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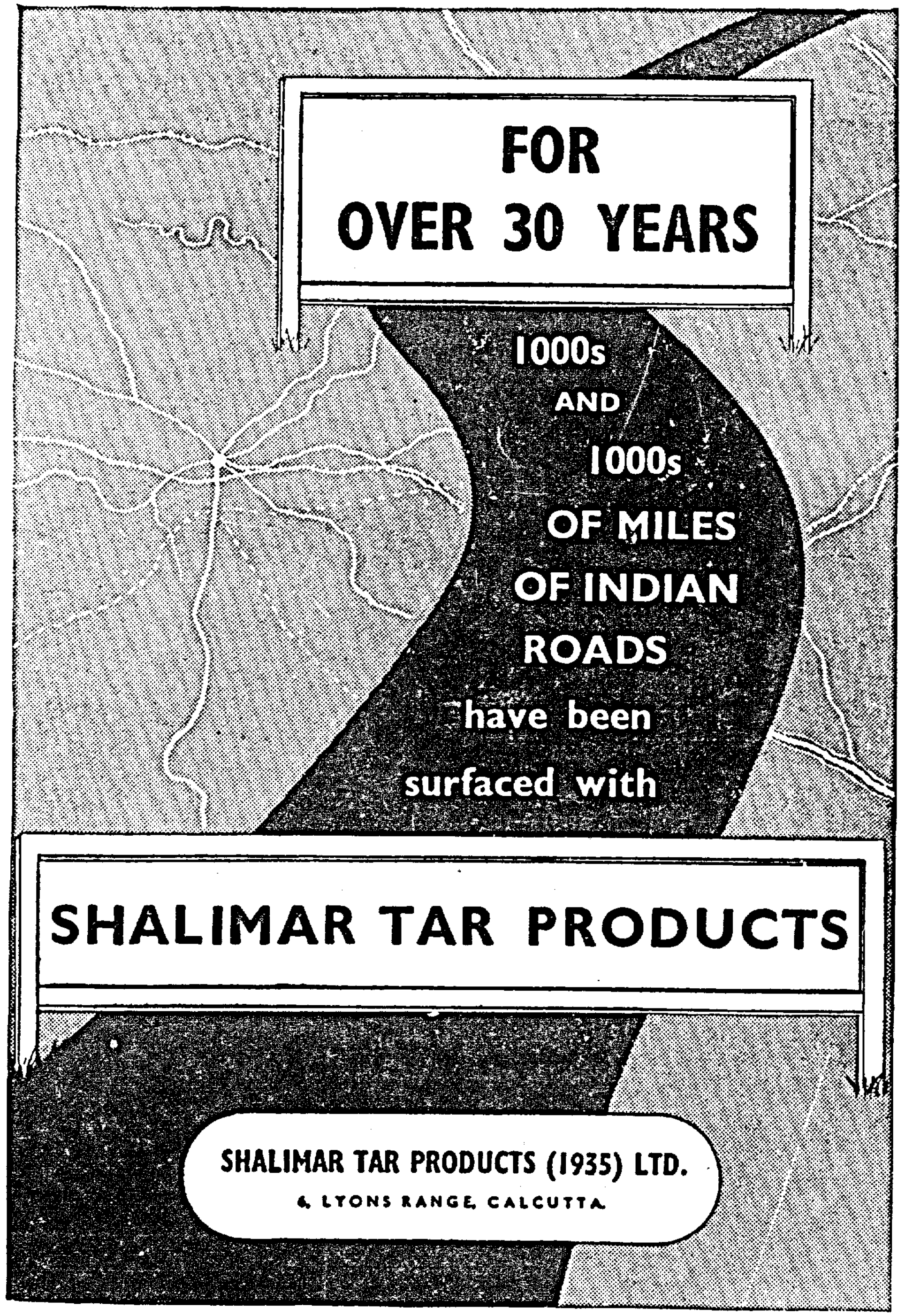
TRANSPORT-COMMUNICATIONS

MONTHLY REVIEW

APRIL 1957—No. 120

INDIAN ROADS CONGRESS, NEW DELHI.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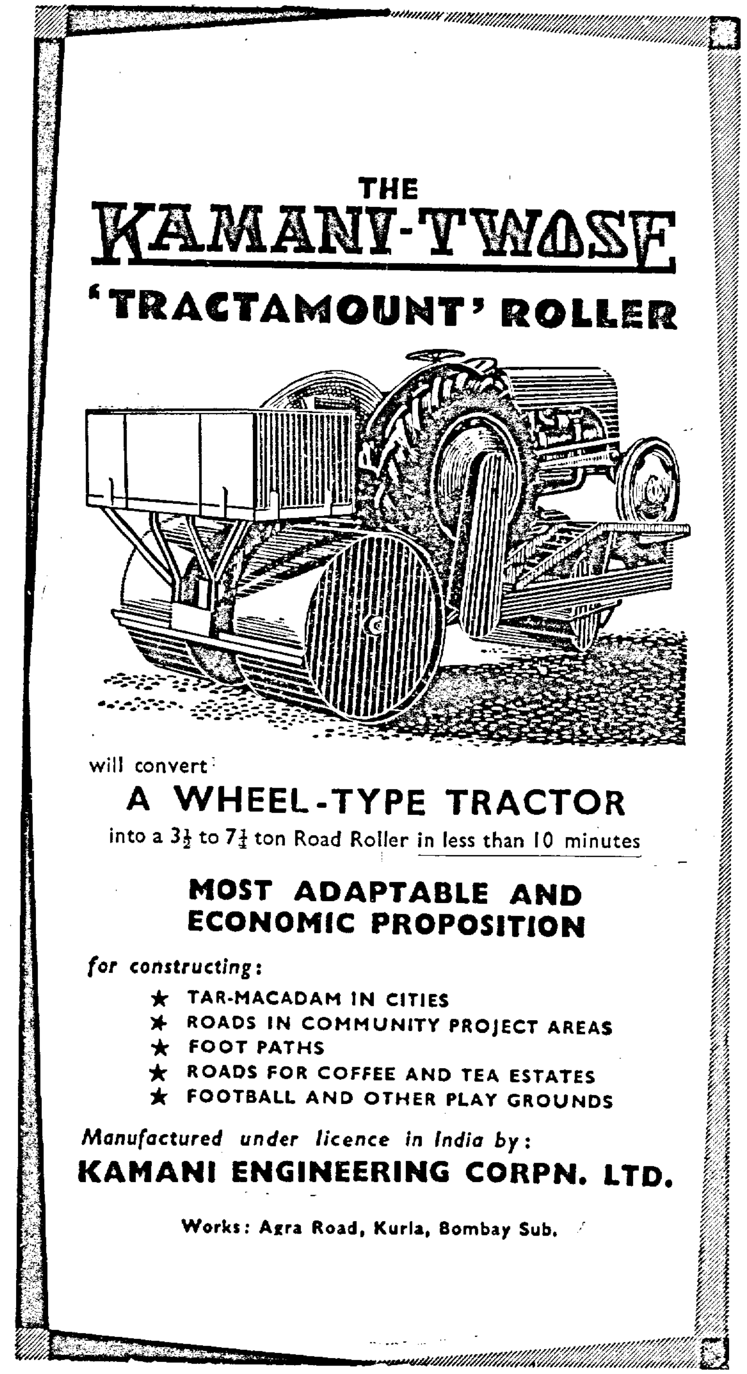
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TRANSPORT-COMMUNICATIONS MONTHLY REVIEW

APRIL 1957—No. 120

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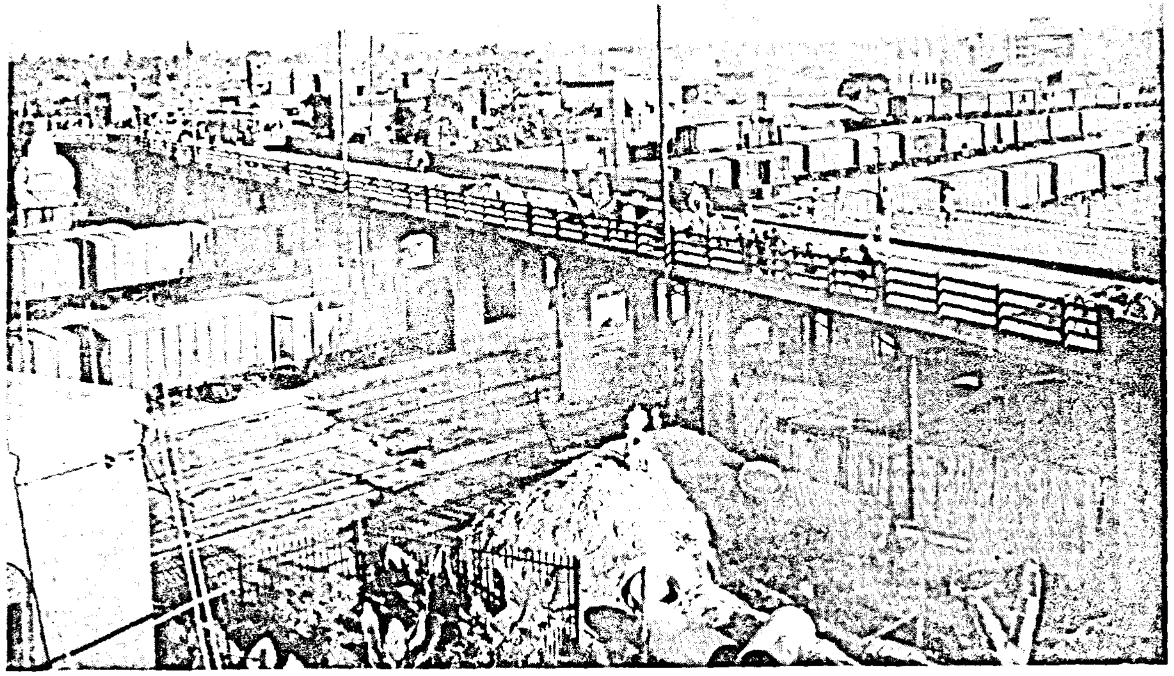
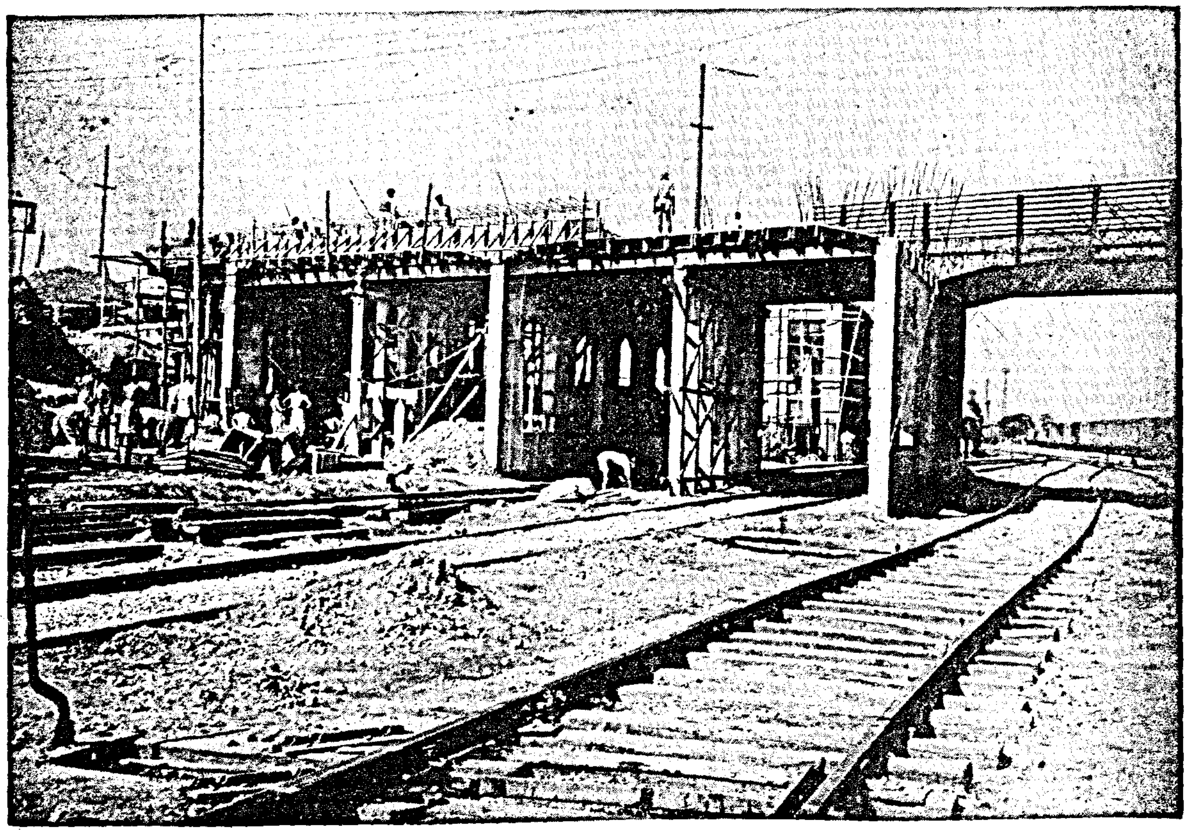


BALGACHIA BRIDGE, CALCUTTA N. H. 35



TRANSPORT-COMMUNICATIONS MONTHLY REVIEW

A REVIEW OF
ROAD ENGINEERING, DEVELOPMENT & TRANSPORT

APRIL 1957

THE BELGACHIA BRIDGE

Introduction

THE Chitpur railway yard situated on the northern end of the city of Calcutta is crossed by a link road connecting the city with National Highway 35. A steel over-bridge of 315 ft length between faces of abutments with 17 ft spans was constructed by the Railways. This bridge was 24 ft in width with a carriageway of 18 ft 3 in. and two narrow footpaths. Also, a tramway track was running along the carriageway. The steel troughs of the superstructure of this 25 degree skew bridge was supported on steel trestles on raft foundations. The troughs were filled with lime concrete. The bridge was narrow and inadequate to meet the needs of traffic.

In view of the fact that the bridge would be subject to corrosive action of smoke from engines using the yard, it was decided that a reinforced concrete bridge be constructed. The new bridge is at the same site and almost at the same angle of skew as the old one.

The bridge has been designed for a single lane of I.R.C. Class AA loading or 4 lanes of Class A, whichever gives higher stresses. The footpaths are designed for a crowd load of 80 lb per sq. ft.

The following working stresses have been adopted in the design;

Compression in concrete to give an ultimate strength of 3000 lb per sq. in. at 28 days.	950 lb per sq. in.
Tension in mild steel rods with a modular ratio of 15.	1800 lb per sq. in.

Foundations

Because the bridge had to be constructed under restricted conditions without hindrance to the railway traffic, reinforced concrete Frankie piles have been preferred. There are 12 piles under each pier. The piles are designed for a load of 70 tons and tested for a load of 105 tons.

Piers

The piers are reinforced concrete thin walls 1 ft 3 in. thick with openings as shown in Fig. 2 on page 5.

Abutments

Abutments had to be constructed with the very high embankment of the approaches of the existing bridge on one side without hindrance to the very heavy traffic using the road. Therefore, open foundations were not practicable. Two R. C. boxes of 6 compartments each were provided with a wall thickness of 1 ft 3 in.

Superstructure

The 61 ft 8 in. wide deck consists of 53 ft wide slab and a cantilever projection of 4 ft 10 in. on each side. The slab is 1 ft 6 in. thick, but near the piers the depth has been increased uniformly from 1 ft 6 in. to 2 ft 6 in. over a distance of 5 ft. The balancing is effected by cantilevers of 10 ft with a suspended span of 14 ft $3\frac{1}{2}$ in. The total length of the bridge is 357 ft 2 in., consisting of 9 spans of 34 ft $3\frac{1}{2}$ in. each and two end spans of 24 ft $3\frac{1}{2}$ in.

The superstructure rests over the piers on a lead sheet $\frac{1}{8}$ in. thick. In order to allow for the rotation of the slab due to deflections under live load, the tops of the piers have been rounded to a radius of about 10 ft, see Fig. 6. The slabs are connected to the piers by means of $1\frac{1}{4}$ in. diameter bars at approximately 3 ft centres. These bars have been put in so as not to foul with the main reinforcement of the slab. To allow for the expansion and contraction of the slab independent of the pier, a copper sheet lining has been introduced over the bar. The $\frac{1}{8}$ in. space between the copper sheet and the bar is filled with a compressible packing.

At articulations at the ends of the suspended spans also, a $\frac{1}{8}$-in. thick lead sheet has been interposed between the cantilever ends and the suspended span. Here again, the suspended spans and the cantilevers are connected by means of $1\frac{1}{4}$ in. diameter dowels. Details of these are shown in Fig. 3 & 5. The expansion joints at the deck consist of mild steel angular irons with a copper U-strip. Details of are shown in Fig 4.

Parapets are of precast concrete rails of barrel shape with intermediate posts to support them.

Approaches

Because land was not available to allow for the side slopes of the embankment, retaining walls have been constructed to retain the earth. Timber poles have been provided as foundations for the retaining walls wherever the pressure on the foundation soil exceeds 0.5 ton per sq. ft.

Costs

The cost particulars of the bridge are given below:

Piles	Rs 2,93,976/-
Piers	54,795/-
Abutments	2,23,636/-
Total cost of substructure	Rs 5,72,407/-
Superstructure	Rs 3,86,166/-
Total cost of the bridge	Rs 9,58,573/-
Approaches	Rs 8,69,849/-
Low level road	Rs 17,113/-
Renovation of drain	Rs 62,694/-

Percentage of Expenditure of the Bridge Proper

Substructure		
Piles	30.7 per cent	60 per cent
Piers	5.8 per cent	
Abutments	23.5 per cent	
Superstructure		40 ,,
Cost per sq. ft. of carriage of the bridge		63/12
Cost per cu. ft. of the bridge (volume calculated on the total sq. ft. of the bridge and the elevation of the bridge from G. L. to the top of deck		2/8/-

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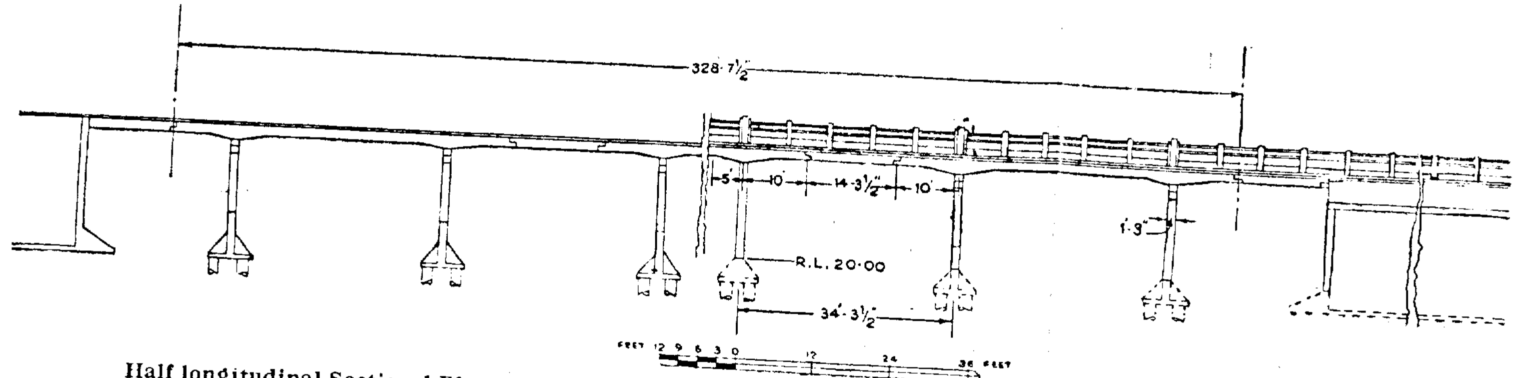
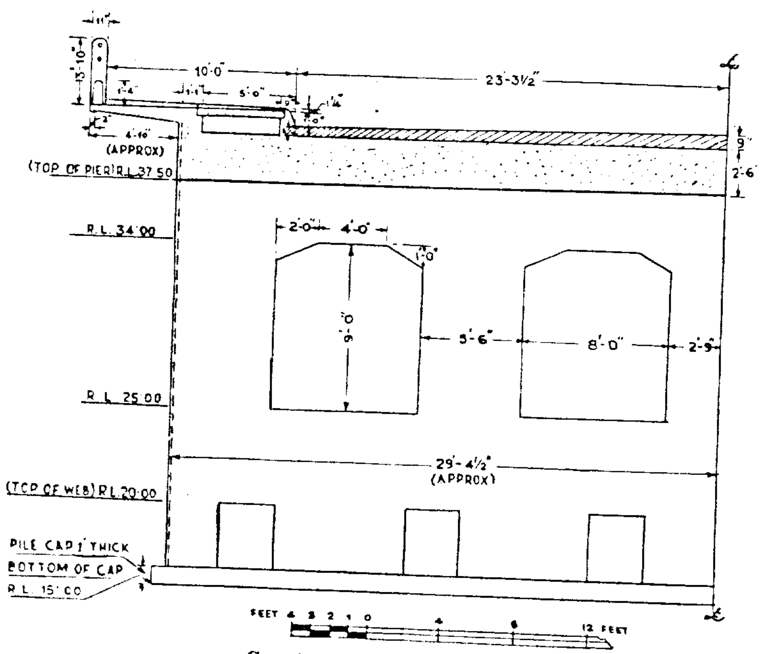
Bad roads waste motor fuel.



Half longitudinal Sectional Elevation
(Parapet Removed)

Half longitudinal Elevation twisted
about the central line

Fig. 1.



Section along a pier
Fig. 2.

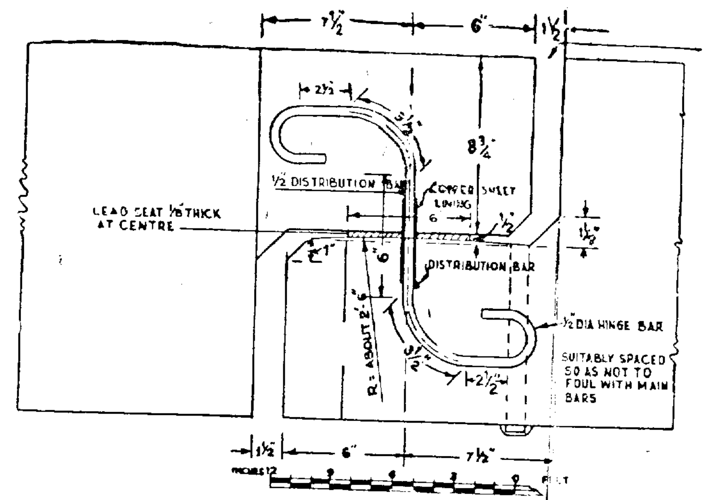


Fig. 3.

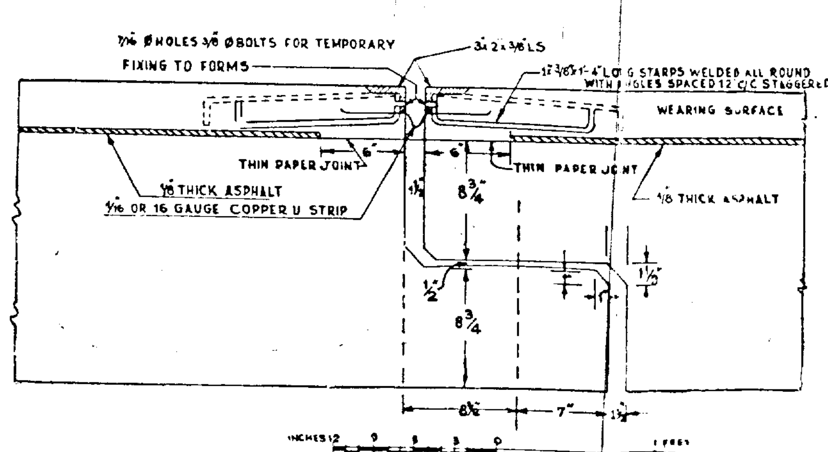


Fig. 4.

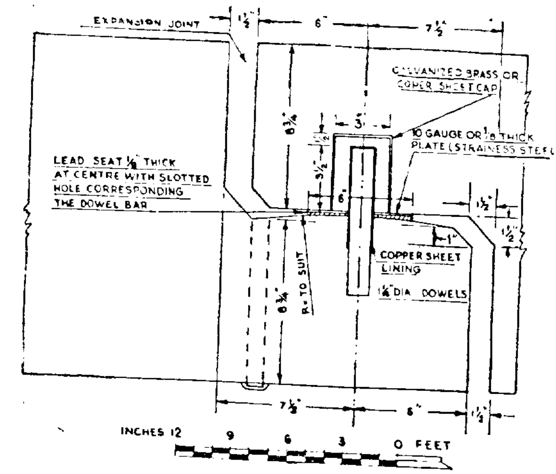


Fig. 5.

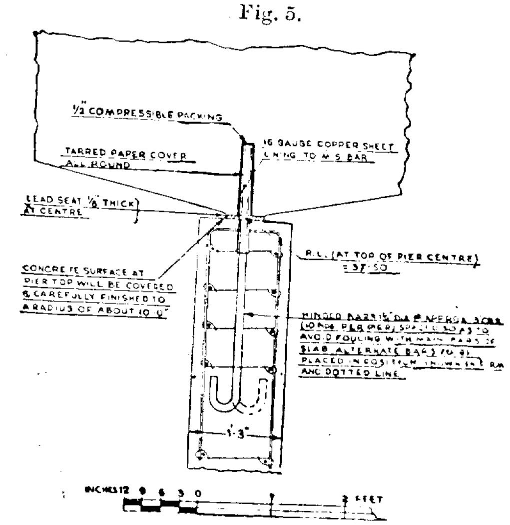


Fig. 6.

THE 21ST SESSION OF THE INDIAN ROADS CONGRESS TO BE HELD AT SHILLONG—MAY 1957

ON the invitation of the Government of Assam, the 21st Session of the Roads Congress will be held at Shillong from 11th to 18th of May 1957. Nine Papers, brief summaries of which are given below, will be discussed. A general report on road research done in India will also come up for discussion on the 15th afternoon. There will be a panel discussion on " Use of Soil for Cheap All-weather Road Construction." It is expected that Monsieur Y. Guyon, an eminent authority on prestressed concrete, will attend the Session and deliver lectures. An engineering exhibition on a modest scale in which various State P.W.Ds. and engineering firms will participate, will also be held. The Governor of Assam will inaugurate the Session on the 12th forenoon.

Summaries of Papers

1. Paper No. 189, " Load Testing of the Prestressed Concrete Bridge across Bhima River at Takli on Sholapur-Bijapur Road "—S. V. Natu.

The Paper describes the load testing of the prestressed concrete bridge across Bhima river near Takli on Sholapur-Bijapur road, 18 miles to the south of Sholapur. The bridge has 7 spans each of 153 ft 4 in. centre to centre of piers. In two of the 7 spans the extensions of the prestressing tendons obtained during the stressing were considerably less than the calculated ones due to the sheaths having got wrapped round the cables. In order to get the designed prestress at the critical section, tendons of these two spans were restressed after a lapse of time.

These two spans and one out of the rest were also tested for cracking load. Contrary to what was expected, testing revealed that the load carrying capacity of the beams in the two spans, in which the extensions obtained originally were less than necessary, was considerably deficient. The Paper also deals with the strengthening of the girders in the two spans.

2. Paper No. 190, "Study of a Clay Bank Failure on an Indian Railway "—U.G.K. Rao.

A clay embankment, about 35 ft high, on the Central Railway, was giving trouble from the time of its construction. The trouble in the earlier stages appeared to be due to inadequate slopes. Also, some of the remedial measures then adopted, though not justified when judged by principles of soil mechanics might have reduced the strength of the embankment. More recently, the bank seemed to have been affected by moisture movement both from the top and from the ground below.

In 1955, detailed investigations were carried out. The Paper gives the history of the embankment from the date of its construction, the observations made during the investigation, and the recommendations made for remedying the defects.

3. Paper No. 191, " Resistance to Abrasion of Concrete Pavements " — P. J. Jagus and M. R. Chatterji.

The Paper emphasises the importance of considering the resistance to abrasion in the design of concrete mixes for rigid pavements and in the selection of materials and methods of construction. Poor resistance to abrasion is more serious in rigid pavements than in flexible surfaces.

It is considered that the standard tests in use for judging the wearing qualities of aggregates and the limiting values of abrasion resistance specified in the different specifications may not be suitable for conditions in India, where the principal damaging force is that of the steel-tyred bullock cart. So, a method of testing abrasion, called Pneumatic Test, was evolved at the Central Road Research

Institute, Delhi. The test could be used for testing aggregates as well as cement mortars. The apparatus used in the test and the test procedure are described.

The wearing qualities of some road aggregates used in India determined by the Pneumatic Test are compared with the values obtained from other standard methods of tests. It is hoped that the pneumatic test will yield reliable results.

The effect of compressive strength, fineness modulus of sand used for the mortar, lapses in curing,use of various membrane curing compounds, and replacement of cement by surkhi on the resistance to abrasion of mortars has been studied and included in the Paper. It is found that coarser the sand that is used for the mortar the better the resistance to abrasion.

4. Paper No. 192, "Design and Construction of a Prestressed Concrete Bridge Across River Coleroon"—K. K. Nambiar & P. G. Nambiar.

The bridge across Coleroon river on the Chidambaram-Sirkali road consists of 14 spans of 150 ft each. The superstructure of the bridge consists of unbalanced cantilever prestressed precast T-beams. The deck of the bridge is cast at site and is transversely prestressed. The system of prestressing adopted is the Freyssinet type.

The foundations consist of 3 square wells under each pier. Originally they were to be taken down 5 to 6 ft into compact clay. Actually, the wells have been sunk to depths varying from 50 to 55 ft below the bed level and stopped on a layer of fine sand about 6 ft above the compact clay layer. Before deciding upon the stopping of wells at the higher elevation, the wells were to be tested to 1½ times the design load. Plugging the wells and conducting full-scale tests meant expense, delay and damage to the wells when the plugging was removed, if the tests showed further sinking to be necessary. Therefore, plate bearing tests on the foundation soils have been conducted and the test results interpreted to the prototype. Also, tests of soils below the foundations for ascertaining the settlement were made. It was found that differential settlement of 4.4 in. might result. Therefore, to make good the difference in levels of the superstructure consequent on the differential settlement that might occur and to avoid damage to the bridge, provision has been made for lifting by jacks.

The Paper describes in detail the design of the mix, the procedure adopted for control of quality of the concrete for precasting work, the precasting of the beams, and the launching of the beams from the casting yard to their positions on the piers. The girders, each of which weighed 85 tons, were transported to position, using the girders already laid in position, by specially manufactured cars and employing a V-shaped launching girder 235 ft long. Salient features of the design of the superstructure, calculations of stresses and elongation in the cables, the precautions to be observed to reduce friction between the sheaths and the cables, and practical hints on safety measures to be observed during prestressing work, are given in detail.

5. Paper No 193, "Influence Fields for Finite Concrete Slabs Supported Freely along Two Opposite Edges and Free at the other Two"—K. C. Ray, R. Subramoniam and S. Badaruddin.

The Paper presents unit influence fields for R. C. slabs freely supported on two sides and having breadth span ratios of 1, 1.2, 1.5, 2.0, 3.0 and 6.0. A worked out example for two lanes of I. R. C. Class A loading and one lane of I. R. C. Class AA loading is given.

6. Paper No. 194, "A New Method of Supplying India's Requirements of Bitumen for Blacktopped Roads"—W. A. Griffiths.

7. Paper No. 195, "Earth Moving Machinery in West Bengal"-D. N. Ghosh.

In West Bengal, heavy earth moving machines were employed for the construction of some road embankments. The Paper describes the organization for the work, gives performance of the machines, advantages and disadvantages of employing them, costs of their maintenance

(*Continued on page 23*)

SOME REMARKS ON BITUMINOUS SURFACE DRESSINGS

By
C. G. SWAMINATHAN

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Introduction

THE use of bituminous materials for surfacing of roads has been known for a considerable period. One of the earliest methods of construction is surface dressing. The process is very simple consisting of spraying of a fluid bituminous binder on the existing road surface, applying a layer of uniformly spread stone aggregates, and compacting. In effect, it is purely an adhesion process in which stones are stuck to the road surface by means of a binder. When the binder is in a fluid condition, it wets the sides of the aggregate by rising up between their inter-spacings and when the binder sets by cooling and/or by evaporation of the volatile constituents, it holds on the aggregate from being dislodged by traffic.

Functions

Surface dressing started initially as a repair measure and became a routine maintenance operation to be adopted whenever the surface condition needed attention. The various functions that the surfacing is called upon to play give a different picture.

At first, surface dressing was used as a dust palliative for untreated gravel and for water-bound macadam roads. At the same time it was realised that it formed a good waterproofing medium and a preservative course which would take the wear and tear of traffic.

But of late with the advent of high speed vehicles on the road, the surface dressing is called upon to serve as a non-skidding surface and to provide better riding comfort. The former aims at making the road safer by providing a surface which would have anti-skid properties whereas the latter demands a texture that would lessen glare and driving fatigue, provide better visibility and road delineation and thereby increased driving comfort.

In addition to the above mentioned requirements, surface dressing can strengthen the old mat, either by increasing the strength of the original road surface or by adding to the thickness of the road structure as a whole. Just as in water-bound macadam roads which when become rutty are given a course of metal and rolled, thereby strengthening the road, so too it may be possible by a series of surface dressings to strengthen the road structure. In the U.S.A., the strengthening or reinforcing of an existing pavement is achieved by constructing what is known as an "armor coat," which in effect is only a multiple surface treatment or inverted penetration type done in two or more layers at the same time. An increase in traffic would demand a stronger road structure than what was sufficient for the traffic of a couple of decades ago. And strengthening by the application of armour coats would mean a very high initial cost and, in order to minimise this cost, distribution of the applications over a period years may be desirable. Here it should be noted that a surface dressing will help towards the reinforcement of the existing road surface only so long as the base and sub-base are quite good.

Types

Surface dressings can be broadly classified under three types, namely, single coat, two coat and multiple coat. In two coat and multiple coat work, the various courses could be laid all at the same time or at definite intervals of time. Normally a single coat is done mainly in the form of a renewal coat and to maintain the uniformity of the riding surface. By this the base of the main road structure is protected from the damaging effect of traffic. Undoubtedly a two coat surface dressing is better and has a longer life. When tar is used it may be preferable to have the various layers constructed immediately one after another to protect the tar in the bottom course from being oxidised and weathered. Otherwise, the second or third coat is usually best done after the first layer has been compacted by traffic for about a year or two. The choice of the type and the time interval for the application of the successive coats would depend not only on the quality or quantity of materials used and the nature of the old mat, but also on the immediate functions that the course is called upon to perform. There are numerous instances in foreign countries where a well designed single coat and a two coat surface dressing have lasted for periods up to 10 years (without any renewal coat), the former functioning as a wearing course only whereas the latter functioning as a strengthened mat as well as a wearing course. Here, it should be noted that a structural reinforcing layer makes demands which are quite different from those of a purely wearing course. The former in addition to providing a wearing surface should add to the structural strength of the road. The distinction set forth for the two aspects is perhaps too fine, but it must be realised that sound practice and overall economy necessitate that the layers of surface dressing are to be laid at definite planned intervals of time. For, whereas for a surfacing layer cohesion, stability and good interlock are essential, for a purely wearing course, anti-skid wearing qualities etc. are important. If a surface dressing layer of today has to perform the strengthening layer of tomorrow, it seems obvious that a proper blending of the two requirements is absolutely essential. How far this can be achieved depends on factors such as planning, design, materials, phasing of the construction programme and the method of construction. However, there is a limit to which periodical applications of dressings could be done to any existing surface. The number of phased coats depends on the merits and demerits of each individual case and is governed by the various factors such as the intensity of traffic, nature of original surface materials used in the construction, etc. Above all, the success with which the previous surface dressings have been laid is a very important factor. Hence any surface dressing that is done with the objective of providing a structural mat for the future in view should be done with a thoroughness, exactness and all the skill that an engineer can muster to his aid.

Objects

Although surface dressing is a very simple operation and a low cost construction, it may frequently happen that little attention is paid to control and supervision of the work, as compared to the diligence that is bestowed on the more expensive forms of construction. "Since surface dressings are not manufactured according to a previous plan in the sense that asphaltic concrete mixtures are, the success or otherwise of this method of construction depends much on the experience of the engineer in charge of the work and the attention that he bestows on details, such as the choice of material, method of application and the planning of the procedure of construction, so as to give the best results." For, whereas slight flaws and discrepancies get buried in most of the other types of bituminous roads, in this form of construction the shortcomings get very well reflected on the road surface, especially during adverse conditions of weather, time, etc.

Whereas in all other forms of engineering construction, the testing laboratory has played a very vital part in facilitating the engineer to arrive at a proper design, in the case of surface dressings it has not. This is because of the fact that too many variables come into play that it is not always possible in the laboratory to take into account all these factors. It is because of this again that the existing practices are purely empirical and are based more on broad and general experiences gathered from various failures and successes, than on definite scientific data. However, certain valuable information has been collected by the various laboratories all over the world and so, it is now possible to lay down the broad fundamental principles involved in the construction of surface dressings.

Failures and Surface Conditions

Before the broad fundamentals are laid out in detail, it may be worth while to state briefly the types of failures that usually occur on surface dressings. Roughly the failures can be of three types. The first and most prevalent is 'scabbing'. This is as a result of the stone metal being dislodged from its seat. This could be due to any one of the many causes such as stiff binder, lack of sufficient binder, lack of attention during construction etc. The second type of failure is bleeding or fatting up, which is as a result of binder working its way to the surface. Of the many factors which contribute to this are use of the wrong quality and quantity of binder, excess of binder and less of aggregates, etc. The third type is the starved condition or the dryness of the surface as a result of the wearing away and crushing of the aggregates combined with extreme oxidation and weathering of the binder. Each type of failure, if not properly attended to, contributes to further deterioration of the road surface. Bleeding might cause corrugation and creep. Scabbing would lead to deep potholing. Each of these failures could be stayed and prevented considerably if only proper and adequate attention is paid to the materials and method of construction. How this can be achieved is dealt with in detail in the various sections of this Paper.

A survey of many of the surface dressings in India shows that the surfaces usually appear blacker and richer than their counterparts abroad, especially in the U. K. This may be either due to repeated applications of seal coats or due to the tendency to use a higher quantity of binder than what is perhaps necessary for the quantity of aggregates used. Further, owing to the effect of traffic, after the lapse of sufficient time, the surface is really in the nature of a rich premix carpet, as a result of which the required sand paper or rough texture is not obtained. These indeed suggest that a greater control especially regarding the quantity of binder is necessary.

Most of the failures can be attributed to the lack of uniformity in application of both the binder and aggregates. In the opinion of the Author, it is high time that mechanical spreaders and sprayers are employed for this purpose. Considering the fact that a good milage of roads have to be surfaced in the very near future and keeping the strengthening of the mat as a primary objective, it would work out to be very economical in the long run if mechanical spreaders and sprayers are employed as early as possible.

Life and Economics

In foreign contries especially in U. K. surface dressings last for quite a good length of time of say 10-15 years even. An analysis of the dressings in U. K. shows that the average life of a surface dressing is about 5 years. It is also said that by careful control, the life can be extended to 7 years.

But in India the life of a surface dressing appears to be about 2-3 years. This life can quite reasonably be increased if careful attention is given to the fundamentals.

A break up of the cost given below shows that about 70-80 per cent of the total cost is due to materials.

	per cent
Aggregate	25-30
Binder	45-50
Labour etc.	20-30

Less of binder means better spraying and an increase in life by about 2 years or so besides substantial saving. Such savings will enable making necessary allowance for the capital cost of sprayers and spreaders employing which will ultimately result in over-all economy.

(To be continued)

THE OSMOTIC METHOD OF INCREASING CONCRETE STRENGTH

PRACTICAL and experimental physics have shown that the theoretical strength of glass, concrete, iron, etc., according to Bohr's atomic theory are 1,000 times greater than those found in practice. On the basis of experiments carried out by Griffith, and described at the Congress of Applied Mechanics at Delft in 1924, the tensile strength of glass, which is normally 200 kg/cm² had been proved to increase to 3 400 kg/cm² after drawing into a thread of 0.0033 mm, i.e., half the strength (7,000 kg/cm²) calculated from Bohr's theory. The difference between the actual and theoretical strength, according to Griffith, is due to the weakening by micro and macro pores of the material during the process of glass rolling, i.e., in the period in which some of the pores are eliminated.

According to the theory of Hummel and Grun, the strength of concrete depends 90 per cent on its porosity, and the micro-photographic investigations of Probst have shown that the origin of micro and macro-pores is the high water-cement ratio. The water content of concrete can be reduced by several methods: (1) beating by hand or by mechanical devices (ramming); (2) by "concrete spraying" (gunite); (3) compression; (4) shaking; (5) vibration; (6) spinning; (7) deaeration by pumping; (8) steam heating; (9) heating by means of the thermo-electric method; and (10) electro-osmosis.

All methods 1 to 9 can be used for plastic concretes, but are not satisfactory for liquid-plastic or liquid concretes, method 10 being the only one suitable. Methods 3 and 6 can be used only for prefabricated elements, whilst 7, 8 and 9 require costly mechanical installations. The Author's investigations in 1952 and 1953 into the electro-osmotic method, showed that the strength of concrete could be increased by 35 to 45 per cent at relatively low cost.

Principles of Electro-Osmosis

Direct current is used, the anode consisting of a round iron bar, whilst the cathode is a perforated steel tube. If the voltage is between 40 v and 70 v, water passes to the cathode and can be drawn off through the perforations. For stronger reinforced concrete, liquid-plastic or liquid concrete is used with a water/cement ratio of more than 1.

If high strength is wanted, water should be drawn off to keep the water content between 20 and 25 per cent. Clearly, this process should be done before the concrete hardens and it should be vibrated in order to minimise the pores from which water has been removed. During this process, the temperature rise caused by the passage of the electric current should not exceed 50 deg. C in order to prevent water evaporation, which would increase the pores. It should be emphasised that only direct current can be used. While alternating current can of course produce the necessary heat for concrete drying, it causes rapid evaporation, which weakens the structure of the concrete. In addition to electro-osmosis, direct current can be used for electro-cataphoresis electrolysis and electro-thermal drying. The phenomenon of electro-osmosis, explained above, can be produced only when the potential difference is less than 1.7 v/cm. In practice, a potential difference of 1 v/cm is the most advantageous. If the potential difference is greater than 1.7v/cm the process of electro cataphoresis occurs in which not only water but also cement-milk passes to the cathode; this, of course, has a weakening influence on the concrete. Further increase of the potential difference causes electrolysis, where by the water is decomposed into oxygen and hydrogen. If the potential difference is increased still further, we obtain an electro-thermal phenomenon, which is characterised by complete drying of the concrete

An Analogous Process

A further explanation of the theoretical foundations of the electro-osmotic process can be given on the basis of the analogy between the osmotic drainage of concrete and the electro-osmotic drainage of soil. Whereas no papers have, to his knowledge, been published (apart from the Author's) on the electro-osmotic method of concrete drainage, literature on electro-osmotic soil drainage is considerable. This problem has been studied by Casagrande, Bendel, Biernatzik, Winterkorn, Schaade, Hafeli, Rzanicyn and others, and the basis of the theory of electro-osmosis has been laid by Helmholtz, Perrin and Smoluchowski.

On the basis of the above analogy it can be said that a freshly prepared concrete has three phases of hardening:

1. The first phase, which lasts for one-third of the hardening period during which no essential difference, from the point of view of the electro-osmotic water movement is manifested between the concrete and a wet aggregate. All electro-osmotic rules are applicable for any moisture containing materials.

2. The second phase, in which hardening begins and internal resistance appears.

3. The third phase, according to Vicat, in which the concrete is in the hardening state, in practice from 0.66 T (where T = the hardening period) and where the analogy between concrete and soil ceases.

(From 'Civil Engineering and Public Works Review', December 1956).

DEFINITIONS OF HIGHWAY ENGINEERING TERMS

SUSPENSION BRIDGE: A bridge with its deck suspended from chain or wire cables, usually carried over massive towers and suitably anchored.

THROUGH BRIDGE: A bridge in which the roadway is at or near the bottom chord level of the main supporting members.

PROGRESS

THE woman who used to run home to mother the minute she had trouble with her husband now has a daughter who runs to her lawyer.

HERE AND THERE

1. A SPECIAL ROAD-BUILDING TAX UNDER CONSIDERATION IN GERMANY

THE German Federal Ministry of Finance has estimated that DM 55,000 million will be required to finance the road-building programme of the next ten years. The programme includes the rebuilding of 11,000 kilometres of main roads; new main road construction totalling 1,100 kilometres; 3,200 kilometres of by-pass roads; and a further 1,400 kilometres of "Autobahnen". It will be difficult to raise the necessary finance from existing sources and possibility of introducing a special road-building tax is said to be under consideration.

(From 'Highway and Bridges and Engineering Works,' January 9, 1957).

2. IRAQ ROAD IMPROVEMENTS

A five-year economic plan for Iraq, begun in 1955 which authorises expenditures of one thousand million dollars, has as its aims large irrigation, flood control and road building programmes in the Tigris-Euphrates flood plain. When completed, the plan is expected to bring an additional five and a half million acres into production, and multiply farm income many times. The wide-spread 1954 floods washed out many sectors of the important Baghdad-Fallujah-Ramadi Road. This 65-mile thoroughfare connects with the desert road leading to the Mediterranean ports of Syria and Lebanon. Approximately half the imports and exports of Iraq enter or leave the country by this route. In November, 1955, the Iraq Development Board awarded a 2,800,000 dollars contract to Dijla Construction & Saraji Trading Company for the modernisation of the existing Baghdad-Fallujah-Ramadi Road. The working force of 1,200 men is expected to have the thoroughfare completely open to traffic again by November, 1956. To withstand the extreme summer temperatures and the severe winter frosts, the specification is for a 12 in. sub-base of gravel and sand, 8 in. of crushed stone and 3 in. of concrete and asphalt.

(From 'Civil Engineering and Public Works Review' October, 1956, Vol. 51.)

3. TRENDS IN HIGHWAY SLAB DIMENSIONS

SURVEYS conducted in the U. S. A. to determine the trends in concrete pavement design show that changes are taking place in the thinking of engineers regarding slab dimensions.

Slab length is defined by the distance between transverse joints, both expansion and contraction joints.

Transverse expansion joints – There is a decided trend away from their use. Several years ago 27 states used expansion joints and 18 did not. In 1952, only 17 states used expansion joints and 25 did not use them. In those states using expansion joints, there is a wide range in spacing, from 60 ft up to 1000 ft, and there is no particular spacing which seems to be most universally used.

Transverse contraction joints–Transverse contraction joints are generally used, although there are some states in which no contraction joints are specified. Slab lengths vary from 15 to 100 ft; 16 of the states used lengths of 15 to 20 ft in 1952; seven states used lengths of 70 to 100 ft; in those states using 30 to 42 ft lengths, there seems to be a trend away from the 30-and toward the 40- ft length.

As might be expected, generally when transverse joints are spaced at intervals of 20 ft or less, no reinforcement is required. However, there are several states not requiring reinforcement even when the joint spacing exceeds 20 ft, but these are in the minority.

Pavement width

There is a decided trend toward the use of wider pavements. A 24-ft pavement is now almost universally used with two 12-ft lanes, although there are some states building 22-ft pavements. It is significant that not a single state has reported building pavement widths of 20 ft, whereas several years ago this width was still being constructed.

Thickness of pavement

So far as thickness is concerned, there is a definite trend away from the thickened-edge pavement. Thirty-three states now specify uniform cross section only. There is a definite trend towards thicker pavements; those constructing 9 and 10-in. pavements have changed from 2 states in 1948 to 5 states in 1952, and those states constructing 8, 9,and 10-in. pavements have changed from 6 states in 1948 to 18 states in 1952.

(From 'Journal of the American Concrete Institute,' November 1956, Vol. 28).

4. A NEW TYPE PAVING TEST TRACK

A NEW type of model test track for research on various highway pavement materials and design has been developed in the College of Engineering at the University of Washington in Seattle.

Miniature truck tires, mounted on an endless chain, apply variable loads at variable speeds to different types of paving and subgrade soils under laboratory controlled climate and moisture conditions.

University officials say this is the first model track for highway testing that has been constructed along a straight path. Circular tracks now in general use require large dimensions with greater amounts of subgrade, points out Prof. Martin Elkse of the University's civil engineering department, in charge of the project. Constant acceleration of the wheels on the circular path tends to rut the surface. Full-size test roads are costly and control of weather and soil conditions is impossible.

The model test track is mounted on an insulated metal tank 12 ft long, 3 ft wide and 3 ft high.

A highway subgrade has been constructed in the tank to simulate a portion of highway soil used in many roads. Water and refrigeration connections with the tank can be controlled to provide the desired temperature and moisture conditions. Soil-pressure measurements are made through electrically connected cells imbedded in the soil at varying levels, with the pressures recorded automatically on a graph and an oscillograph tube.

Experiments will be conducted with portland cement concrete and asphaltic pavements, constructed to state highway department standards.

Pavement deflections and the variance in soil-pressure distribution will be studied under various conditions of pavement thickness,subgrade moisture and soil types.

The equipment can provide a comparative analysis of any type of pavement, under any known conditions, according to Professor Elkse. "The research can deal with the effects of such variables as soil type or classification, moisture content, temperature, load intensity and load frequency."

(From 'Engineering News Record,' December 20, 1956)

5. JAPANESE SUSPENSION BRIDGE

IN Japan, a suspension bridge of the Florianopolis type, particulars of which are given below, was completed in 1954. The Span is 374 ft (114 m), with straight backstays. The cable sag is 36.8 ft (12 m). Each cable is made up of 19 wire ropes (7×19 wires), each strand $1\frac{3}{4}$-in (45 mm) diameter.

The stiffening truss is of the Florianopolis type, utilizing the middle portion of the cables as a top chord for the truss. This provides maximum depth and stiffness near the quarter-points, where the greatest bending moments in a suspension bridge occur. The truss span is 368 ft (112 m), made up of 32 panels at 11.5 ft (3.50 m).

The roadway is 15 ft (4.60 m) wide. Carried on stringers spaced 4 ft 3 in. (1.35 m), the roadway is made up of a reinforced concrete slab 6 in. (15 cm) thick, topped by a cement concrete wearing coat $\frac{5}{8}$-in. (16 mm) thick.

(From 'Acier Stahl Steel,' 1 January, 1957)

6. FLEXIBLE PIERS TO TAKE EXPANSION, NORTHAM BRIDGE, SOUTHAMPTON—U. K.

THE BRIDGE has five spans, the two outer of 85 ft and the three centre ones of 105 ft. Headroom for navigation is 15 ft at the centre. A small bridge over a rail-track, which was diverted to eliminate a level-crossing, is provided near the south abutment, and a scouring span is incorporated in the north embankment. The highway consists of two 22 ft carriageways, with a 5 ft central reserve and two 8 ft footpaths.

The reinforced concrete piers are founded on ballast, which was consolidated chemically. Within the upper portion of the pier-shafts are housed reinforced concrete columns which carry the deck and cater for expansion movements of the deck by flexure. The bridge is anchored at the north abutment, all expansion movements being towards the south abutment, where the deck is carried on a a thin flexible concrete wall.

The deck consists of pre-tensioned precast concrete beams post-tensioned transversely after erection. Diaphragms at intervals along the beams, prestressed by post-tensioning at low level, enable the deck to be stiffened transversely, in addition to providing supports for services. The prestressed beams were cast in pairs in two stressing pits constructed on site, the wires being tensioned simultaneously from both ends.

Concrete strength for the prestressed units was specified as 7,000 lb/sq. in. at 28 days, and 5,000 lb/sq. in. on release, which was achieved in about 3 days, with a cement aggregate ratio of 1 : 3.80 and a water/cement ratio of 0.30. The heaviest beams weighed 48 tons. The new bridge replaces the 65-year-old three-span, wrought-iron bridge which was damaged by bombing during the war.

(From 'Civil Engineering and Public Works Review, Vol. 50, February, 1955).

7. CONTINUOUS BEAMS IN PRESTRESSED CONCRETE

SIGNIFICANT economies result in normal design in reinforced concrete by using continuous beams, since the absolute values of bending moments under the same loading conditions are less in the case of continuous beams than in the case of simple beams. This leads to the use of smaller sections. However, in prestressed concrete it is not the absolute value of the bending moments but the ranges of bending moment that usually have to be considered.

With a beam of constant section, continuous over three equal spans and loaded with a uniform load over the whole structure or zero load, then the maximum moment at the inner supports will also be the maximum moment variation 0.8 $\frac{WL^2}{8}$. If, however, the loading may also include cases where not all the spans are loaded, the maximum range of moment is $1.07\frac{WL^2}{8}$ varying from $-0.94\frac{WL^2}{8}$ to $+0.13\frac{WL^2}{8}$. In this case continuity leads to larger moment variations than those in the corresponding statically determinate case. As the number of spans increase the effect can be shown to increase, and the maximum range of moment reaches $1.15\frac{WL^2}{8}$ for five or more spans.

Permanent loads, dead loads, acting on prestressed concrete beams usually have no influence on the dimensions of the beam section since the effect of such loads can be annulled by tendon eccentricities additional to those required for carrying live loads. However, there will be a critical span length, for a given intensity of permanent load and beam-section shape, above which the additional eccentricity would cause the tendon to have insufficient cover, and an indirect design method must be employed.

The effects of these permanent loads are less stringent for continuous beams than for simple beams since the absolute values of moments in continuous beams are less. This means that (a) the additional eccentricity required to carry a given dead load will be less, and (b) the reduced absolute values of the live-load moments will require less eccentricity of the tendon limiting zones. Thus less displacement is needed due to (a) and more displacement is available due to (b) than in the case of corresponding simple beams. This results in larger critical spans for continuous beams, and economy can be achieved by making use of continuity in the case of long spans when the dead-load moment influences the size of the section.

The economy may be extended even further by applying linear transformations to the tendon profile. When indirect design becomes necessary a smaller section than previously obtained is possible for any span length by the application of a transformation.

(From 'The Surveyor and Municipal and County Engineer' Volume CXV, 1 December 1956').

8. THE STATUS OF THE CIVIL ENGINEER

BY the breadth of his experience, his ability to manage men and machines, and his practical and realistic approach to the problems of design, construction, and organisation, the civil engineer would appear to be pre-eminently fitted to hold managerial appointments. It is therefore somewhat surprising that so often such executive positions are filled by men of other professions, or even by those with no professional background at all. It seems unfair that, although the civil engineer has made—and continues to make—very substantial and far-reaching contributions to the welfare of the community, his efforts are rarely brought to the notice of the general public. It is true that civil engineering is so interesting in all its aspects—human and material—that those so engaged get such immense satisfaction in the conception of schemes and in their execution that they become indifferent to recognition. To assess the status of any professional man merely in terms of money is a mistake; the real measure of his worth is the service he renders to the community, which is not measured by any monetary standard. If in addition to technical competence he brings to his work breadth of vision, integrity and independence, then the engineer will receive the respect to which he is entitled.

(From 'The Surveyor And Municipal And County Engineer' Number 3368, 19 November 1956.)

CURRENT LITERATURE

ABSTRACTS

TOLL HIGHWAYS: THEIR ECONOMICS AND CONSTRUCTION by H. D. Morgan, V.F. Bartlett, H.S. Smith, and Edward W. W. Richards, Proceedings of the Institution of Civil Engineers, Part III, December 1956.

THE purpose of this Paper is to demonstrate the possibility of building some of the badly needed long-span road bridges and tunnels in Great Britain as financially self-liquidating projects. The methods of forecasting the diverted and generated traffic to be anticipated on a new crossing are described, and a typical example is given in detail showing how a long-span highway bridge could be financed without resort to public funds, and would pay for itself in a short term of years by means of tolls charged on traffic using it. Thereafter it would be freed. Particulars of the operation and excellent financial position of the Mersey tunnel are described.

Numerous examples are also given of toll bridges and tunnels in America and elsewhere, and particulars of some badly needed facilities, such as the proposed Severn, Forth, and Humber bridges, and the Tyne and Dartford tunnels in Great Britain.

The road section of the Paper describes the principles on which the systems of toll roads must be established to be successful, the constitution of the turnpike authority, and its investigations into traffic engineering and revenue, the relation of the toll-road system and turnpikes, and the basis of both in a national highway programme. An account is given of some of the major American turnpikes with an analysis of their uses and sources of revenue.

STRESS CONCENTRATION IN POST-TENSIONED PRESTRESSED CONCRETE BEAMS by Gerald Pickett and K. T. Sundara Raja Iyengar, Journal of Technology, Vol. 1, No. 2, December, 1956.

THE use of the multiple Fourier method to analyze the stress distribution in the end regions of a post-tensioned prestressed concrete beam has been shown. The multiple Fourier method demonstrated here is a relatively new method for solving those problems for which the "Saint Venant principle" is not applicable.

The actual three-dimensional problem and a two-dimensional simplified representation of it are treated. The two-dimensional case is treated first and rather completely to gain further experience with multiple Fourier procedures. The appropriate Galerkin Vector for the Three-dimensional case is found and the required relations between the arbitrary functions are stated.

CONTINUITY IN PRECAST REINFORCED CONCRETE by K. K. Banerjee, Journal of Technology, Vol. I, No. 2, December, 1956.

THE points of weakness of a structure constructed of precast reinforced concrete units (ordinary reinforced or prestressed) are the joints. The efficiencies of some of the common types of joints were determined from experiments conducted on two model slabs, constructed of precast reinforced concrete units with both longitudinal and transverse joints. The variables in the tests were, span-

(Continued on page 22)

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2. **A Variation of the Relaxation Method**; R. N. BASU, *Journal of the Institution of Engineers (India), Vol. 36, No. 12, Part 2*, August 56, pp. 2017-2022.
3. **Direct Design of Hingless Arches of Constant Section**; JAMES MICHALOS, *Civil Engineering*, July 56, pp. 61-64.
4. **Prestressed Precast Platform Built in Gulf**; ROBERT N. BRUCE, *Civil Engineering*, July 56, pp. 41-43.
5. **Self-Checking Moment Distribution**; G. SVED, *The Journal of the Institution of Engineers, Australia, Vol 28, No. 9*, September 56, pp. 231-234.
6. **Torsion in Reinforced and Prestressed Concrete Beams**; HENRY J. COWAN, *The Journal of the Institution of Engineers, Australia, Vol. 28, No. 9*, September 56, pp. 235-240.
7. **The First Large French Rail Road Bridge in Prestressed; The Voute Viaduct**; L. CARPENTER, *Travaux, Vol. 40, No. 264*, October 56, pp. 545-551 (in French).
8. **Experimental Investigation on the Mechanical Characteristics of Prestressing Cables used for the Reconstruction of the Villeneuve - Saint-George Bridge over Sein**; MICHEL BONNET, *Annales des Ponts et Chaussees, Vol. 126, No 4*, July-August 56, pp. 462-526 (in French).
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11. **Assembly of Planks Forms Arch Centering for Concrete Bridges**; *Roads and Engineering Construction*, August 56, pp. 94 & 155.
12. **Economic Advantages of Prestressed Concrete**; *The Surveyor, Vol. CXIV, No. 3313*, September 3, 55, pp. 881-882.
13. **Protection of Tunnel Trusts**; OTTO FREY. BAR, *Schweizeri sche Bauzeitung, Vol. 74, No. 38*, September 22, 56, pp. 567-572 (in German).
14. **Outline of Girder Design**; THOMAS JAEGER, *Der Bauingenieur, Vol. 31, No. 8*, August 56, pp. 273-291 (in German).
15. **The Bending Stresses of Two Dimensional Frames**; S. FALK, *Der Bauingenieur, Vol. 31, No. 8*, August 55, pp. 305-307 (in German).
16. **Vertical Trusses Resist Wind Load**; ROSS H. BRYAN, *Engineering News Record, Vol. 157, No. 10*, September 6, 56, pp. 36-38.
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(*Continued from page 18*)

width ration of slab, types of transverse joint and types of longitudinal joint.

Though full continuity may be achieved through a joint over a support, it is difficult to obtain a perfect longitudinal joint. Experiments show that even the presence of steel across the latter type of joint does not materially help in resisting transverse moments at small loads, although the steel is certainly beneficial and therefore a necessity at loads near failure of the slab. A strong mortar key is capable of complete shear transfer across a longitudinal joint. This fact alone is enough to cause distribution of the applied load to other parts of the slab away from the point of application of the load. However, the behaviour of such an anisotropic slab is inferior to that of a monolithic slab, but with more substantial research it will be possible to admit and allow some distribution of load in bridge or floor slabs constructed of precast concrete unit.

THE EFFECT OF TEMPERATURE ON THE COMPRESSIVE STRENGTH OF CONCRETE by H. L. Malhotra, Magazine of Concrete Research, Vol, 8, August 1956.

AS part of an investigation on the effect of temperature on the crushing strength of concrete, tests have been carried out using 2 in. diameter by 4 in. long specimens made with ordinary Portland cement, river sand and gravel aggregate, having various mix proportions and water/cement ratios.

The crushing strength of concrete at temperatures up to 600° C was independent of the water/cement ratio used but was influenced by the aggregate/cement ratio. Concrete specimens loaded to produce normal design compressive stress during the period of heating showed less reduction in strength than specimens without imposed load. There was a further loss in the compressive strength of the specimens when cooled after heating to a given temperature.

SCIENCE IN INDUSTRY

" Science in industry will only become truly effective when scientists and technologists are completely integrated with all levels in industry and themselves concerned to see their results applied." That result will certainly not be attained if the older and more eminent men shut themselves up in their laboratories. Hermits, no doubt, have the most wonderful thoughts. But they are not very helpful in improving the lot of the rest of mankind.

SCIENCE TO THE RESCUE

"TELL me what's wrong with me, doctor—in plain, simple language."

" Very well then; you're just lazy."

" Oh ! Now what's the scientific name for it, so that I can tell my wife."

(*Continued from page 8*)

and operation, including consumption of spare parts, and the outturn.

8. Paper No. 196, " An Investigation for Mass Production of Pozzolanic Portland Cement from Overburnt or Fused Jhama and Well-burnt Bricks by Utilizing Brick Kilns "—A. K. Datta.

In this Paper, the Author describes the experiments at Rajgangpur and Banjari Cement Factories which show that the addition of jhama containing high percentages of lime gives tensile strengths comparable to that when cement alone is used. The resulting cement, called silica cement, would be cheap. The Author suggests that brick kilns in the various parts of the country could be used for the manufacture of jhama.

9. Paper No. 197, " Study of Soft Aggregates from Different Parts of India with a view to their use in Low Cost Road Construction " Rajasthan—Dr. H. L. Uppal.

55 Samples from all over Rajasthan which yield low grade road making materials have been studied. The investigation shows that the aggregates could be used in place of stone after screening the fine materials. Where screening is not economical, the mixture as it occurs could be used after stabilization. For convenience in handling during stabilization, the materials have been grouped into four categories and methods of stabilization of each of the groups are given.

A SCIENTIST, ARCHITECT AND AN ENGINEER

A scientist, architect and an engineer were taken to the top of a high building and asked to estimate its height with the usual instrument. The scientist compared the position of the sun with the time of day, took many observations and said 364 ft 2 in. The architect tied the instrument to a piece of string let it down to the ground, made a knot in the string, measured the string and said 300 ft exactly. The engineer pocketed the instrument and asked the caretaker, who gave him the precise answer—295 ft.

BUDGETS AND ADMINISTRATION REPORTS

GOVERNMENT OF KERALA CIVIL WORKS BUDGET 1956-57

The following extracts relating to Civil Works have been taken from the Government of Kerala Budget for the year 1956-57.

Revenue (Civil works)

Heads	Actuals 1954–55	Revised estimates 1955–56	Budget estimates 1956–57
	(In lakhs of rupees)		
Rents	1.86	1.85	1.85
Receipts from workshops	—	0.22	0.15
Recoveries of Expenditure	0.16	0.15	0.20
Transfer from Central Road Fund	6.72	—	—
Receipts from Water Works and Drainage Schemes.	6.02	6.06	0.06
Miscellaneous			
(1) Sale of Avenue trees	0.99	1.26	1.21
(2) Special Tolls	0.32	0.34	0.34
(3) Grant-in-aid from the Government of India towards construction of Roads of economic or interstate importance.	—	15.00	23.00
(4) Other items	20.55	7.50	8.00
Deduct—Refunds	-0.05	-0.08	-0.05
Total	36.57	32.30	40.76
Expenditure (Civil Works)			
Original works			
Buildings	19.88	37.00	43.97
Communications	49.95	60.00	21.36
Miscellaneous	1.82	2.00	1.12
Repairs	69.28	71.50	68.17
Establishment	20.88	31.18	36.63
Tools and Plant	25.26	10.00	10.00
Grants-in-aid	0.98	2.00	2.00
Suspense	6.76	1.50	1.50
Development Schemes			
(Five Year Plan)			
1. Works.			
(i) Buildings	8.19	25.00	47.91
(ii) Communications	59.93	76.00	39.96
(iii) Miscellaneous	—	2.00	—
2. Establishment.	6.56	5.00	4.20
3. Tools and Plant	—	2.00	4.50
4. Suspense	—	0.25	0.50
Total	269.49	325.43	281.82

Capital account of Civil Works outside the revenue account

Heads	Actuals 1954–55	Revised estimates 1955–56	Budget estimates 1956–57
	(In lakhs of rupees)		
Original Works			
Buildings	7.51	4.00	1.90
Communications	0.74	3.50	41.74
Miscellaneous	0.96	10.50	2.38
Establishment	0.67	0.13	0.48
Suspense	5.57	0.05	0.05
Development Schemes			
(First Five Year Plan)			
(i) Works	7.16	78.50	228.24
(ii) Establishment	0.22	2.00	18.40
Total	22.83	98.68	293.19
Revenue from Roads			
Receipt under the Motor Vehicle Act	2.94	3.25	3.25
Taxes on Motor Vehicles	78.68	78.50	78.00
Taxes on other Vehicles	3.09	3.00	3.00
Other Receipts	0.01	0.02	0.02
Deduct-Refunds	-0.07	-0.07	-0.07
Total	84.65	84.70	84.20

Government of Kerala Civil Works Budget 1956-57.

THE budget estimate of the Government of Kerala for the year 1956-57 indicates revenue receipts of Rs 1889.90 lakhs against an estimated revenue expenditure of Rs 2198.38 lakhs leading to a deficit of Rs 308.48 lakhs. The revenue estimates for 1955-56 (Revised) placed revenue receipts at Rs 1805.99 lakhs and expenditure at Rs 1947.15 lakhs with a deficit of Rs 141.17 lakhs. Actuals for 1954-55 revealed revenue receipts of Rs 1751.49 lakhs and revenue expenditure of Rs 1268.38 lakhs resulting in a deficit of Rs 483.11 lakhs.

Revenue expenditure on Civil Works for 1956-57 is estimated at Rs 281.82 lakhs which works out to 14.9% of the total State revenue. It was Rs 325.43 lakhs in 1955-56 (Revised Estimate) and Rs 269.49 in 1954-55 (Actuals) which amounted to 18.0% and 15.4% respectively of the State revenue for the corresponding years.

Apart from the revenue expenditure a sum of Rs 293.19 lakhs has been provided in the Budget Estimate of 1956-57 for Civil Works on account of capital expenditure outside the revenue account. The same for 1955-56 (Revised Estimate) is Rs 98.68 lakhs and for 1954-55 (Actuals) is Rs 22.83 lakhs respectively.

LIST OF APPROVED WORKS ON NATIONAL HIGHWAYS

S. No.	Job No.	Name of work	Amount (Rs in lakhs)
		ANDHRA PRADESH	
1.	TA 59 AH 7	Removing the hump and eliminating the curve in mile 48/2-4 of the Kurnool-Gooty Section of N.H.No. 7.	0.25
		BIHAR	
2.	1706 BR 28 A	Construction of a bridge over the Tilaway Nala in mile 12 of Sugauli-Raxaul Road, N.H.No 28 A.	2.60
3.	TA 58 BR 30	Windening of miles 8/III to 30 of Patna-Bakhtiarpur Road, N.H. No. 30	8.82
4.		Two works each costing less than 2 lakhs.	1.72
		BOMBAY	
5.	TA 54 BM 4	Reconstructing the Central arched span of the existing bridge across the Kalwa Creek near Thana in mile No. 24 of the Bombay-Poona Road, National Highway No. 4.	1.26
		DELHI	
6.	1707 DLH 2	Widening of culverts on Delhi-Mathura Road, N.H. No. 2 between miles 5/2 and 11/6.	1.40
		MYSORE	
7.	TA 56 MY 7	Construction of a culvert at mile 2/41 of Bangalore-Bellary Road, N.H. No. 7.	0.16
		PUNJAB	
8.		Two works each costing less than 2 lakhs.	0.81
		WEST BENGAL	
9.	TA 61 BG 34	Improvement of the Barasat-Jaguli Section of National Highway No. 34.	3.95

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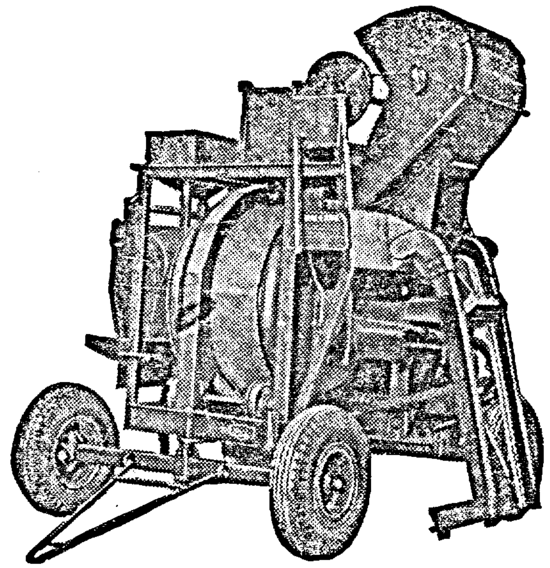

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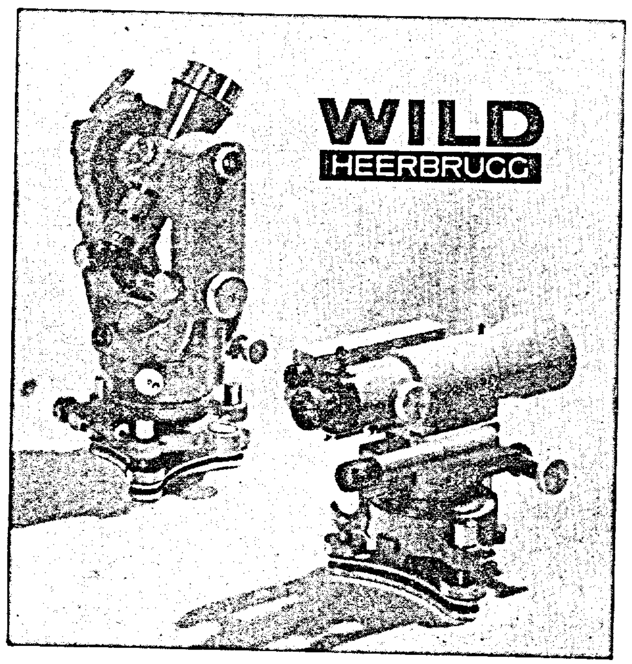

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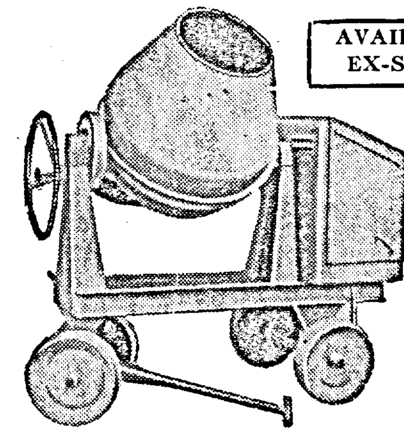

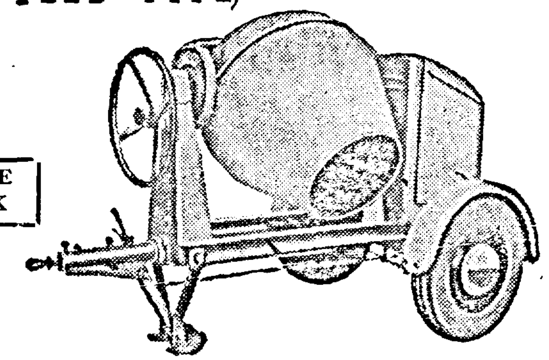

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