaving width is used in the calculations, the observed flow of 1,500 vehicles per hour compares with 1,400 given by 75 per cent of Clayton's maximum, and 1,608 given by 60 per cent of the maximum derived from Wardrop's formula.

The P.C.U. Factor

The P. C. U. Factor, obtained by dividing the flow expressed in p.c.u.'s per hour by the flow expressed in vehicles per hour, is a useful measure of the "viscosity" of the flow, since it gives a numerical value of the obstructive effect of large, heavy vehicles running at a comparatively slow speed, but it does not necessarily give an indication of the relative importance of a road from the industrial standpoint.

This was shown clearly when a study was made of a road junction in north-east London. In this case the proportion of commercial and public service vehicles, as shown by a census taken in 1956 by Scotland Yard, was 38 per cent of the total motor traffic, but 27 per cent of the total motor traffic consisted of light commercial vehicles which count as cars in the p.c.u. classification. As a result, this junction has the low p.c.u. factor of 1·2, compared with the average figure of 1·5 or 1·6.

On the other hand, a high p.c.u. factor combined with a large total volume is a reliable *indication of a road's* industrial importance. A recent count on the London-Carlisle Road (A. 6), near South Mimms, for example, gave a p.c.u. factor of 2, compared with 1·1, on the western end of the Guildford By-pass and 1·2 on the Kingston By-pass near Tolworth.

It seems legitimate, when estimating the capacity of a roundabout, to make allowance for the difference between the local p.c.u. factor and the national average of 1·5.

Continental Developments

By the courtesy of M. De Bussy, the Chief Engineer of the Netherlands Highways, the writer has been enabled to include some interesting photographs of roundabouts in Holland. Fig. 3 illustrates a large one-level design at Oudenrijn, near Utrecht, at the intersection of the motor roads from the Hague to the German frontier and from Amsterdam to 's-Hertogenbosch, one of the most important junctions on the Netherlands motorway system. The circular island has a diameter of 282 ft and the width of the circulating road is 30 ft, with slip roads 8 ft wide for non-weaving traffic. An interesting feature is the provision of service stations on the loop roads branching from two of the *quadrants*.

Figs. 2 and 4 illustrate two level *junctions* incorporating roundabouts at Utrecht and Rotterdam.

These are, of course, a logical development of rotary traffic systems and are

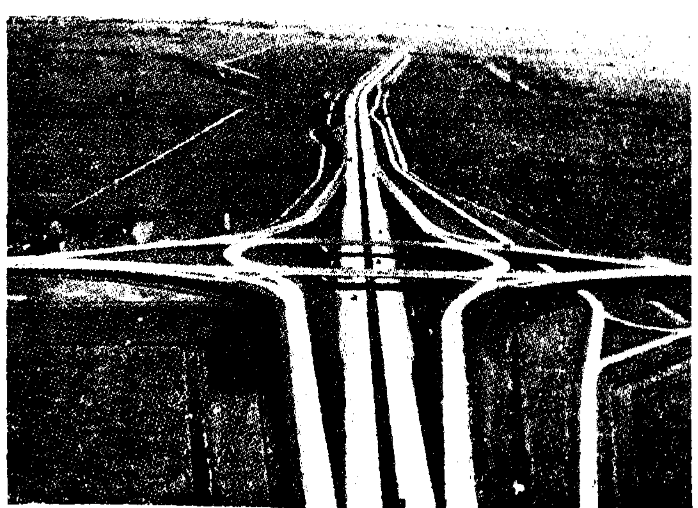

Fig. 2

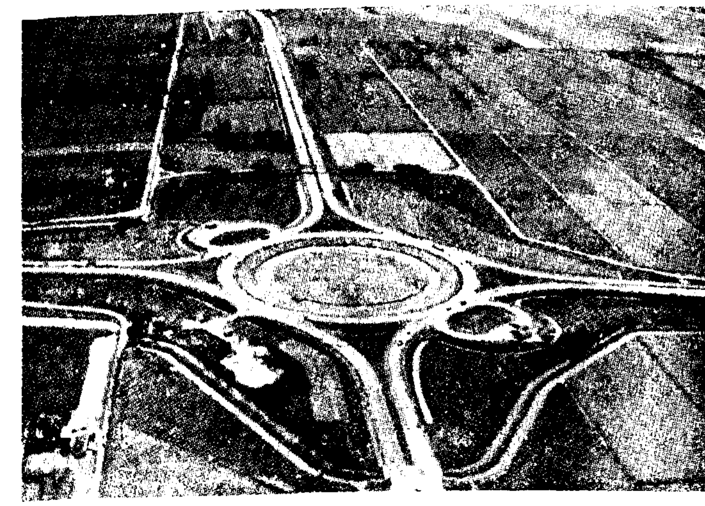

Fig. 3

justified when their high cost will yield a reasonable economic return.

General Conclusions

The inadequacy of certain obsolete roundabouts at peak periods should not be accepted as evidence that the traffic capacity of this system of junction design is strictly limited. The re-modelling of old designs can sometimes provide a considerable increase in capacity with comparatively little expense. The Middlesex County Council, for example, acting as agents for the Ministry of Transport, is about to reconstruct one such roundabout, without any demolition of property or serious encroachments, with the result that its capacity will be increased by at least 33 1/3 per cent.

It is estimated that the modernised design will carry some 4,000 vehicles per hour, with an overload capacity beyond this at short peak periods. The entire area occupied is only some 10,000 sq. ft. and even at peak flows it should prove much more effective than a signal controlled crossing, owing to heavy right-hand turns which traffic signals cannot handle satisfactorily.

Both Clayton's method of estimating capacity and Wardrop's formula serve as useful bases for calculation, but abnormal local conditions, such as exceptionally short weaving lengths at an oblique intersection, should be specially considered.

Some of the earlier roundabouts function excellently except for short peak periods, often of less than an hour's duration, and the possibility of temporary signal *control*, to break up persistent flows into workable units, might be tried as a remedy.

Legislation enforcing disciplined driving practice would assist in giving smoother progress with gyratory traffic working and clear advance direction signs should be provided to enable drivers to get into their correct lane at the earliest opportunity. Where possible, directive signs on the road surface are more effective than signboards on the verge. Floodlighting is perferable to a maze of dimly lit pylons.

If adequate weaving lengths are provided, together with easy curves at exits and at corners of quadrilateral islands, a design capacity of about 600 vehicles per hour per lane on each segment may be anticipated. A minimum weaving length of 150 ft is suggested with a minimum radius of 100 ft for exits and 70 ft for the central island.

This capacity is based on a p. c. u. factor of 1·5. With a lower factor, indicating greater fluidity of flow, a higher

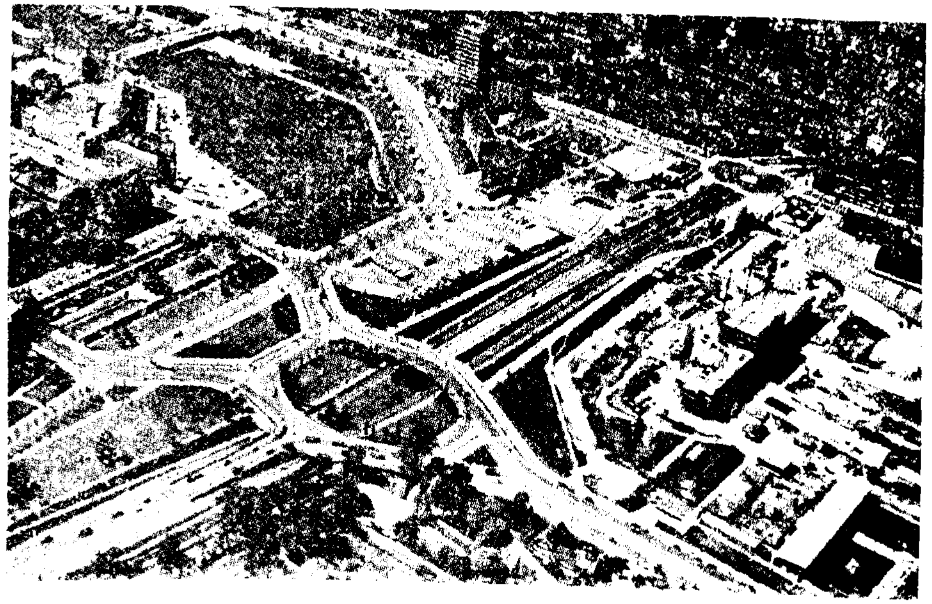

Fig. 4

capacity would be possible. This would also be obtained if the lane width were increased from the normal 10 ft to 12 ft. According to Nicholas[13] a capacity of 2,600 v. p. h. per segment is obtainable from a 36-ft carriageway with a weaving length of 220 ft.

Acknowledgments

The writer gratefully acknowledges the help he has received in preparing this article from the Commissioner of Police, Scotland Yard, the Ministry of Transport, the Road Research Laboratory, and the County Surveyors of Buckinghamshire, Middlesex and Surrey.

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(From "Highways and Bridges and Engineering Works", June 4, 1958).

SURFACE DRESSING AND CARPETING IN NOTTINGHAMSHIRE

REDUCED COST FROM GREATER MACHINE EFFICIENCY

IN his interesting paper on road maintenance, presented at the 85th annual conference of the Institution of Municipal Engineers at Scarborough, Mr. Reginald A. Kidd, B.SC., M.I.C.E., Nottinghamshire County Engineer and Surveyor, referred in some detail to an investigation into the suggestion that in addition to the introduction of mechanisation, efficiency all round should have increased. It was further thought that it should be possible to undertake the same volume of work for considerably less than double the pre-war amount despite doubled costs.

Unfortunately there was no direct comparison between costs at that date on certain specified work and corresponding costs in 1937. Comparisons were, however, made of costs in the year 1945-46 on the one hand and 1952-53 on the other, in respect of the two most extensive and in fact most expensive operations in the road maintenance programme, namely, surface dressing and surfacing. These are given by Mr. Kidd as follows:

(1) *Surface Dressing.* The figures produced are truly representative of the work in the two years, comparisons being taken over work extending to over 250,000 square yards. The costs quoted are actual costs in the respective years.

	Cost per sq. yard.		
	Materials	Application, etc.	Total
(a) 1945-46 Slag and Tar applied by hand methods.	3.55	2.54	6.09
(b) 1952-53 Slag and Tar applied by Flapper machine.	5.34	1.21	6.55
Difference.	+1.79	−1.33	+0.46

The saving of 1.33 d. per square yard on application relates to factors over which there is some control; the increase in expenditure on materials, namely, 1.79 d. per square yard, is accounted for purely by rising costs, the standard coverages having been obtained. The controlled saving of 1.33 d. per square yard on the figures produced is factual in relation to costs obtaining in the two respective years; the effective saving was in fact greater, having regard to the increase in costs which are not reflected in these figures.

(2) *Surfacing.* Comparison was made in respect of the complete surfacing programme in two respective years.

	Cost per square yard excluding materials.
1938-39 ...	9.68 d.
1951-52 ...	7.88 d.
Difference ...	−1.80 d.

These figures must be treated with some reserve as in 1938-39 there was a substantial amount of three-coat work while in the 1951-52 programme the bulk of the work was single-coat.

(3) *Machine Surfacings.* Comparison of similar individual works—

(a) *Thin slag carpet.*

	Cost per square yard excluding materials.
1945-46 ...	7.11 d.
1952-53 ...	5.38 d.
Difference ...	−1.73 d.

(b) *Thick carpet.*

1945–46	...	10.50 d.
1952–53	...	6.14 d.
Difference	...	– 4.36 d.

(c) *Thin carpet.*

1946–47	...	6.32 d.
1952–53	...	4.11 d.
Difference	...	– 2.21 d.

Savings indicated by the above figures in respect of laying and rolling are actual as occured. Effective savings were in fact greater when regard is had to incidence of increased costs between 1945–46 and 1952–53.

A logical conclusion to be drawn from these figures is that between 1945 and 1952 efficiency in the application of materials to road surfaces by machine methods increased considerably. No doubt this is due to several factors, including the urge for increased output per day, while overhead costs on machines tended to remain stable, and the extension of mechanical methods to, for instance, loading of chippings.

Another very productive factor in increased efficiency and reduced costs is undoubtedly the system that has been developed over the past few years in laying down a standard for every operation, based on man/hours in relation to output, and the setting out in detail each year, for the benefit of divisional surveyors and their foremen, of defined standards and the preparation of a complete works programme on a man/hour basis.

(*From "Highways and Bridges and Engineering Works", July 2, 1958*).

THIRTY EIGHT YEARS AGO

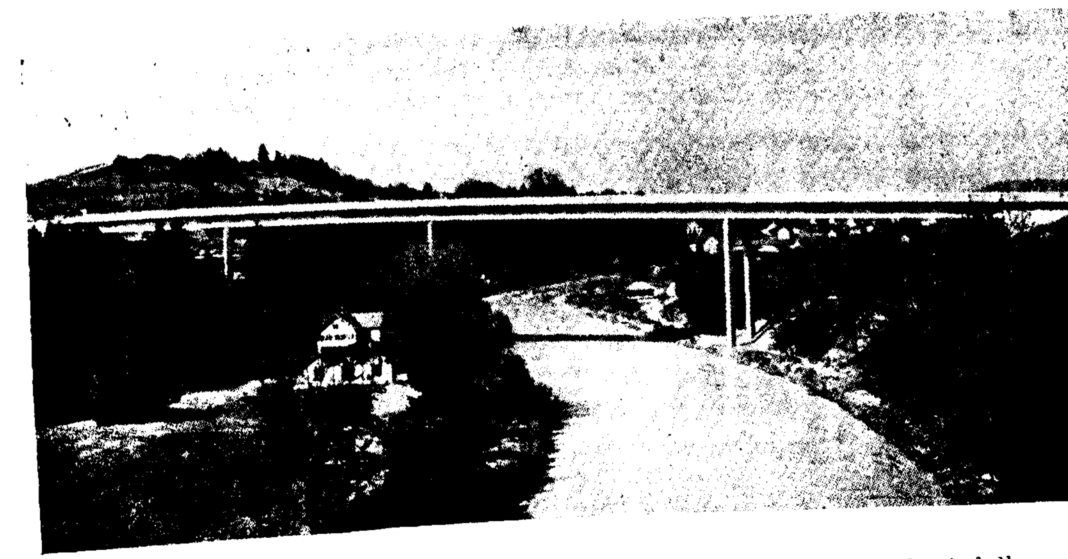
Some engineers and other authorities, when discussing widths of roads, have been accustomed to look upon them as a means of providing for traffic requirements only, and in my view this is a serious error. As one who has had the opportunity of observing almost daily for over 30 years the use made of a roadway, somewhat exceeding 120 feet in width, within the built-up portion of the City, I could not fail to recognize the very great value of such a space to the residents in the closely-housed areas on each side of it immediately behind the more imposing frontage residences.

Especially in the evenings after business hours, and during the winter months, when parks and recreation grounds are practically unlit and therefore not available, the roadway is largely used as a promenade and exercise ground, and it is not too much to say that no other space provided by the public authority is more appreciated and used.

(*From: "The Address by John Alexander Brodie, President, Institution of Civil Engineers," U. K., 1920*)

HERE AND THERE

1. THE WEINLAND BRIDGE



● THE Weinland bridge is the chief engineering structure on the Andelfigen by-pass road; it was built between 1956 and 1958.

This bridge crosses the valley of the Thur at a height of 40 m and has a total length of 293 m. The width between the hand rails is 16.50 m.

Certain difficulties were encountered in the construction of the foundations because the soil consists of fine sand and morainal clay in the underground water. The maximum pressures on the soil amount to 7.5 kg/cm². The superstructure consists of a continuous girder with three webs extending over 4 bays, having lengths of 57, 76, 88 and 66 m, respectively, and a height of 3.90 m; this girder is fully prestressed in the longitudinal direction; in the transverse direction the girder is partially prestressed. The prestressing was carried out by means of the BBRV system.

The superstructure was erected in three stages, on the basis of cantilevers measuring 34.5 m. These stages were designed in such a manner that with the above-mentioned cantilevers no stress occurred during the course of the work which differed substantially from the design stress when the construction was completed.

(*From "Bulletin AIPC - Mitteilungen IVBH - BULLETIN IABSE", August 15, 1958*).

2. AUSTRALIAN ROADS CAMPAIGN

● THE Australian Road Federation has drawn up an operational plan applying to all regions to bring about improvement of the national road system. It emphasises that a new approach to the road question is called for; at present states have the constitutional responsibility for road development but it is beyond their financial resources. The Commonwealth, on the other hand, has no constitutional powers regarding roads but augments state road-building funds with an annual grant. The A.R.F. urges therefore that the Commonwealth assume entire financial responsibility for arterial roads, financing this from existing revenue taxation on motor vehicles and associated products, from consolidated revenue and from specific loan funds. The States would devote existing federal road grants and state road taxation revenue to the development of inter-state secondary highways and other roads.

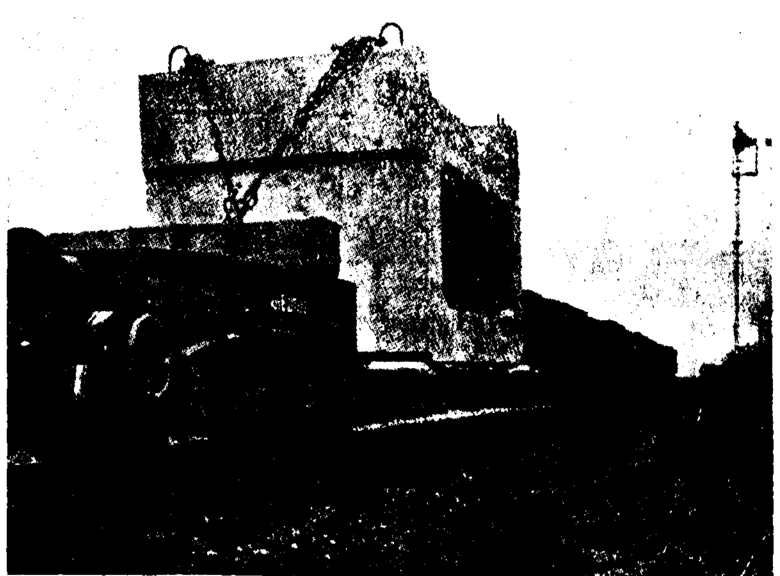
(*From "Modern Transport", July 12, 1958*).

3. SPECIAL COURSE IN PRESTRESSED CONCRETE

● THE University of Roorkee is running a three weeks' Special Course in Prestressed Concrete from 1st to 20th December, 1958 in close collaboration with the Central Building Research Institute, Roorkee. The Course is designed to be of Post Graduate level and high order for the benefit of serving Engineers in the country. Fees for the course is Rs 125 only. Engineering Graduates who have put in atleast two to four years of service in the field are eligible for admissison. For details regarding syllabus etc., kindly write to the Director, Refresher Courses, University of Roorkee, Roorkee.

4. PRECAST CONCRETE BLOCKS OF 35 TONS

● A NEW rail bridge of 122 ft span, made from 35-ton concrete blocks, is being erected by British Railways (London, Midland Region) in Manchester. It will carry the Stockport — Manchester line over Stockport Road and replace two existing bridges which were not suitable for supporting the ballasted tracks



One of the 35-ton precast blocks for the London Midland Region's new bridge on the Stockport-Manchester line is here shown loaded for transport by rail

required for the intensive traffic planned under future electrification. The concrete blocks are hollow and will be post-tensioned in a slightly arched span. Because of the arching and the fact that the new bridge will cross the roadway on the skew, the blocks vary a little in shape. Such large precast units minimise construction time, and, hence, interference with train services.

Sixty-four of these 35-ton blocks will be needed; special arrangements have had to be made to transport them by rail from Norwich, where they were cast. The new bridge will be erected alongside the existing bridges and rolled into position in four sections when they are removed. The first beam of the new bridge should by now be erected alongside; the whole job will be completed by September.

The bridge will carry each of the four railway tracks on a post-tensioned hollow concrete beam made up of sixteen of the large blocks, the total weight of each beam being about 500 tons. Each beam will be assembled on a platform between rolling-in trestles alongside the existing bridges, post-tensioned and then rolled in. The post-tensioning will amount to a total force of 3,700 tons in each beam. The blocks were manufactured by Anglian Building Products, Ltd., of Lenwade, Norwich, and were the largest items of their kind ever made at a factory in this country. They are being erected and post-tensioned by L. Fairclough, Ltd.

(*From "The Engineer", May 30, 1958*).

5. MINISTRY OF TRANSPORT, U. K., SET UP TRAFFIC ENGINEERING BRANCH

● IN view of the growing importance of traffic engineering as a branch of highway engineering, Mr. J. F. A. Baker, M.I.C.E., Chief Engineer (Highways), Ministry of Transport and Civil Aviation, has established a Traffic Engineering Branch under Mr. W. F. Adams, an Assistant Chief Engineer.

It is hoped that local authorities will be encouraged to follow the lead given by the Ministry in giving more detailed attention to the need for more statistics and data, so valuable for highway design and planning and in establishing reconstruction priorities and economies.

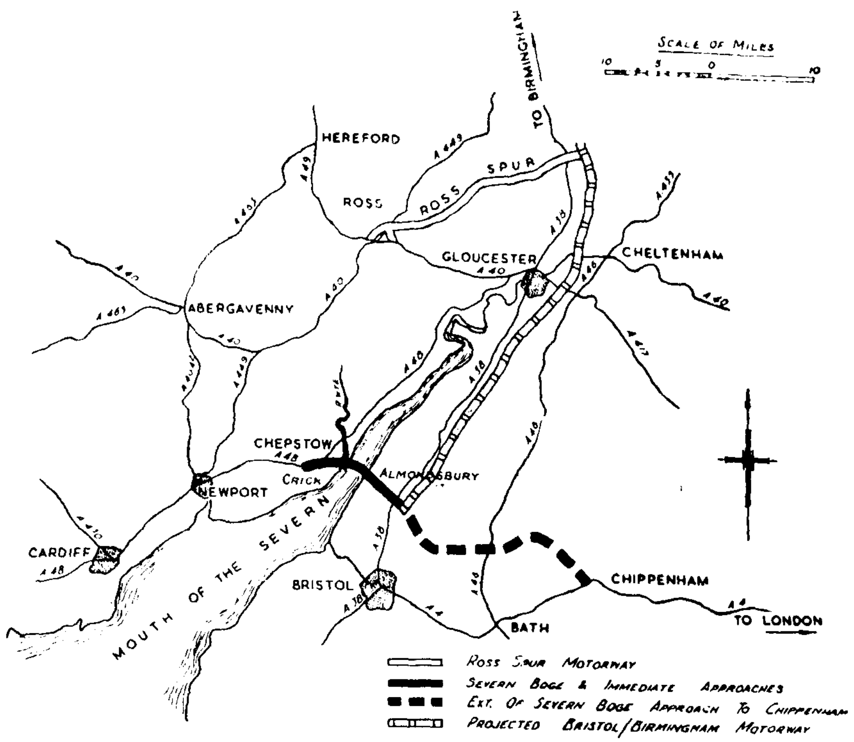
(*From "Highways and Bridges and Engineering Works", June 11, 1958*).

6. THE SEVERN BRIDGE

● THE Government has been advised that in the interest of economy and efficiency the construction of the Severn Bridge should be properly phased with that of the Forth Bridge. In effect this means that, if everything goes according to plan, it is hoped to start constructional work on the Severn Bridge some two years after work on the Forth Bridge is reasonably well advanced.

In the meantime preparatory work on the Severn Bridge scheme will continue. The proposed suspension bridge when complete is expected to be the fifth largest span bridge in the world. It will be sited between Aust and Beachley, where the motor ferry now operates.

In addition to the main bridge over the Severn, the River Wye is also to be bridged and there will be several miles of viaduct and approach roads linking the two new bridges to the existing trunk roads at Almondsbury on the east (A. 38) and grick on the west (A. 48). This full scheme is estimated to cost some $15\frac{1}{2}$ million pounds of which about 10



million pounds will be for the main bridge over the River Severn. The new roads will be restricted to motor traffic except for the two bridges which will have separate provision for cyclists and pedestrians to cross the rivers.

The consulting engineers engaged to prepare the scheme for bridges over the Severn and Wye and the immediate approach roads are Messrs Mott, Hay and Anderson in association with Messrs Freeman, Fox and Partners. Sir Percy Thomas is the consulting architect, valuable information about the behaviour of suspension bridges in strong winds was learned from experiments conducted by the Department of Scientific and Industrial Research. These included the testing of a 52 ft model of the proposed Severn Bridge in a wind tunnel. Continuous records were also kept of the speed, direction and inclination of the winds over and near the actual site. As a result modifications have been made in the design which will ensure that the bridge is fully able to withstand winds of any velocity likely to be experienced.

Tolls

The Minister of Transport intends that the Severn and Wye bridges, in common with other major bridge and tunnel projects, should be financed by tolls.

Technical details

The main structure over the River Severn will be a steel suspension bridge on concrete piers with steel towers 500 ft high. The main span will be 3,240 ft — slightly less than the 3,300 ft proposed for the Forth Bridge—and each of the two side spans will be 1,000 ft. The road level, 140 ft above high water mark of ordinary tides at the piers and 160 ft in the centre, will give a 130 ft height clearance for navigation at the centre of the span. The road deck of steel, with a thin asphalt covering, will be on top of the stiffening trusses which will be 29 ft 7 in. deep. The width between parapets of the bridge will be 94 ft. Twin 24 ft wide carriageways will be constructed, divided by a 10 ft wide air gap in the centre of the bridge. Outside the main trusses, provision is made for cycle tracks and footways.

The bridge over the River Wye will be 1,517 ft long and will consist of nine steel spans carried on concrete piers. This bridge will have a width between parapets of 94 ft containing two 24 ft carriageways, cycle tracks and footways.

It is estimated that 50,000 tons of steel and 130,000 tons of cement will be required for the two bridges and approach viaducts.

(From "Roads and Road Construction", August, 1958).

7. FIRST TOLL ROAD IN CANADA

● CANADA'S first toll highway, the 30-mile six-lane Laurentian Autoroute in Quebec, is due for completion this winter. Some access points will be built along the route but basically it will serve through traffic. There will be two large and four smaller bridges, under-passes and over-passes, 14 interchange and six clover-leaf junctions.

(From "Modern Transport," August 30, 1958).

8. PLAIN WORDS

● SOMETIMES I wonder what an engineer really does. Oh yes, I know the usual definitions—a man who applies science economically to social purposes, who adapts nature to human ends, and so on—but is it as simple as all that? A meteorologist applies science to social purposes, but who would call a meteorologist an engineer? A gardener adapts nature to human ends, but horticulture is unlikely to be taught in even the broadest engineering syllabus. Now-a-days we have biochemical engineering and a whole host of other accretions to the subject. Perhaps, therefore, it is time to reconsider what we mean by engineering.

It is not solely a question of definition, that would be unnecessary pedantry. We talk about training an adequate number of engineers, but are we certain what we should train an engineer to be? Perhaps we should teach him to be a lot of different things, and not care too much whether he fitted any particular definition. But at least he should be able to do the jobs an engineer is called upon to do.

The Americans, I gather, have been complaining that engineering education has become mere tuition in the use of handbooks. Thus when radar and atomic energy came along, for which there were no handbooks, the authorities turned to chemists and physicists to get the new technologies on their feet. In Russia the manual and the handbook have become very well established ; you could design a gas turbine after a course at the polytechnic but you'll be stuck if you have to turn your hand to something new. That is where Britain scores. The teaching of fundamental principles has been the basis of engineering education here, and is no doubt one reason why our qualified men are so welcome in America.

Incidentally, I gather that at the Massachusetts Institute of Technology, where training is also pretty fundamental, they will lend you money to pay your tuition fees ; but you have to pay them back after graduation—unless you win a scholarship. Subtract these repayments from your first few years' salary, and you may be no better off than an engineer in England. The man who emigrates after qualifying at Britain's expense is getting the best of both worlds.

But what an engineer is paid is a comparatively small part of what he is. Some Americans fear that if engineers are taught basic principles alone they will become little more than applied scientists, lacking due regard for the practical conservatism that engineering work requires. An engineer must be concerned both with margins of safety and with economics, neither of which can be numerically scientific. If he also knows how to forecast the weather and to prune an apple tree, all to the good.

(From "Engineering", June 27, 1958)

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9. BOMBAY STATE ROAD TRANSPORT

● THE State Transport buses carried 1848.79 lakhs of passengers during the year as against 1,693 lakhs in the previous year, in spite of the reduction in the area of operation in the last quarter of the year. The daily average number of passengers carried increased from 3,81,993 to 4,39,534 at the end of the year under report, a rate of increase of 15.06 per cent. It will be seen from these figures that there has been a general trend for the traffic offered to rise.

(From "The Sixth Annual Administration Report of The Bombay State Road Transport Corporation for the Year 1956-57).

SPELLINGS

The head of a motoring concern was admonishing his new Secretary.

"Look here", he said, flourishing one of her efforts, "you haven't the remotest idea of spelling. D'you know you've spelt 'pneumatic' 'newmatic'?"

"I'm Sorry", said the girl, drawing herself haughtily, "but the 'K' on my machine is not working."

DEFINITIONS OF HIGHWAY ENGINEERING TERMS

PAVEMENT: The superficial covering of a carriageway, a cycle track or a footpath.

PAVING: A wearing coat consisting of separate blocks or units fitted closely together and having joints between them.

CURRENT LITERATURE

ABSTRACTS

DEVELOPMENT OF NEW NON-SKID ROAD SURFACE TREATMENT; Bulletin No. 184, Highway Research Board of the National Academy of Sciences—National Research Council, 2101, Constitution, Washington, D. C.

THIS bulletin contains two papers on this subject as presented at the 36th Annual Meeting of the Highway Research Board.

The first, by H. S. Nagin, T. G. Nock and C. V. Wittenwyler, describes development and laboratory and field testing of a new skid-resistant roadway surface treatment based on thermosetting epoxy resins. Included in the discussion are descriptions of several methods of application used in the field.

The second, by Warren M. Creamer and R. E. Brown, describes the service testing of the same surface treatment as applied to the concrete apron and toll booth area at the Milford Toll Station on Connecticut's Wilbur Cross Parkway. The good safety record at this location since installation of the surfacing testifies to its effectiveness as a skid-resistant material. Frequent physical testing of the coating has indicated little degradation of the coating or of its adhesion to the underlying concrete.

CONTINUOUSLY REINFORCED CONCRETE PAVEMENT: FULL-SCALE AND MODEL TESTS; Bulletin No. 181, Highway Research Board of the National Academy of Sciences—National Research Council, 2101, Constitution, Washington, D. C.

THE two papers contained in this bulletin were presented at the 36th Annual Meeting of the Highway Research Board under the sponsorship of the Committee on Rigid Pavement Design.

The first paper, by Wayne R. Woolley, proposes certain design principles based on experience gained from existing continuously reinforced concrete pavements. Approximately 0.5 per cent of steel will not break and the frequent cracks formed in the concrete are narrow enough to give many years of satisfactory service with very little maintenance.

The second paper, by R. L. Schiffman, I. J. Taylor, and W. J. Eney, is a Preliminary report on the construction procedures and investigatory details of two experimental continuously reinforced concrete pavements constructed by the Pennsylvania Department of Highways.

SOIL STABILIZATION STUDIES 1957; Bulletin No. 183, Highway Research Board of the National Academy of Sciences—National Research Council, 2101, Constitution, Washington, D. C.

THIS bulletin contains five papers on soil stabilization by means of additives as reported at the 36th Annual Meeting of the Highway Research Board.

The first, by J. W. Reppel, describes the results obtained with "Salt Stabilization on Ohio's Secondary System", especially the low-traffic farm-to-market portion of the highway network.

The second, by R. K. Viskochil, R. L. Handy and D. T. Davidson, describes the methods and results of a study on "Effect of Density on Strength of Lime-Flyash Stabilized Soil.

The third, by Eugene A. Miller and George F. Sowers, describes studies on "The Strength Characteristics of Soil-Aggregate Mixtures".

Paper four, by Raymond F. Dawson and Chester McDowell, gives the results of the use of dust from "Expanded Shale as an Admixture in Lime Stabilization".

The fifth paper, by T. William Lambe and Zu-Cheih Moh, discusses the "Improvement of Strength of Soil-Cement with Additives", including dispersants, synthetic resins, water-proofing agents, and several salts and alkalies.

CORROSION OF REINFORCING STEEL AND REPAIR OF CONCRETE IN A MARINE ENVIRONMENT; Bulletin No. 182, Highway Research Board of the National Academy of Sciences—National Research Council, 2101, Constitution, Washington, D.C.

THIS bulletin comprises the two parts of paper entitled "Causes and Repair of Deterioration to a California Bridge Due to Corrosion of Reinforcing Steel in a Marine Environment", as presented at the 36th Annual Meeting of the Highway Research Board.

Part I, by M. W. Gewertz, discusses the history, character and extent of the deterioration encountered in the San Mateo Hayward Bridge; the inspection and estimating procedures prior to repair; repair procedures; the basis of contract payment; and the costs of repairs.

Part II by Bailey Tremper, John I. Beaton, and R. F. Stratfull, discusses the fundamental factors causing corrosion of the reinforcing steel in this bridge, and points out that the spalling and rupture of the various members are primarily the result of pressures caused by the corrosion products. No evidence was found that stray currents had produced electrolysis.

SURKHI FOR USE IN MORTAR AND CONCRETE

SURKHI has been finding extensive application in mortar in buildings and irrigation works of our country. It is a good Pozzolana when ground sufficiently fine, and hence can find use with lime to form a cementitious mixture, and use with portland cement to improve certain of its properties. In current practice Surkhi is generally obtained as a by-product of the brick industry, by powdering rejected and broken bricks. This is not always a good practice, and some light has been thrown by recent research work on the type of raw material, the degree of burning and the fineness of grinding for obtaining good surkhi. With the object of giving a general guidance as to the manufacture of surkhi on the basis of these findings, and laying down requirements and tests ensuring its suitability as a basic material for structural mortar, the Indian Standards Institution has brought out a draft standard specification for surkhi for use in Mortar and Concrete [Doc: BDC 16 (374)] covering the manufacture, physical and chemical requirements of surkhi.

The standard specifies three compulsory tests namely for fineness, lime reactivity, and compressive strength. Any further tests desired for surkhi for use as a pozzolana may be covered in individual specifications.

As a guidance to manufacture, an appendix has been included on the structure, properties and identification of clay minerals and their influence on the pozzolanic reactivity of surkhi.

Copies of the draft specification are being widely circulated for eliciting comments by *23rd September 1958*. Copies are obtainable on request from the Indian Standards Institution's headquarters office at New Delhi-1, or from its branch offices at Bombay-1, Calcutta-1, & Madras-1.

PROTECTION

"Dad", asked the small boy, "why is a man allowed to have only one wife?"

"My son", replied the father, "When you are older you will realize that the law protects those incapable of protecting themselves."

SELECTED RECENT LITERATURE IN ENGINEERING JOURNALS

I. GENERAL

1. **Responsibilities of an Inspector**; G. BLOODGOOD AND L. H. TUTHILL, *Journal of the American Concrete Institute, Vol. 28, No. 9*, March 1957, pp. 899-904.

2. **The Technical Problems of Spanish Roads at the Laboratory and at the Site**; PROF. JOSE-LUIS ESCARIO, *Revue Generale des Routes et des Aerodromes, Vol. 27, No. 306*, July 1957, pp. 61-70 (in French).

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31. **Determining Run-off from Rainfall**; James Edward Nash, *Paper No. 6282, Proceedings of the Institution of Civil Engineers, Vol. 10*, June 1958, pp. 163-184.

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VANITY

In the midst of her first driving lesson, Mrs. Williams complained to her husband: "George, that little mirror up there isn't set right."

"You think not?" he replied.

"No", his wife protested. "I can't see a thing in it but the car behind."

RECENT ADDITIONS TO THE LIBRARY OF THE INDIAN ROADS CONGRESS

1. **B. S. 473: 1956, Concrete Plain Roofing Tiles and Fittings**; British Standards Institution, British Standards House, 2, Park Street, London W. 1.

2. **B. S. 569: 1956, Asbestos Cement Rainwater Pipes, Gutters and Fittings**; British Standards Institution, British Standards House, 2, Park Street, London W. 1.

3. **B. S. 1076: 1956, Mastic Asphalt for Flooring (Limestone Aggregate)**; British Standards Institution, British Standards House, 2, Park Street, London W. 1.

4. **B. S. 1236-40: 1956, Sills and Lintels (Clayware, Cast Concrete and Natural Stone)**; British Standards Institution, British Standards House, 2, Park Street, London W. 1.

5. **"Manual of Information Concerning the Operation and Maintenance of the Public Roads Relative Road Roughness Indicator"**—(Prepared by the Division Tests, May 1941), Public Roads Administration, Washington.

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7. **Govt. of India—The First Five Year Plan**; Planning Commission, Govt. of India Press, New Delhi.

8. **Technical Bulletin No. 12, "Treatment of Railway Level Crossings", 20th July 1955**; Country Roads Board, Exhibition Building, Carlton No. 3, Victoria, Australia.

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10. **B. S. 368: 1956, "Precast Concrete Flags"**; British Standards Institution, British Standards House, 2, Park Street, London W. 1.

11. **B. S. 550: 1956, "Concrete Interlocking Roofing Tiles"**; British Standards Institution, British Standards House, 2, Park Street, London W. 1.

12. **B. S. 2717: 1956, "Glossary of Terms Applicable to Roof Coverings"**; British Standards Institution, British Standards House, 2, Park Street, London W. 1.

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14. **B. S. 1451: 1956, "Coloured Mastic Asphalt Flooring (Limestone Aggregate)**; British Standards Institution, British Standards House, 2, Park Street, W. 1.

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BUDGETS AND ADMINISTRATION REPORTS

GOVERNMENT OF RAJASTHAN CIVIL WORKS BUDGET FOR 1958-59

The following extracts relating to Civil Works have been taken from the Government of Rajasthan Budget for the year 1958-59.

Revenue (Civil Works)

Heads	(Rupees in lakhs) Revised Estimate 1957-58	Budget Estimate 1958-59
Rents	12.28	20.00
Ferry receipts	0.16	0.16
Tolls on roads	0.03	—
Transfer from Central Road Fund	7.74	19.16
Grants from Government of India for the development of State Roads of Economic or Inter-State Importance	17.22	17.59
Miscellaneous	7.95	8.00
Deduct-refunds	-0.25	-0.21
Total	45.13	64.70
Expenditure (Civil Works)		
Buildings		
Original works	1.40	0.19
Repairs	27.02	27.52
Communications		
Original works	24.96	36.75
Repairs	78.00	79.50
Miscellaneous		
Original works	—	—
Repairs	3.00	3.00
Furniture	0.59	0.42
Suspense	-0.60	0.86
Grants-in-Aid	6.01	6.00
Establishment	6.68	8.69
Tools and Plant	2.82	3.48
Add-New Item	--	3.29
Total	149.88	169.70

Capital Account of Civil Works Outside the Revenue Account

Heads	(Rupees in lakhs) Revised Estimate 1957-58	Budget Estimate 1958-59
Original works		
Buildings	182.38	206.42
Communication	176.00	160.00
Miscellaneous	2.63	0.25
Grants-in-aids	10.00	10.00
Establishment	0.05	0.50
Tools and Plant		
New items of expenditure	...	36.72
Deduct - Receipts and recoveries on Capital Account	-56.50	-104.51
Amount transferred from 57-Miscellaneous	-3.20	-4.20
Grant to Municipal Board		
Add-pro-rate charges transferred from Demand No. XXII-charges on Buildings and Roads (combined)		
Establishment and tools and plant (including New items)	26.46	31.54
	337.82	336.72
Revenue from Roads		
Receipts under the provincial Motor Vehicles	65.14	68.14
Other receipts	0.15	0.15
Revenue from the sales of Motor Spirit	28.40	30.00
Deduct-refunds	-0.34	-0.34
	93.35	97.95

GOVERNMENT OF RAJASTHAN CIVIL WORKS BUDGET 1958-59.

(A brief review)

REVISED estimates of revenue and expenditure for the year 1957-58 are Rs 3069.40 lakhs and Rs 3225.32 lakhs respectively. Thus deficit on revenue account is Rs 155.92 lakhs. Budget Estimates for the year 1958-59 of revenue and expenditure are Rs 3393.91 lakhs and Rs 3374.41 lakhs leaving a surplus of Rs 19.50 lakhs.

Revenue expenditure on civil works in 1958-59 is estimated at Rs 169.70 lakhs, which forms 5.0 per cent of the total revenue. The estimated expenditure on communications (original works and repairs) is 3.4 per cent of the total revenue for the year 1958-59.

The total outlay on civil works outside the revenue account for the year 1958-59 is Rs 336.72 lakhs, out of which Rs 160.00 lakhs are proposed to be spent on communications alone.

LIST OF APPROVED WORKS ON NATIONAL HIGHWAYS

S. No.	Job No.	Name of Work	Amount (Rs in Lakhs)
		ASSAM	
1.	1919 AS 38	Re-construction of bridge No. 334/3 on Makum-Ledu-Lekhapani Road, National Highway No. 38.	0.19
		DELHI	
2.	1922 DLH 24	Survey for the construction of a bridge across the Yamuna river at Delhi from the site of the new proposed railway bridge opposite to Purana Qila upto Okhla.	0.05
		MADHYA PRADESH	
3.	1915 MP 26	Black topping of Narsinghpur Lakhandon Road-miles 3 to 43 (41 miles) Section of N. H. No. 26 in Madhya Pradesh	6.51
4.	1917 MP 3	Breach of National Highway No. 3 in mile 212/1 in Gonda District—Construction of a Culvert at the breached portion.	0.32
		MYSORE	
5.	1921 MY 7	Construction of culvert at mile 2/41 of Bangalore-Bellary Road, N. H. No. 7.	0.16

PERSONAL AND MISCELLANEOUS

SHRI P. N. WANCHOO, has been appointed as Chief Engineer, Irrigation, Kashmir.

* * * *

SHRI B. P. PATEL, has been promoted to officiate as Planning Officer, Ministry of Transport and Communications, Department of Transport, (Roads Wing).

* * * *

SHRI KANWAR SAIN (Life Member), Chairman, Central Water & Power Commission, has proceeded on leave preparatory to retirement.

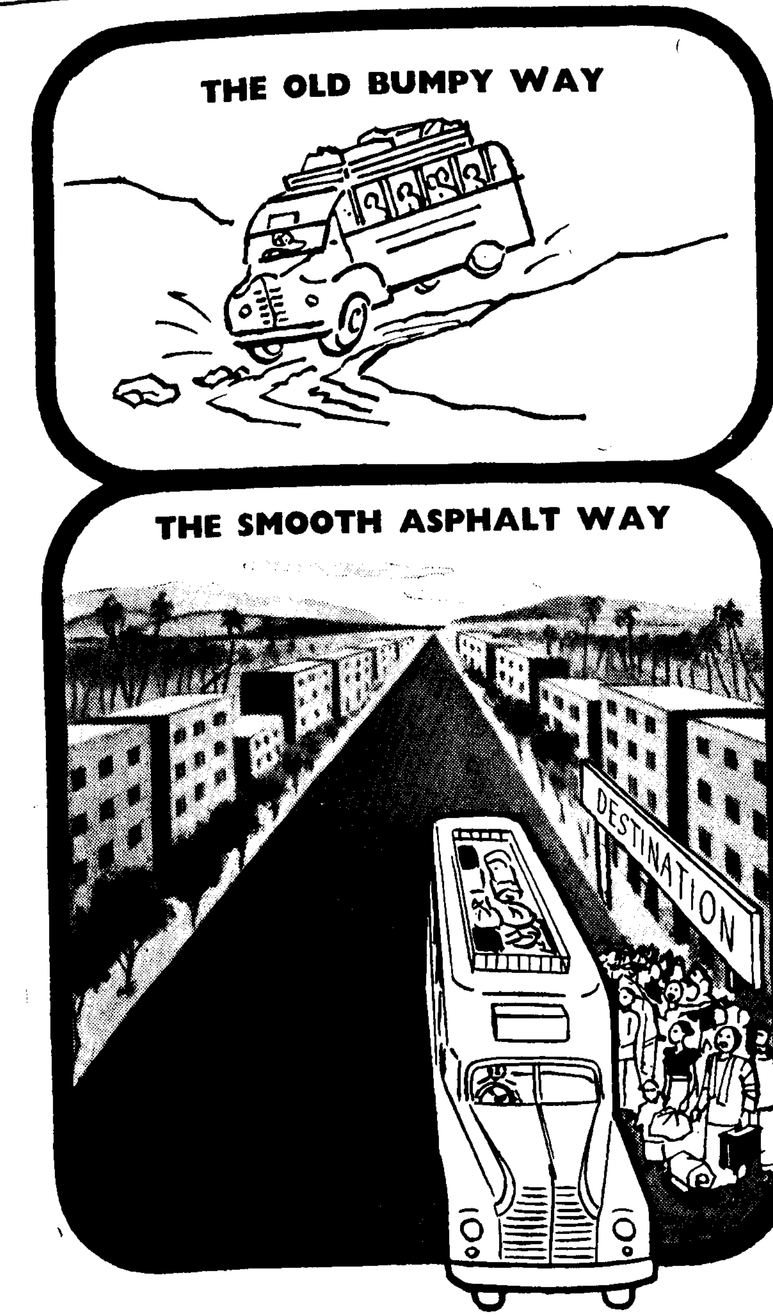
* * * *

OBITUARY

We record with deep regret the sudden death of Mr. E. P. NICOLAIDES, Deputy Managing Director and General Manager, Gammon (India) Private Limited, at Lausanne, Switzerland. Mr. Nicolaides was an active member of the Indian Roads Congress and was closely connected with the work of the Bridges Committee.

* * * *

The Fourteenth Annual General Meeting of the International Air Transport Association is to be held at New Delhi on October 27, 1958. More than 350 delegates from 85 IATA associates from about 50 countries are expected to attend.



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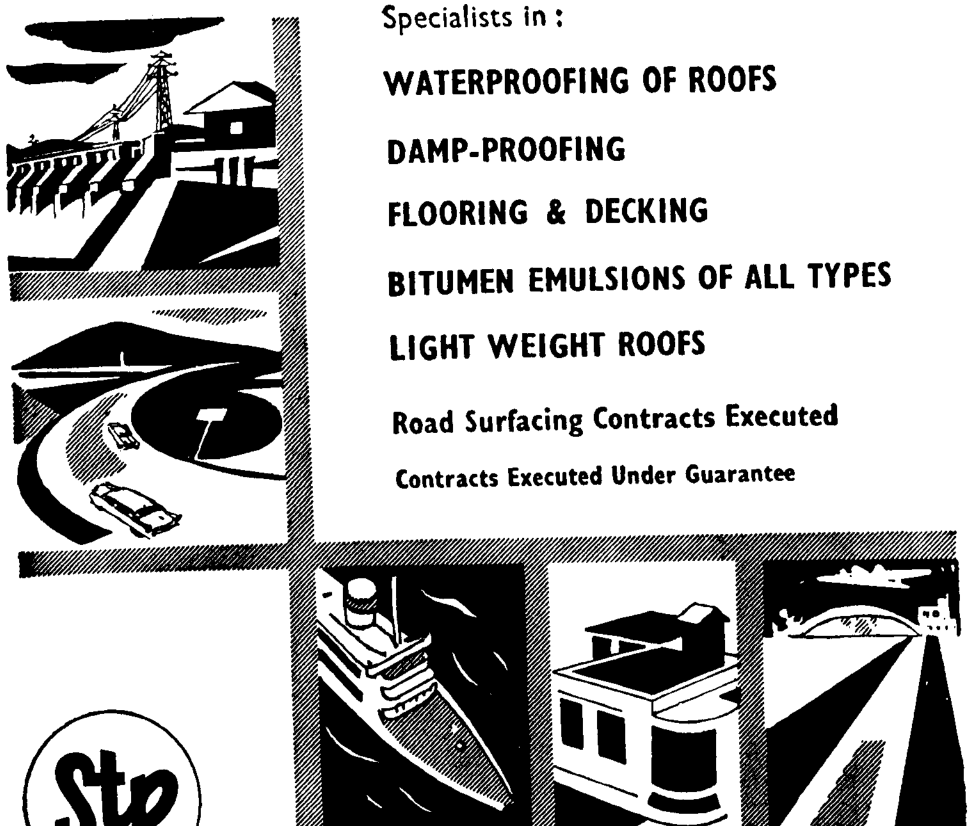

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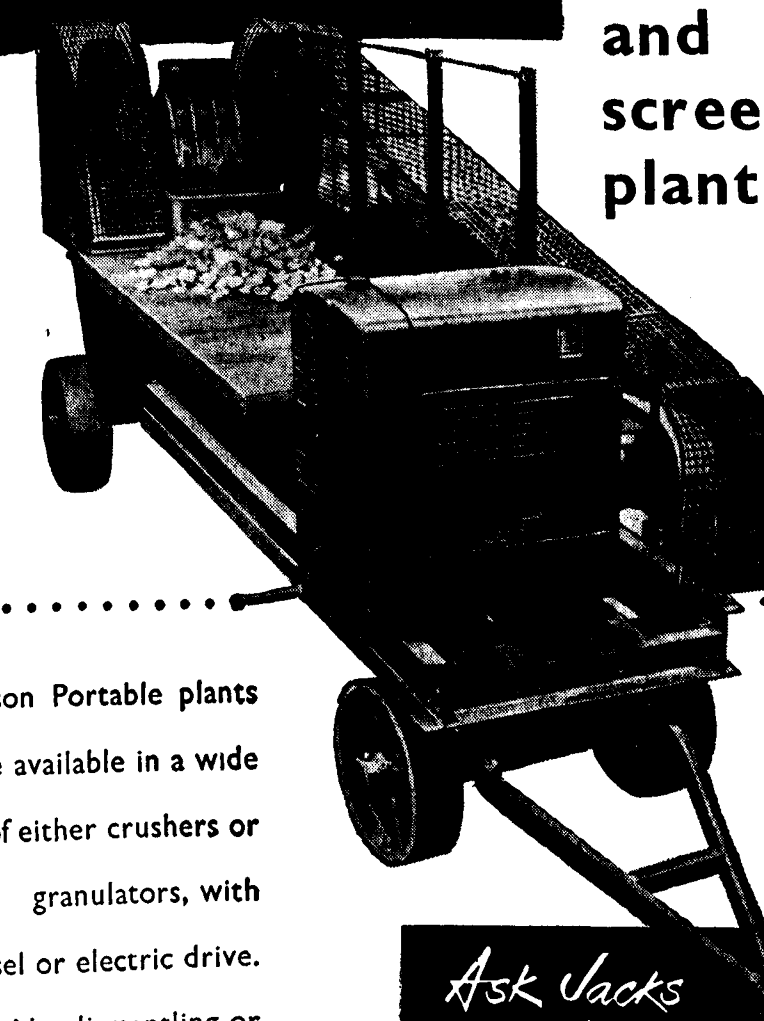

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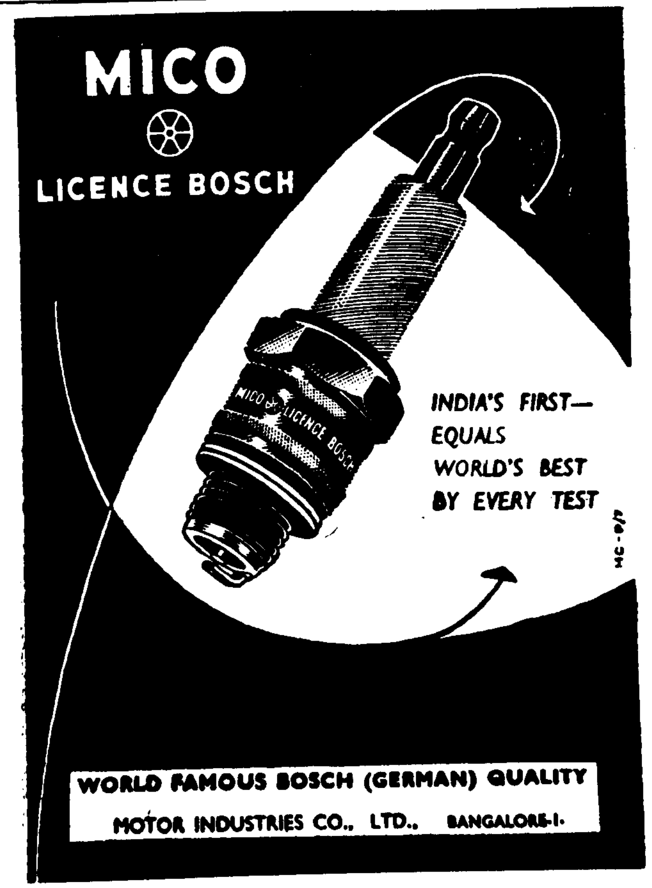

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