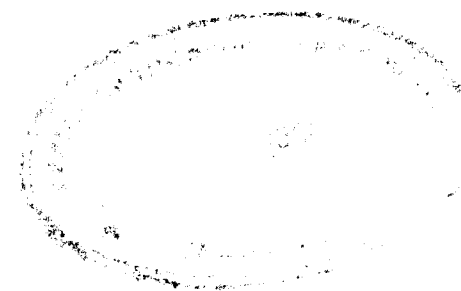


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MONTHLY REVIEW

AUGUST 1960—No. 160



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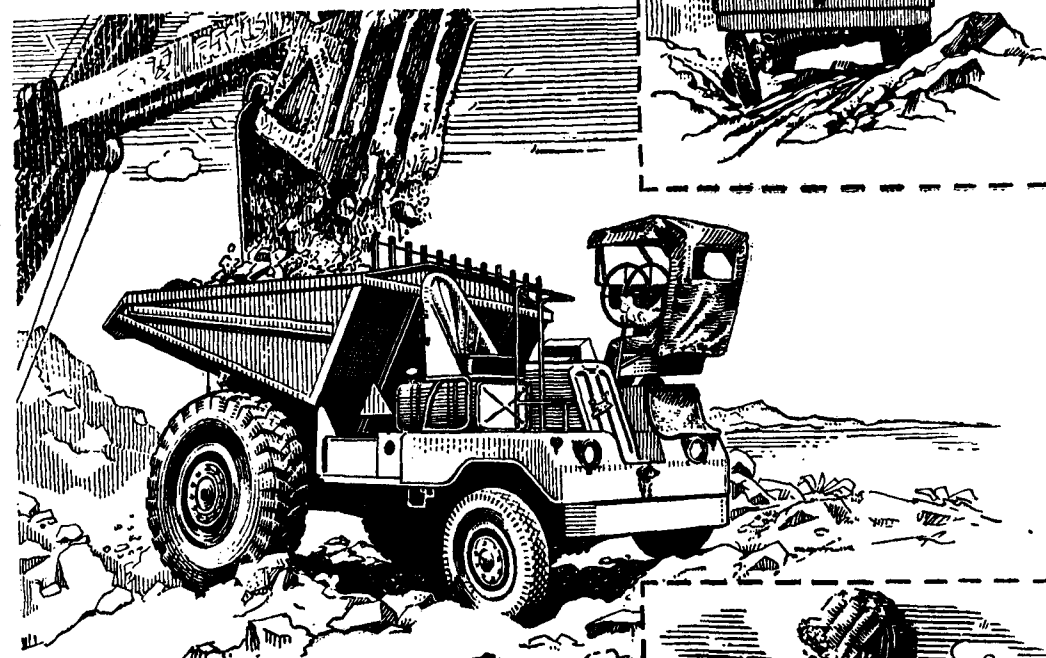
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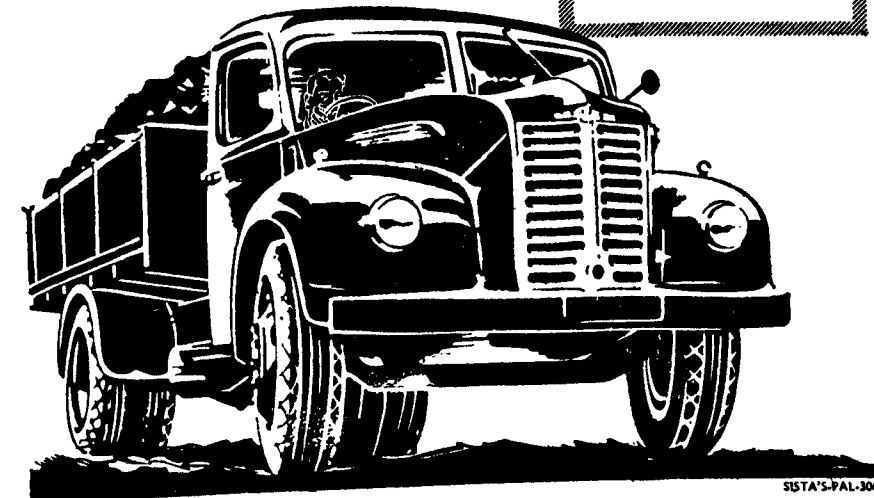
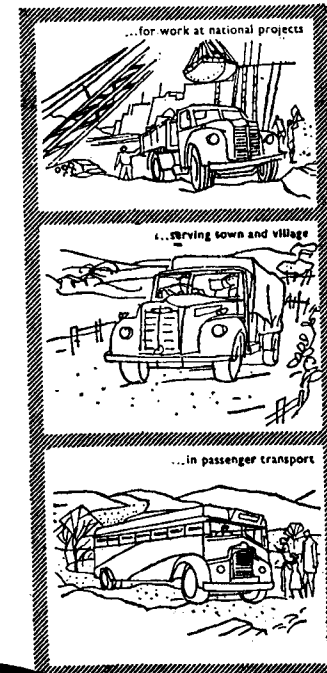
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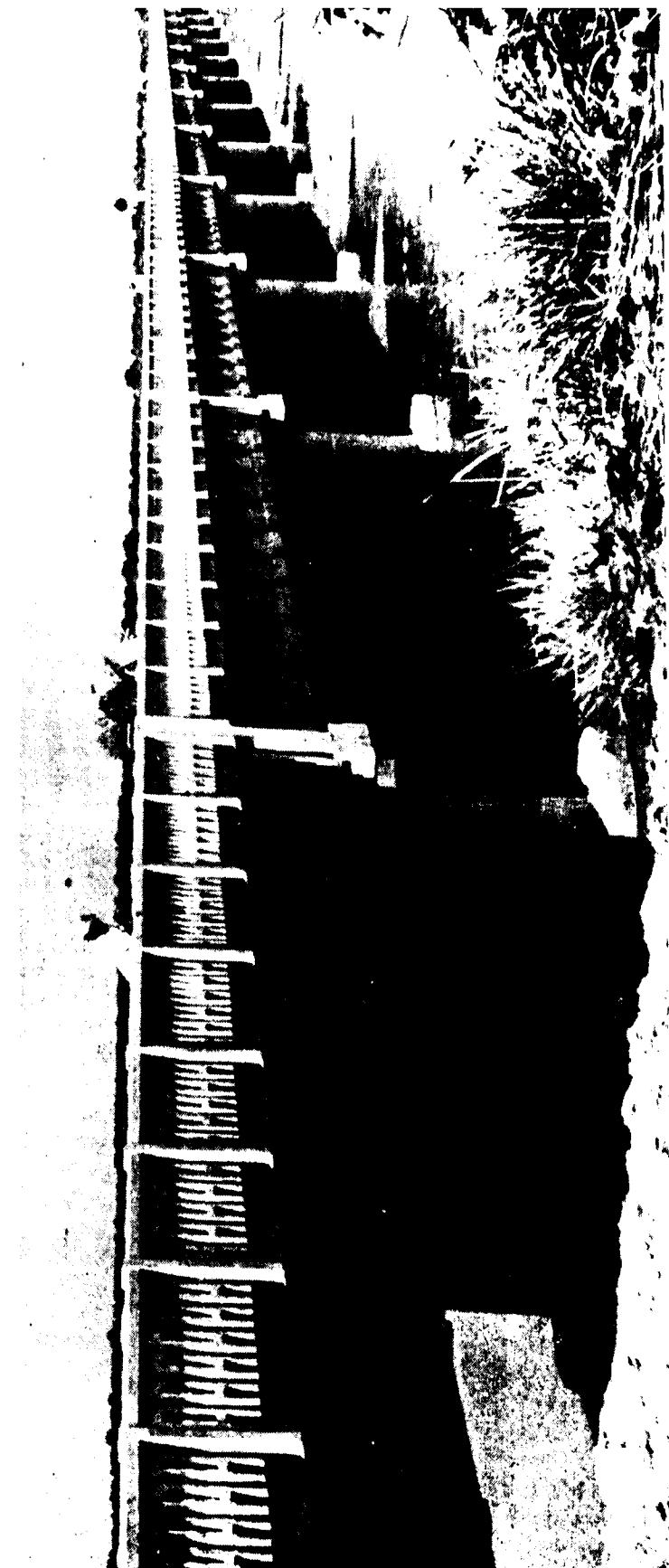
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TRANSPORT-COMMUNICATIONS MONTHLY REVIEW

A REVIEW OF
ROAD ENGINEERING, DEVELOPMENT & TRANSPORT

AUGUST 1960

SOIL STABILIZATION IN THE CONSTRUCTION OF RURAL ROADS

By
GEORG GREISS, Oberregierungsforstrat (Ansbach)

TRANSPORT problems have moved decisively to the fore in the programmes of modernization and reorganization of West German agriculture and forestry. Only a comparatively short period of time was necessary to introduce modern techniques into agricultural enterprises and farms, to intensify them, and to supply the most modern machinery and equipment. It is now imperative to make an efficient road system available so that this machinery and equipment may be used economically, and agricultural and forestry products easily transported.

The road network already in existence no longer fulfils present-day demands and must, therefore, be enlarged. At the same time, many new roads will have to be built in regions which have been neglected up to now. After these road building measures have been carried out, the entire system will have to be constantly maintained and further improved. European economic integration means that the various road building programmes must be put into effect and completed within a very short period of time. Other important considerations are the limited profits of agriculture and forestry, which allow only limited investments, and the steady decline in available manpower.

The main problems in the construction of rural roads and farm tracks, are first, that such roads are normally used by light traffic and carry their heaviest loads only during short, seasonal periods and second, they must be inexpensive to build.

It is obvious from the beginning that the impending road building programmes can never be finished in time if the old, commonly used, largely manual building methods are employed (hand-packed core, crushed rock or gravel surfaces). Increasing modernization and mechanization in road construction are inevitable. On the other hand, excessive demands in road building should be avoided, and, for the time being at least, the predominant aim should be the building of a reasonable road and farm track network, extending to the remotest field, and which, as a result of continuous maintenance, will later be improved and gradually stabilized, as necessary. Basic considerations also show that economical maintenance, is of greater importance for secondary roads and paths than high quality construction.

The trend toward increased mechanization of road building leads naturally to a corresponding change-over to new construction methods.

tion methods, and to implying soil stabilization. The tests carried out in soil stabilization in West Germany have shown that this modern road building technique not only makes the desired saving in manpower and acceleration of the building speed possible, but also brings about considerable structural improvements which are advantageous for rural road building.

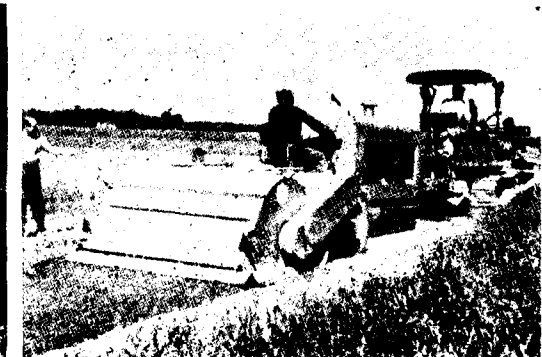
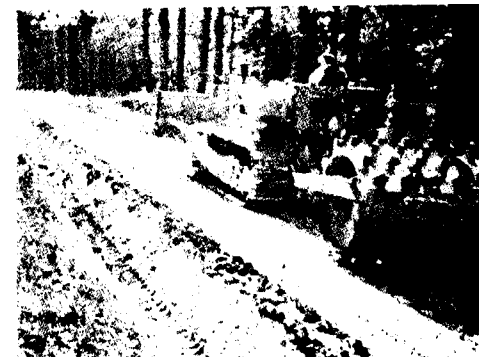
1. As a rule, the soil found in the road strip or in the vicinity of the construction site—with the exception of organic soil—can now be used as building material. Soil which up to now has been considered unusable, such as silt and clay soil, can be stabilized to form a foundation (sub-soil) able to support loads, by adding improving soil material or specific binders, or it can be made passable for construction traffic at least. Thus, the high cost of the removal of such soil from the road construction site

is avoided as well as that incurred for dewatering the road bed soil, which is necessary in most cases especially for the transport of frost-resistant sub-base material. The construction work starts with the building of an embankment—like “grader profile” which from the beginning, in contrast to the roadbed excavation, results in lifting the road above terrain level and so creates the best possible pre-requisite for a maximum overall drainage of the road structure. The drainage problem plays a decisive part in the construction of rural roads because these secondary roads are endangered much less by the effects of traffic loads than by the effects of rain-water and ground water.

2. The solidified sub-soil of the less used farm tracks can also be used without danger as a roadway. For heavier loads



1. Shaped earth farm track made of sandy-silty clay, compacted by layered construction only (built in 1954)
2. Clay-bound wind-blown sand with improved grain (built in 1955)
3. Mechanically compacted farm track (built in 1956)
4. Mechanically compacted forest road (built in 1958)



5. Sheeps-foot roller on highly-plastic clay soil
6. Soil mixer
8. Mechanically compacted sand wearing course on lime-stabilized, highly-plastic clay; the slope of the bench and ditches biologically solidified (built in 1959)
9. Mixing Portland cement into sand course on peaty soil

and traffic, depending upon requirements, construction can be strengthened by additional binders, or by placing base courses or road surfaces, when a step-by-step construction at certain intervals is often advisable. The properties can be varied depending upon the anticipated weight of traffic, a fact which in every case allows for economical adaptation to the minimum demands and so leads to considerable overall savings in costs.

3. A great advantage of stabilization is that it results in flexible structures made of compacted granular skeletons with few hollow spaces. Due to their optimum pressure distribution they are able to absorb elastically comparatively high dynamic load effects even with limited dimensions, and to compensate any weakness in the load

bearing capacities of the natural sub-soil. The flexible characteristics of such structures make it possible even for roads without a costly sub-base to be temporarily used by the heaviest loads.

4. Another advantage of stabilizing methods, used with the most up-to-date building machinery and equipment, especially with the help of the levelling effect of motor graders, is that water-repellent road surface profiles of outstanding evenness can be built and continuously maintained. This is a decisive factor in the life duration of a rural road because every deformation of the surface stores rain-water and as a result of the increased load pressure, further damage is caused. One of the reasons why the commonly used macadam surfacing is unsatisfactory for fast traffic is that the pot-holes,



7
7. Mixing quicklime into heavy clay soil

which are made fairly quickly in such surfaces, can be repaired only by manual work and thus, the evenness is impaired. It would be much too costly, however, to protect every secondary road or farm track with a bituminous surface, apart from the fact that inexpensive maintenance is possible only where sufficient traffic density is maintained.

The practical results of stabilizing tests made in rural road building can be summarized as follows:—

1. With the exception of organic soil, all types of soil can be stabilized. Organic soils (peat, peaty soil, bog, humus) are suitably covered with stabilizing layers of soil.

For secondary farm tracks, purely mechanical stabilization consisting of usable soil mixtures generally suffices. In the case of difficult soil conditions (fine-grained soil in

the range of silt and clay), it is advantageous to improve the sub-base by using binders so that in the first instance, certain types of calcium or sulphite solutions may be used, which are secured against underwashing by adding chemicals. Equally-grained fine sand and coarse silt can be improved by adding fillers. Mechanically stabilized road surfacing can be maintained mechanically if it does not contain grains larger than about 25 mm.

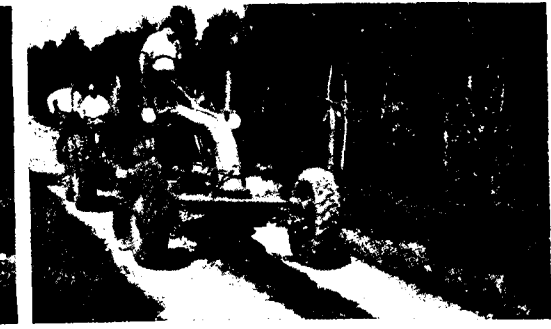
For heavier loads or traffic (main farm tracks, public rural roads) a stronger construction is necessary. Base courses consisting of clay-bound, bituminous or largely hydraulic-bound grain skeletons must be placed on the stabilized sub-base, or additional binders must be mixed into the prepared sub-soil in order to ensure the necessary load bearing capacity with suitable mixing depth.

Far coarse-grained soil (sand, gravel, crushed stone) tar and bitumen binders, cold or hot-laid are suitable as well as largely-hydraulic binders for instance Portland cement. Efficient base courses can be made of fine-grained soil (silt, clay) if, after preliminary treatment with calcium, additional largely-hydraulic or bituminous binders are mixed in.

Clay-bound or bituminous surfacing is usually necessary for these base courses, with the exception of some, such as hot bituminous mixtures.

Clay-bound (mechanically laid) surfaces are the least costly to produce. Judging by experience so far, they are adequate, with conscientious care and maintenance, for secondary rural roads carrying limited traffic and also for a comparatively large number of agricultural farm tracks. The material required for them (well-graduated sand, siliceous sand or chip-containing crushed stone with a proportion of binding

clay) must be selected with special care. It is also advisable to have the top surfaces of equal thickness for long distances so that mechanical maintenance can be carried out under uniform conditions as economically as possible. Generally, for normally used roads, re-compaction by a pneumatic-tyred roller at least once a year, shortly before the drying of the road surface after snow melts or after a prolonged rain period, proves to be sufficient. Much greater deformations which cannot be levelled and repaired by a pneumatic-tyred roller, are eliminated by means of a grader blade or, still more satisfactorily in most cases, by regular roughening of the surface with iron rake teeth attached to the grader blade, followed by pneumatic-tyred roller compaction. In the case of certain isolated deformations, it is advisable to carry out repairs with an iron hand rake and small vibrating devices. Dirt can be removed with a grader blade. Worn surface material must be replaced promptly.



10. Cement-solidified silt soil with a mechanically-produced sand wearing course (built in 1958)
 11. Double bituminous surface treatment in mechanically-stabilized flexible base course (built in 1955)
 12. Hot-laid, plant-mixed bituminous surface on a public forest road (built in 1959)
 13. Light motor grader in the course of maintenance work on road profile



14. Roughening of a sand wearing course with a toothed grader blade during continuous maintenance work



16. Field laboratory

Bituminous surfaces are used wherever heavier loads and traffic are encountered. It must be remembered that such surfaces are used only when traffic is sufficiently heavy, which seldom is the case on single-lane farm tracks. Moreover, close-textured wearing courses demand a perfect sub-base because they prevent the "breathing" of the road structure and can cause the formation of harmful condensation. Obviously, bituminous wearing surfaces also feature a more prolonged life when they are placed on flexible base courses than on the relatively hard, conventional macadam surfaces.

2. The equipment required for stabilization is quite extensive: Tactor-dozers, excavators of track-mounted front-end loaders, transport vehicles, tractors, motor

graders, pneumatic-tyred rollers, sheeps-foot rollers, vibrators, light smooth-wheeled rollers, rippers, rotary hoes, binder distributors mixing plants, laying machines, water carts and, if required, movable stone-crushing plants, etc.

In view of the amount of equipment needed, maximum saving in cost can only be achieved if sufficiently large projects are carried out. In the construction of rural roads and farm tracks, therefore, smaller projects must be combined with more important ones and, if possible, linked with maintenance work. Early planning, and extensive preparatory work are essential so that all machinery and equipment can be employed according to an exact working plan. The value of the equipment lies to a large extent in the fact that its use is supervised by qualified engineers.

3. The great variety of soil and terrain conditions means that stabilizing cannot be carried out according to a general, overall scheme. For every project, one or several soil analyses of the road itself are required, as well as discovering the location of suitable aggregates. Foundation conditions, with regard to the type of soil and water bearing strata, must also be accurately examined. On the basis of these results, the most suitable construction plans and formulae are then compiled in which the special requirements of each case are considered in deciding the layer construction. Compared with conventional construction methods, the cost of preliminary examinations and buildingsite controls is relatively high when stabilization methods are used. Even with simple construction projects, the necessary preliminary examination should not be omitted unless absolutely unvarying conditions are certain to prevail, about which sufficient knowledge is already available.

4. The building costs of stabilization depend to a great extent upon the prevailing soil and terrain conditions, climatic conditions, the availability of suitable soil in the vicinity of the construction site, and finally upon the size of the building project. According to experience gained in the Federal Republic, stabilizing processes enable a saving in costs of up to 50 per cent as compared to the building methods commonly used up to the present. The most important factor, however, is that the average building costs can be reduced even further as the uses of all possible suitable soil conditions are better understood.

In the Federal Republic, it has been decided to promote the development of soil stabilization methods systematically and to draw up well prepared, large-scale test programmes, the results of which will be made generally available. In the meantime two comprehensive test programmes for typical soil conditions have already been begun in the south and north of West Germany.

The German Road Research Association founded a new Working Committee in 1957, with the title "Soil Stabilization in Rural Road Construction", in which both agriculture and forestry are represented. This committee is working, at the moment, on provisional guiding principles for soil stabilization which have already been partially published in individual information

papers and which are being taken over by the most important agricultural and forestry organizations as part of the framework of special directions for their particular spheres. In this manner, co-ordinated progress by the competent authorities in close contact with the relevant research institutes and industrial organisations is ensured.

In addition, the setting up of a Federal Institute for Rural Road Construction as a partner of the already existing Federal Institute for road construction is seriously contemplated. Its work would be to safeguard the technical progress of rural road construction, to develop suitable construction methods systematically and to test them in test institutes: to work out uniform test methods for laboratory tests and construction site controls: to encourage the employment of new types of machinery and equipment by accurate performance tests, and to promote new designs in co-operation with the machinery building industry; to experiment with the possibilities of application of new binders: to suggest research in special problems to scientific institutes: to lay down statistically the results of test programmes and general building practice, and to evaluate these results accordingly: to share in the working out and evaluation of engineering soil analyses and construction methods for certain types of soil, to put the latest technical knowledge rapidly into practice by means of publications, training courses, conferences, meetings and advice, and particularly to cultivate a continuous exchange of experience in such developments with foreign countries.

All the signs show, however, that with the enormous dynamic of our era only extremely generous measures and teamwork carried out on a broad basis can lead to success in road construction technique. It is a pleasure to note that the necessary development has already started and that, for several years, the problem of soil stabilization especially has brought about intensive and cordial co-operation with many foreign experts.

The editors of Trends; Schofferstrasse 15, Darmstadt, shall be pleased to make the necessary contacts here in West Germany for interested readers abroad.

(From "Trends German Engineering" 12-4-60.)

BRIDGING INDIA'S RIVERS

THE GHAGGAR BRIDGE

(By Courtesy of the Chief Engineer, P.W.D. Punjab, Patiala)

(a) Introduction

The Ghaggar River crosses Ambala Kalka Road, National Highway No. 22, in mile 22, near Mubarikpur village and Ghaggar Railway Station on Ambala Kalka Section of the Northern Railway. Prior to the construction of a high level bridge, the vehicular traffic between Ambala, Chandigarh and Simla and other important cantonments in the Himalayas was put to a very great inconvenience. For 4 to 5 months in a year, the traffic had to detour via Rajpura, which meant an additional distance of 9 miles. Transhipment of bus passengers and their luggage over the Railway Bridge during the rainy season was not only inconvenient, but dangerous. The necessity for an all-weather road link had, therefore, been felt for a long time.

(b) Site

For selecting a suitable site, detailed investigations were carried out. The old ferry crossing site was a little upstream of the railway bridge, but since the river takes a right-angled turn about half a mile upstream, location of a road bridge at this site was ruled out. At first, a bridge site about 900 ft downstream of the railway bridge was selected, but later on considering the importance of a direct link between Ambala and Chandigarh, the new Capital of the Punjab State, the same was shifted about a mile and a half downstream of the railway bridge. The construction of the bridge on this site has saved a distance of about 6 miles between Ambala and Chandigarh. The additional cost of approaches has been paid for by the Punjab Govt. while the major portion of the bridge and the approaches has been financed by the Government of India.

(c) Discharge and Waterway

The discharge of the river has been worked out from the cross sections taken

at various places, as also from the consideration of the intensity of rainfall and the catchment area on the basis of Dicken's formula with a value of 3000 for the constant. This high value of the constant is justified because the catchment of the stream is subjected to a very heavy rainfall and cloud bursts. The total designed discharge of the main stream and the Sukhna Choe, a tributary which meets the River a little upstream of the present bridge site was worked out to 1,52,000 cusecs.

To pass this discharge 12 spans of 87.5 ft each have been provided and the waterway thus provided is in agreement with Lacey's formula which gives a waterway of 1040 ft. The Railway bridge has 14 spans of 100 ft each but the end span on Ambala side is completely blocked and the end two spans on Kalka side function very rarely.

(d) Super-Structure

While calling tenders from various firms for this work it was left to their discretion to tender for the R.C.C. Hollow Box Girder type departmental design or submit their own alternative design. Finally the lowest tender of Messrs Gammon India (P) Ltd., for a bridge with prestressed concrete super-structure was accepted.

The bridge consists of 12 spans of 87½ ft each giving a deck length of 1050 ft from end to end of beams over the two abutments. Each span comprises of 7 Nos. prestressed precast concrete beams launched in position by means of the launching truss and supported over cast steel roller and rocker bearings on piers or abutments.

The overall depth of each of the 7 beams is 4 ft-6 in. The web as well as the flange is 5 in. thick and the width of the flange is 3.61 ft. The bottom bulb is 1.08 ft wide

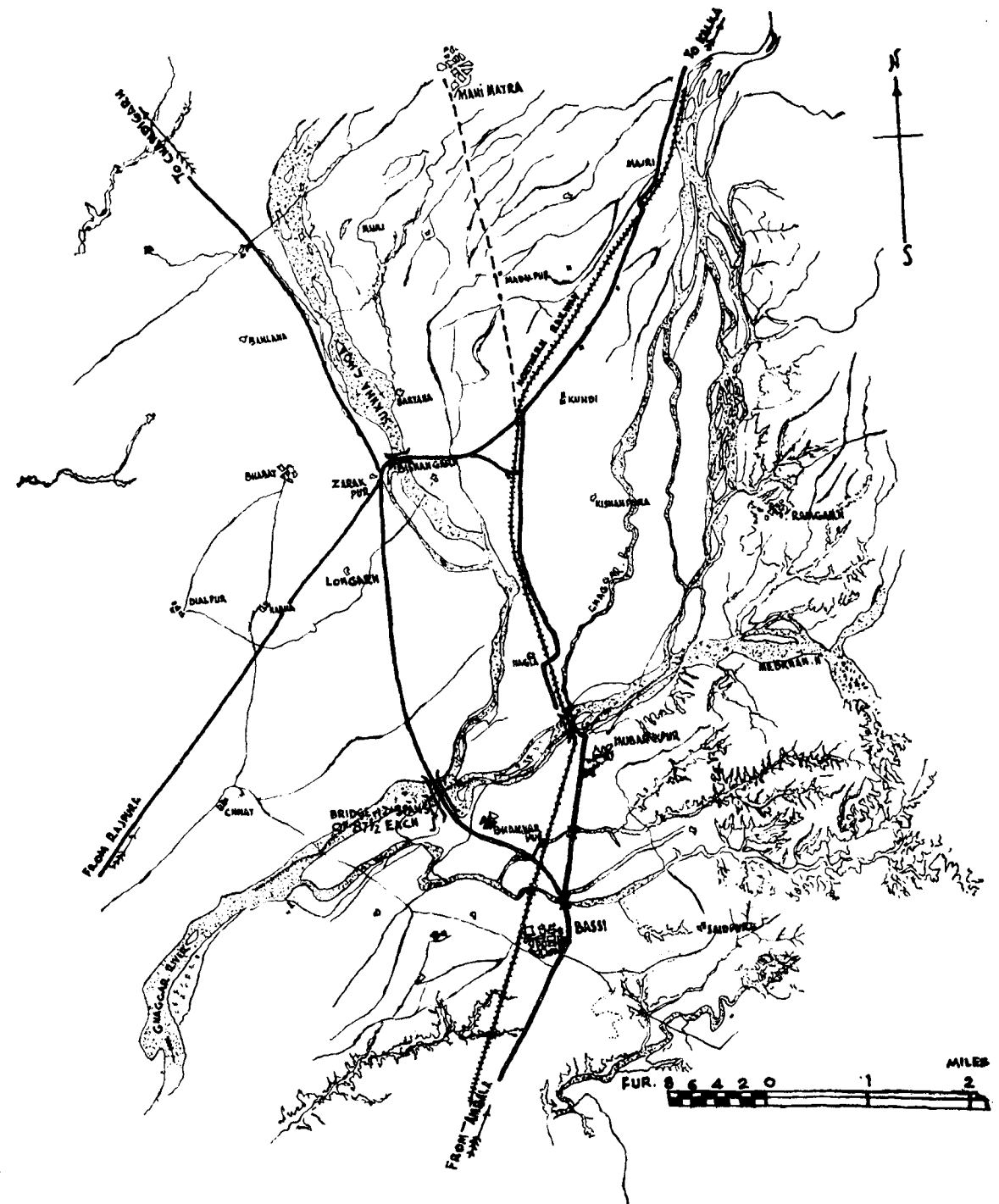


Fig. 1. Key map

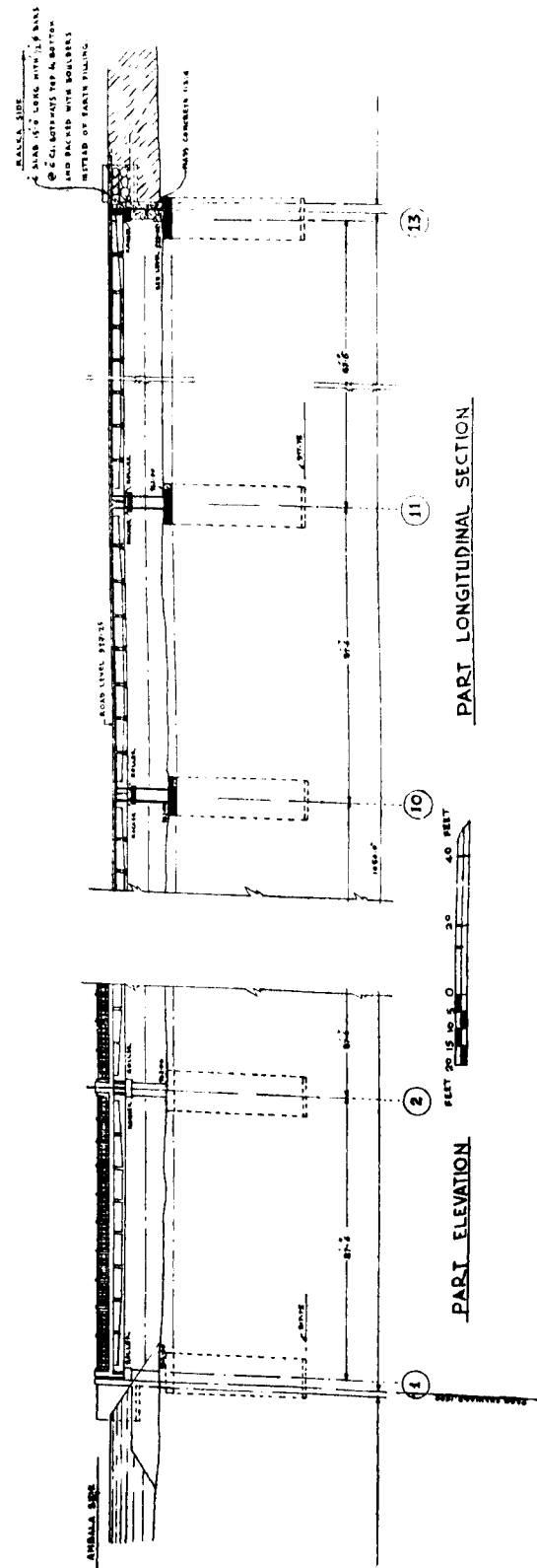
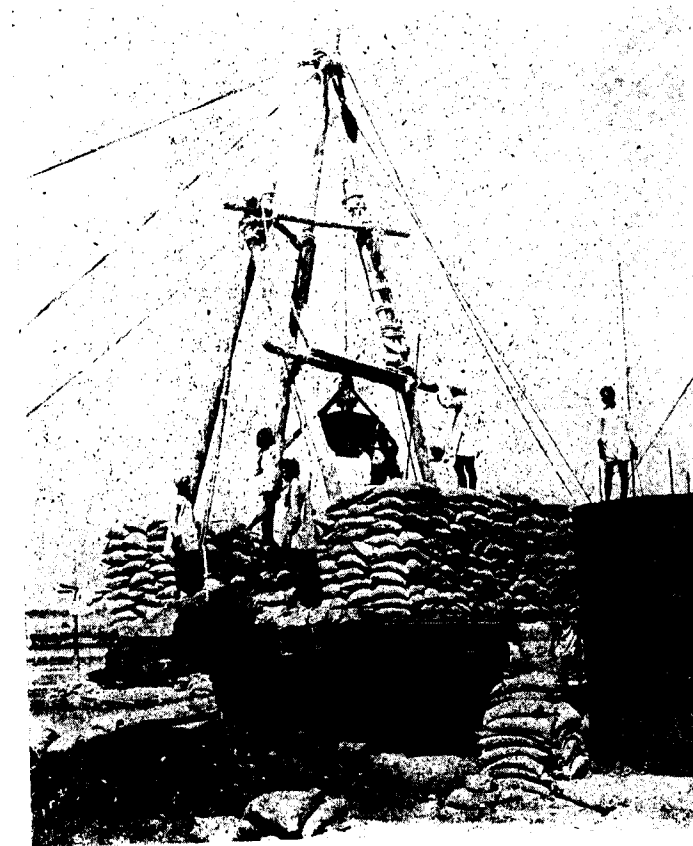
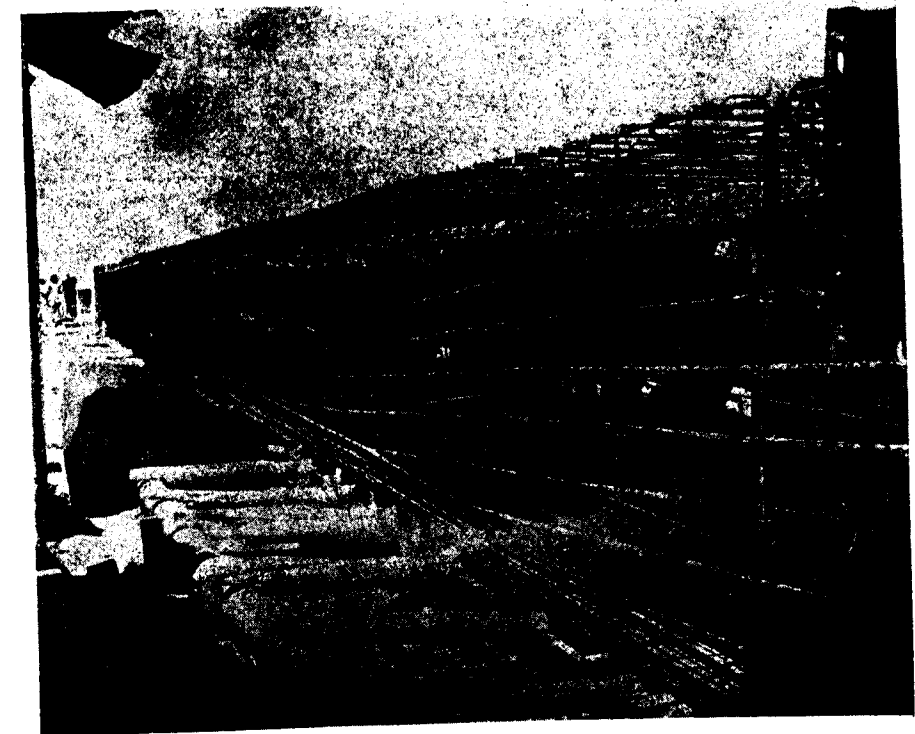


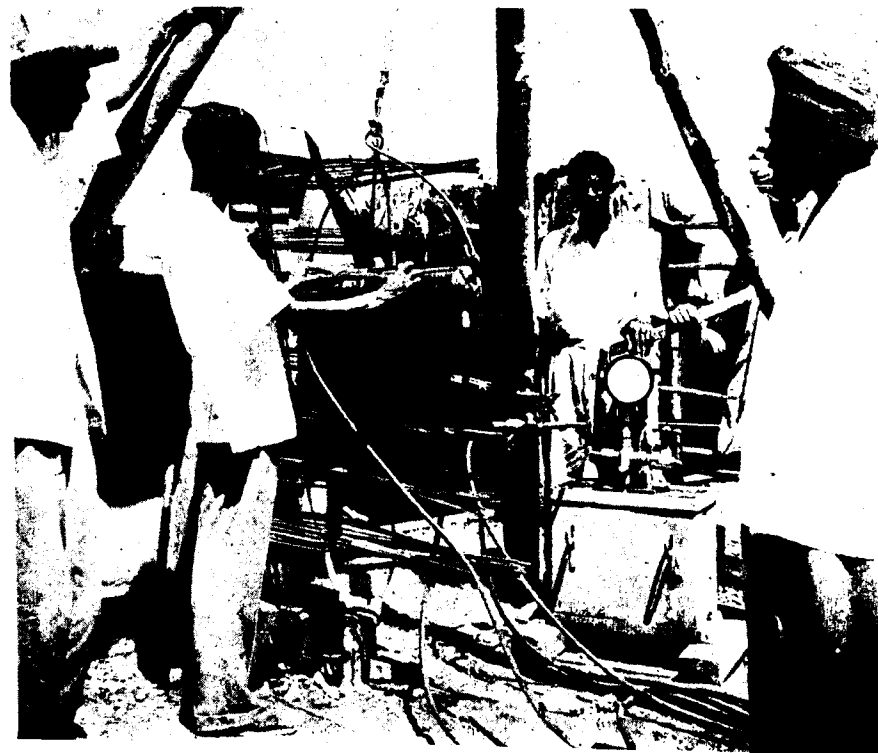
Fig. 2.



Sinking of well
in progress

Reinforce-
ment in
Beam





Prestress of
Beam in
Progress



Beam
launched in
position

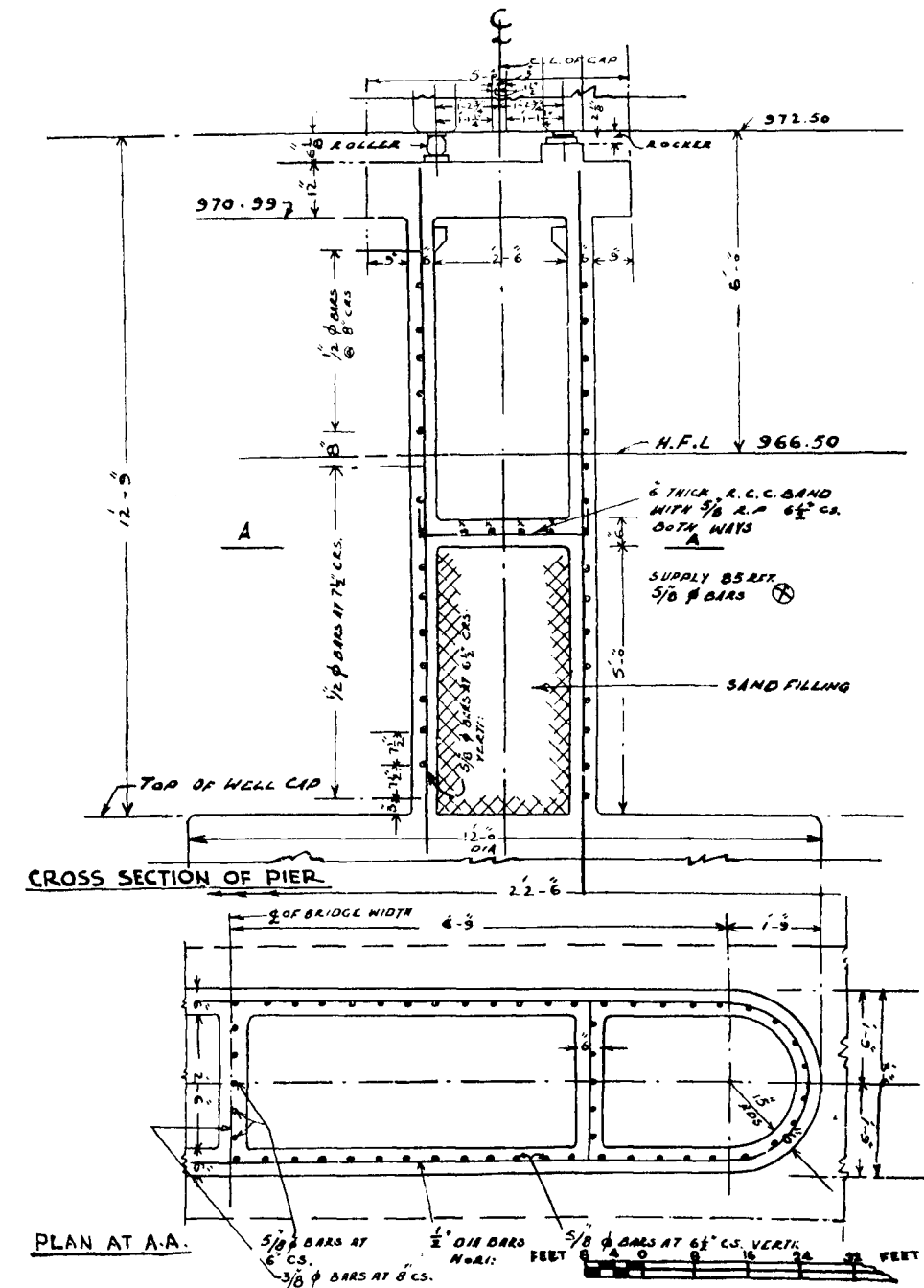


Fig. 3. Details of Piers

and 1.08 ft deep at face of the web. At the outer edge of the bulb the depth is 9 in. Each beam was pre-stressed according to Freyssinet system by means of 9 cables each containing 12 H.T.S. wires of 0.2 inch

diameter. Stiffening diaphragms have been provided in each span at 8 ft intervals and the beams have been cross prestressed together. The bridge has been designed for two lanes of Class 'A' or one lane of

Class 'AA' loading whichever creates severer stresses in various members, 58 tons of H.T.S. wire and 80 tons M.S. were used for the super-structure.

(c) Substructure

The decking is supported on R.C.C. cellular piers having two 6 in. thick walls of R.C.C. spaced 3 ft. centre to centre and stiffened by three 6 in. thick vertical cross walls running right through the height of the piers. A horizontal diaphragm, 6 in. thick of R.C.C. was also introduced at a height of 5 ft from the base. Pier noses were filled with sand upto 5 ft height to make the structure safe against impact of any floating debris or trees.

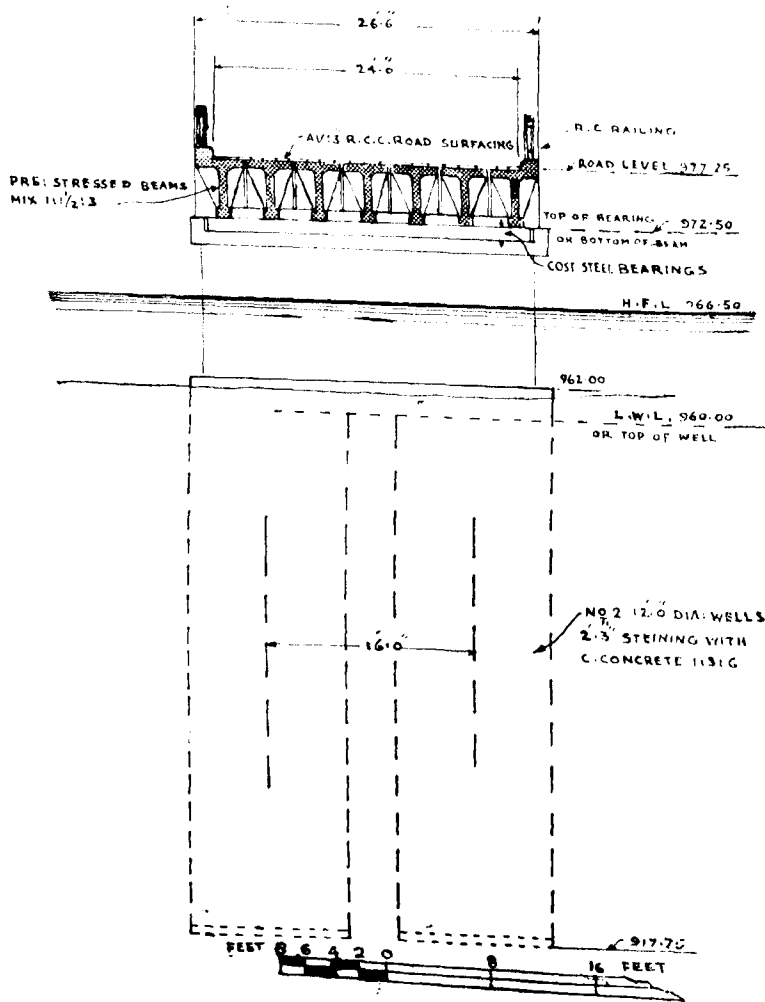


Fig. 4. Cross Section

(f) Foundations

Each pier is founded on two 1:3:6 cement concrete wells with 12 ft outside diameter and a dredge hole of 7 ft 6 in. dia. The wells are spaced 16 ft centre to centre and have been sunk to about 42 1/2 ft below the bed level.

4 ft thick bottom plug was laid in 1:2 colerete while two intermediate plugs 1 1/4 ft thick each were laid in 1:3 colerete. The space between the plugs was filled with sand. The two walls are capped at the top by a 2 ft thick R.C.C. Transom slab. The well curbs are 2 ft 4 1/2 in. thick and 3 ft deep. They were cast in 1:2:4 cement concrete lightly reinforced. The cutting

edge was of M. S. Angle iron 3 in. x 3 in. x 1/4 in. welded on to a M. S. Plate 6 in. x 3/8 in. The steining was reinforced with 1 in. dia. round bars 10 in number placed circumferentially.

The wells were sunk by open dredging, making use of kentledge as and when required. Two grabs of 9 cu. ft. capacity each operated by 2 1/2 tons double drum winch and 6 grabs of 2 1/2 cu. ft. capacity operated by manual labour were used during sinking operations. Maximum kentledge on any well was not more than 80 tons. The tilts were checked from time to time by means of a tri-square and a plumb and any small amount of tilt noticed was corrected by eccentric kentledge or grabbing. Maximum tilt observed was 1/4 in. and maximum shift observed was 1 1/2 in.

One of the wells was tested with a super-imposed load of 270 tons approximately. This load was maintained for 24 hours and no sinking of the wells was noticed. This test load is about 1 1/2 times the vertical load of 190 tons coming on to the walls.

and 400 ft on the downstream side excluding the noses.

The water side of the guide bund has been provided with 1:5:10 cement concrete pitching laid in blocks of 4 ft x 2 1/2 ft x 1 ft upto 4.3 ft above H.F.L. The 30 ft wide apron consists of cement concrete blocks of 1:5:10 mix laid in sizes 5 ft x 5 ft x 2 ft. These blocks were inter-connected by means of M.S. bars forming hooked joints between the two blocks which had a gap of 3 in. on either side.

(h) Allowable Stresses

The following stresses have been allowed in the design of the bridge:

	Tons per sq. in.
Max. working stress in H.T.S.	51
Failure stress in H.T.S.	100
Min. cube strength of concrete at 28 days	5000
Working stress in concrete	1670

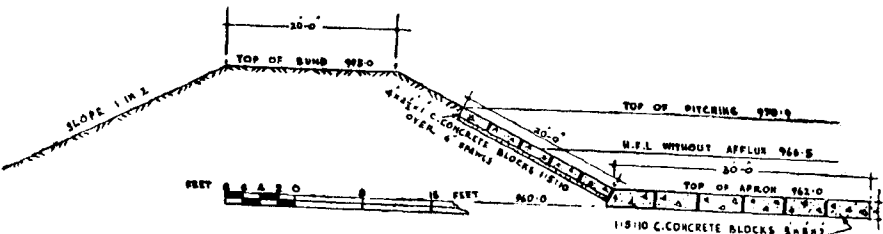


Fig. 5. Cross Section of Guide Bund

(g) River Training Works

At the site of the bridge the river flows over a very large width and during high floods has the tendency to overflow the banks on the Chandigarh side which is inundated to a depth of about 2 1/2 ft. To restrict the river width and to prevent the overflow of water guide banks have been provided on both sides. Chandigarh side abutment has been located in the natural bank of the river and on this side, length of guide bund is only 640 ft on the upstream side and 460 ft on downstream side excluding the noses. On Ambala side the abutment had to be buried in the guide bund whose length on the upstream side is 1800 ft

	Lb per sq. in.
Initial stress in concrete during pre-stressing	1800
During service no tensions in the bottom fibre	
Permissible tension in concrete during prestressing	160
Max. allowable principal tensile stress	107

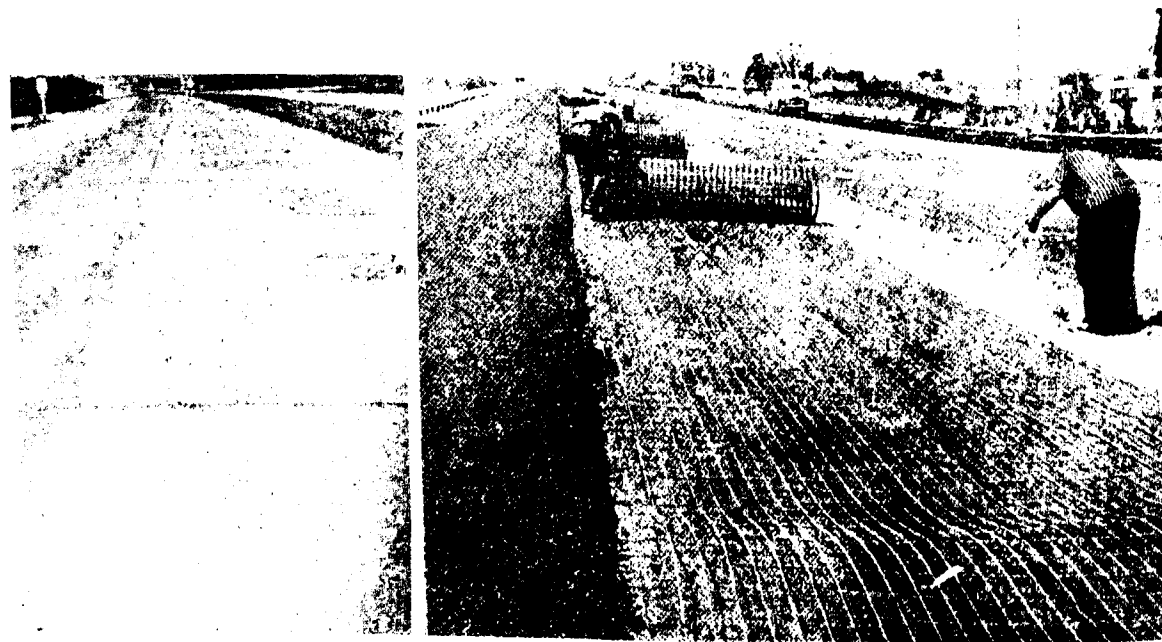
(i) Cost

The cost per foot run of the bridge works out to Rs 1025 and per square foot of decking Rs 42.75. The bridge was opened to traffic in early, 1958.

WELDED-WIRE FABRIC IN AN ASPHALTIC-CONCRETE PAVEMENT OVERLAY

THE Highway department of Ontario, Canada, this summer made the first major use in Canada of welded-wire fabric for reinforcement of an asphaltic-concrete pavement overlay. The fabric was used in all four lanes of the first 2-mile stretch of Ontario Route 400 where it joins Ontario Route 401 bypass on the northern outskirts of Toronto.

When it was decided to restore to full service the 9-year-old portland-cement-concrete pavement of Ontario Route 400, using a bituminous overlay, engineers felt some concern about reflected cracking because the old pavement was badly cracked, sealed, and it had faulted slabs. As a result of the earlier test, engineers specified that wire fabric be used to control cracking.

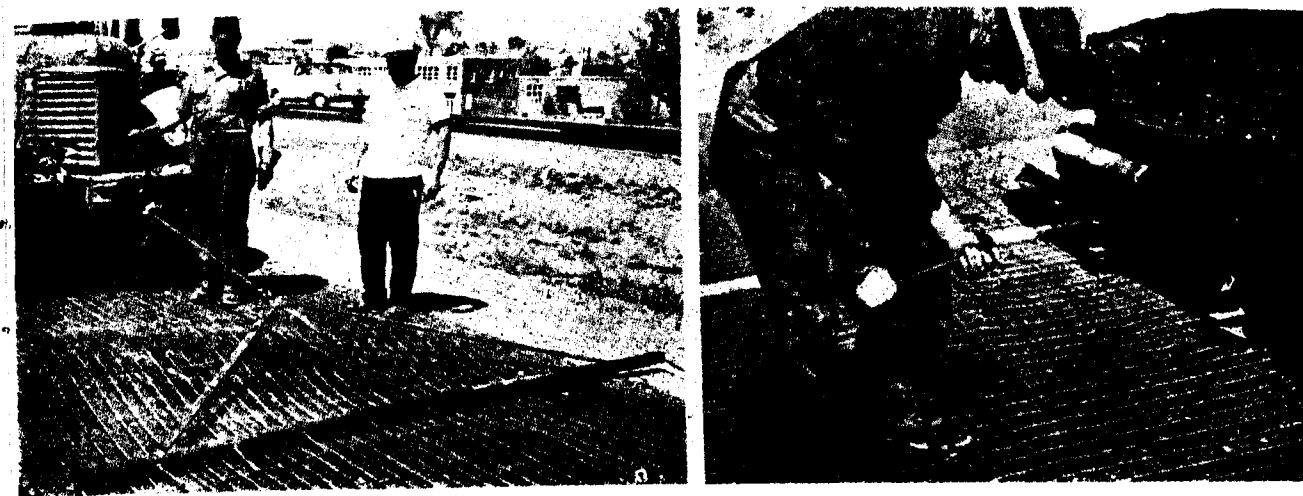


Workers unroll lane-wide rolls of wire fabric next to previously laid reinforced base course of adjacent lane. On curves, fabric must be laid and tensioned in much shorter lengths. At right, faulting, scaling and mid-slab cracking on Ontario Route 400. These surface failures led to decision to resurface the old highway

The only previous use of the fabric-in-asphalt process had been a short test section installed in 1958 on the queen Elizabeth Way, west of Toronto. The purpose of the test was to determine the ability of wire reinforcement to reduce and minimize the formation of reflection or sympathetic cracking of the new asphaltic concrete over cracks and scaling in the original pavement.

The resurfaced section of Ontario Route 400 is the most heavily travelled portion of the important artery between Toronto, its northern suburbs and the northwoods country.

The same contractor was awarded the contract for the 2-mile section using wire-fabric reinforcement and for the 2.3 miles



Job-devised tension bracket, at left, eliminates slack, bulges and waviness in wire fabric, and enables paver to lay ho mix over the wire without difficulty. Worker at left is applying pressure by arm of portable winch, anchored to truck. Contractor-designed tool at right, a length of pipe with a handle, ends in two prongs, which when twisted, eliminate slack wires. A similar tool has a notch in end of pipe.

of unreinforced highway that immediately adjoined. Because cracking and scaling of the old pavement was at its worst where the fabric-in-asphalt was employed, a severe but convincing test of the benefits of using the fabric is expected.

Except for the actual operation of placing the wire fabric, the contractor proceeded as he would for normal bituminous overlay work. His crews made practically the same time on reinforced as on unreinforced work, except for one curved stretch of the pavement at the very outset of the project. In an 11-hour day, a maximum of 1,400 tons of asphalt on two lanes was placed.

On straight stretches of the reinforced overlay, the wire fabric, furnished to the job in 1,000-ft-long rolls, could be placed and secured in one length, but on the curve, it was necessary to cut and joint the fabric into short lengths in order to conform to the curvature.

At each joint of the short lengths of fabric fitted about the curve, the wire ends were trimmed, and the lengths lapped over each other one space, about 6-in. and tied with wire fasteners. These laps were wedged-shaped, narrower at the inside of the curve and wider at the outside.

The fabric was unrolled on the 22-ft-wide lanes in two widths, 9 ft and 12½ ft. The widths were butted against each other and

thus allowed 3 in. of clearance on either side of the pavement. Except for the one curved section, the rolls were unrolled their entire 1,000-ft length, and fastened to the next roll in a lap joint, and another roll unrolled, and so on. At the start of any length of reinforced overlay, the wire fabric was secured to a fastener "shot" into the underlying portland-cement-concrete pavement by percussion cap.

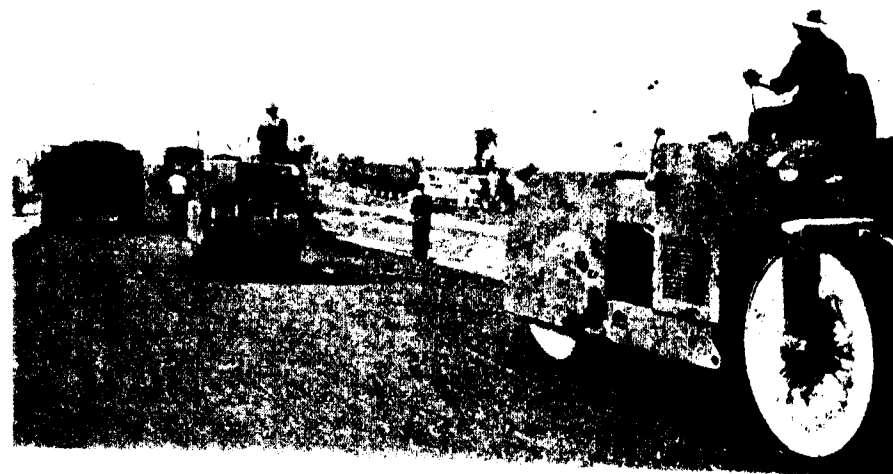
With the welded wire fabric in place the contractor began to use three job-built devices that greatly facilitated laying of asphalt over the wire. First, using a 12-ft length of heavy pipe into which were fitted "J" hooks at 1-ft intervals, he grasped the entire width of wire fabric and by means of a bridle and winch, which was anchored to a truck, applied tension to most or all of the roll at once. This eliminated waviness and bulges in the fabric, and eased the passage of the paver.

If any localized bulges or waviness were noticed as the paver approached, a two-pronged fork device at the end of a pipe and handle was dropped over the bulging wires and the waviness was crimped away by a deft twist of the handle.

Finally as further assurance that the wire fabric would not catch or hang-up in the feeder screw of the bituminous paver, the contractor devised a sled and runners to



Workers form construction joint. Paper is unrolled over end of roll of welded-wire fabric, which has been secured to pavement with cartridge-fired fastener, and will be covered over with feathered-out hot mix. Normal traffic will use surface, but when construction is resumed paper will be rolled back, stripping away the asphalt and exposing the fabric, ready for lapping with next roll. Below, final step in overlay construction—thorough compaction by rollers



ride between and just outside the paver's crawler tracks and iron out any tendency of the wire to catch, and to keep it down in the overlay.

The two widths of fabric, 9 and 12½ ft were placed so that the joint between lanes of asphaltic concrete were offset from the joint formed by the two strips of fabric.

The order of operations on the job was, placement of 2½ in. of a levelling course; placement of wire fabric; 2½ in. of base course, and a 1½ in. surface.

Heavy rush-hour and weak-end traffic hampered high-speed production on the job. As each course was laid down, section by section, it was necessary to throw the day's newly placed asphaltic concrete open to traffic.

The resurfacing of Ontario Route 400, a Toronto district project, was under the direction of F.C. Brownridge, of the Ontario Department of Highways.

(From "Better Roads", January, 1960).

'YIELD' SIGNS

By

J. INWOOD, B.Sc., A. INST. P., AND R. F. NEWBY, B.Sc. F.R.A.S., F.S.S.,

Road Research Laboratory, Department of Scientific and Industrial Research, U.K.

THIS article describes experience of the 'Yield' sign so far obtained in Great Britain and the United States of America.

In America the road sign controlling entry from a side road into a major road, and corresponding in its effect to the British 'Halt' is the 'Stop' sign. In recent years a need has been felt for a less restrictive standardised sign and the 'Yield right-of-way' sign has been tried in certain States including Oklahoma, Rhode Island, New York, Washington, California, Illinois, Texas, and Oregon. It has also been tried in Manitoba, Canada. At a 'Halt' sign every vehicle controlled by it is required to stop before entering the junction, but at a 'Yield' sign vehicles controlled by it need not come to a complete stop unless this is necessary to avoid interfering with the stream of traffic to which the sign gives right-of-way.

In Britain the use of 'Yield' signs arose out of a proposal made in May, 1955, to the Ministry of Transport and Civil Aviation by its Committee on Road Safety that 'Yield' signs of the American type should be tried out experimentally to meet requirements not satisfied by 'Halt' or 'Slow' signs. It was suggested that some of the new signs should be used in the Slough Safety Experiment and that some others should be tried elsewhere. The three British signs are shown in Fig. 1.

Effect on traffic delay

American experience with 'Yield' signs has been described in various highway journals (see references) and no exhaustive discussion of the results is here attempted.

Few exact measurements of the changes in traffic behaviour produced by the 'Yield' sign are quoted in the American references and no measurements of delays are mentioned.

Although one aim of the 'Yield' sign is to reduce delay at junctions it is a legal requirement in many American States that vehicles must slow down on passing a 'Yield' sign, even though there is no necessity to stop. In some cases a maximum passing speed is prescribed: this is indicated by a plaque below the 'Yield' sign and may be as low as 10 mile/h.

Kell¹ mentions that 'Yield' signs have been found useful in Virginia and Maine for controlling the entry of traffic to roundabouts, and the signs have also been proposed for use in controlling access to dual-carriageway roads where two separate movements may be required for a vehicle joining the offside traffic stream from a minor road.

While generally in favour of the 'Yield' sign, American traffic engineers usually emphasise that further experience is needed before the true value of the new signs can be estimated.

In Britain, where the 'Slow' sign is already available as a less restrictive alternative to the 'Halt' sign, the question of the usefulness of the 'Yield' sign is somewhat different. The problem is whether, and in what circumstances, the 'Yield' sign would be an improvement on the existing signs as regards safety and convenience to road users.

Road tests to measure the usefulness of 'Yield' signs have been carried out by the Road Research Laboratory on behalf of the Ministry of Transport and Civil Aviation. The first experimental 'Yield' signs replaced six 'Halt' signs and seven 'Slow' signs as part of the Slough Safety Experiment in 1956². In the spring of 1957, 15 additional junctions with 'Slow' signs and eleven with 'Halt' signs in West London, Buckinghamshire, Middlesex,

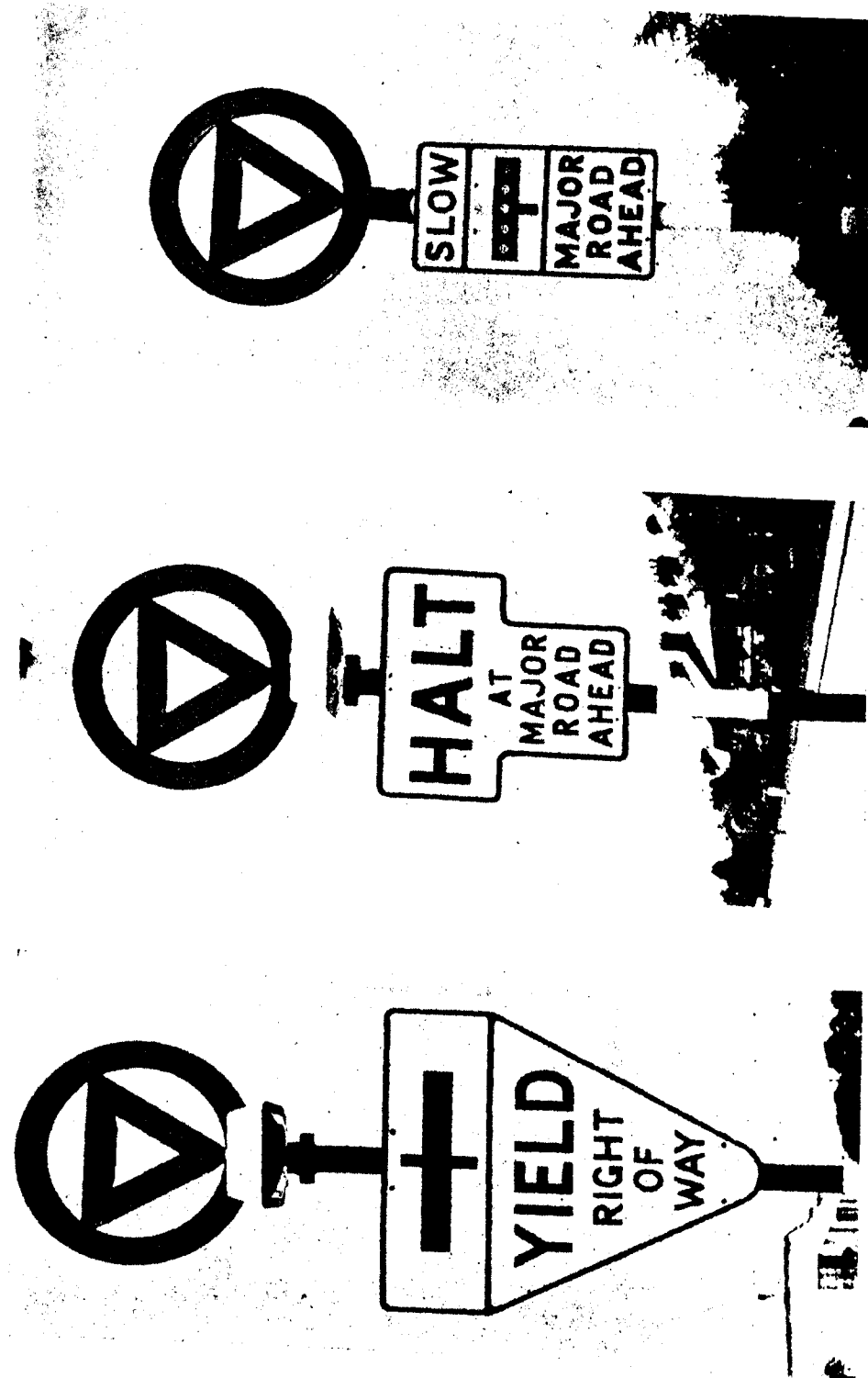


Fig 1. 'Yield,' 'Halt' and 'Slow' signs on the same scale (photographed from a distance of 13 ft)

Oxfordshire and Berkshire were selected for experimental conversion to 'Yield' signs. Corresponding to each of the converted signs of the 1957 group a similar junction with a 'Slow' or 'Halt' sign was chosen as a statistical control for studying driver behaviour during a test period. Accident records were also compared in a 'before-and-after' study. In this experiment, the 'Yield' signs were being tried as alternatives to existing British 'Halt' or 'Slow' signs and not, as was frequently the case in the United States, as innovations at previously unmarked junctions.

The reaction of drivers to the signs was studied by observing their choice of the periods required for certain movements involved in making an exit from a minor road. It was found empirically that the behaviour of vehicle drivers emerging from minor roads was unaffected by traffic on the major road if they had a traffic-free interval in the major-road traffic of not less than 12 seconds following the instant of their exit from the minor road (whether or not the exit was preceded by a precautionary pause at the mouth of the minor road). Exits made under these conditions will be referred to as 'free exits' and the delays or pauses before such exits as 'free exit delays.' These delays were the intervals during which the wheels of the vehicle emerging from the minor road were not turning, and they varied from zero, in the case of drivers who did not stop as the result of the road signs, to several seconds for cautious drivers who stopped at the signs. It was found that, where 'Yield' signs replaced 'Halt' signs, the average free exit delay for all movements (right-turn, left-turn and 'straight-over') was reduced by a statistically significant amount of 42 per cent. As examples of the actual delays involved, the average for 'straight-over' crossings of the major road decreased from 3.3 to 1.8 seconds, and the average for left-turn exits fell from 2.3 to 1.2 seconds, the right-turn values being intermediate between the above. The proportions of drivers who stopped at the major road fell after the 'Yield' signs replaced the 'Halt' signs.

No significant change in free exit delays nor in the proportion of drivers who stopped at the major road could be detected when 'Yield' signs replaced 'Slow' signs.

When a vehicle emerged from a minor road in the presence of main road vehicles closer than described above for free exits, it might risk making its exit in a period of less than 12 seconds before the transit of the next oncoming main-road vehicle, or it might stop and await some other time interval in the main road traffic. It was found, in practice, that when drivers from the minor road were required to consider only gaps in the nearside or the offside traffic the resulting figures for interval selection (or preference) could be usefully analysed, but that when they were preoccupied with continuous traffic from both directions of the major road their behaviour was much more difficult to interpret. Analysis of the available data for interval selection showed that the installation of 'Yield' signs produced no appreciable change in driver behaviour.

Effect on accident rates

In America the 'Yield' sign is regarded as having on the whole reduced accidents at previously uncontrolled junctions both in urban and in rural areas. Little improvement if any was expected or was obtained at intersections that previously had 'Stop' signs (equivalent to British 'Halt' sign) because the degree of control was reduced.¹ For example, 28 such places in Oklahoma City accidents in the 12-month period before and after the signs were installed were 23 and 21 respectively.² The numbers of accidents at other experimental sites were in most cases, small, but some encouraging results appear to have been obtained: at Seattle, Washington, accidents were said to be reduced by 52 per cent at 30 previously uncontrolled intersections. At 17 uncontrolled intersections in Berkely, California, where 'Yield' signs were introduced, injury accidents in one year fell from 13 to 3 and damage only accidents from 64 to 41. In this case, as in some other States, the sign was reinforced by the word 'Yield' painted on the carriageway.¹ At 89 sites where 'Yield' replaced 'Caution' signs in San Diego, California, there were 64 accidents in the year before the signs were installed and 28 accidents in the year after. In some cases there were 'Stop' signs on other approaches to the intersections. Seven of these locations showed a slight increase (one accident) but all the others experienced either a decrease or no change.

In the investigation carried out by the Road Research Laboratory a comparison was made of the number of injury accidents at the experimental sites before and after the 'Yield' signs were installed. It was assumed that if the existing signs ('Slow' or 'Halt') had not been replaced, accidents at them would have changed in the same proportion as they did in the surrounding area. The number of reported injury accidents at these places during the 'after' period was about equal to the number expected on this basis, so that the evidence did not suggest that 'Yield' signs were in any way better or worse than the former 'Slow' or 'Halt' signs. The differences between expected and observed numbers of accidents could have occurred easily by chance and were not consistent from one area to another. For instance, in country districts there were more accidents than expected at sites that previously had 'Halt' signs and fewer where there had been a 'Slow' sign; the reverse tendency was found at sites in or near London. At some places in Slough there were slightly fewer accidents with the 'Yield' sign but the reduction was not statistically significant and other road changes made at the same time may have contributed to the result.

The limited evidence therefore failed to show any advantage obtained by installing 'Yield' signs. However, a reduction in accidents of less than 40 per cent would not have been regarded as statistically significant because of the small numbers of accidents available for comparison.

Conclusions

Tests so far completed in Great Britain indicate that, in the case of free exits into quiet (traffic-free) conditions on main roads, drivers were delayed less by 'Yield' signs than by 'Halt' signs at the same junctions. Drivers tended to treat 'Yield' signs in

much the same way as 'Slow' signs. When choosing opportunities for moving into denser main-road traffic drivers behaved much as they had done before the signs were changed.

As regards road accidents, experience in U.S.A. suggests that little if any improvement was obtained by changing 'Stop' to 'Yield' but that substantial reductions have been achieved by providing 'Yield' signs at junctions previously uncontrolled. In Great Britain limited studies have so far failed to establish any reliable conclusion either for or against 'Yield' as compared with 'Slow' or 'Halt' signs as regards safety. No study of the effect at previously uncontrolled junctions has been made.

Acknowledgement

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(From "The Surveyor and Municipal and County Engineer", 19th December 1959.)

Office boy: "Sorry, madam, but Mr. Brown has gone to lunch with his wife."

The wife: "Oh, well...tell Mr. Brown his stenographer called."

WIDENING AND RECONSTRUCTION OF ROAD BRIDGES

By

G. M. MILLS, B.Sc. TECH, A.M.I.C.E., A.M.I. MUN. E., A.M.I. T. E. *

MANY old road bridges exist which are now inadequate for present-day traffic requirements. The principal faults are insufficient width, poor alignment horizontally and/or vertically, and low load carrying capacity. A bridge may be weak not only due to the inadequacy of the original design but also as a result of serious deterioration to the original structure.

It is part of the responsibility of the engineer to a council to ensure that road bridges within his area are satisfactory and from time to time surveys of existing bridges should be undertaken to determine their condition. In addition to the usual ground survey for checking width and alignment, a thorough inspection of the existing structure is essential to discover any weaknesses and defects and estimate their seriousness. In his report, the engineer should try to ascertain the rate of deterioration of the existing structure in order to decide on its probable remaining life, to determine the safety of the structure under all probable conditions of loading and to decide on the necessity for repairs or renewals and their urgency. If the latter are required, he must also decide how the live loading may be safely carried while repairs, renewals or part reconstruction is in progress.

Where an existing bridge is seriously deficient in several respects, the simplest procedure is to demolish the existing structure and build a completely new one. If however the same object can be achieved by widening, strengthen or partial reconstruction of the existing bridge with a consequent saving in cost as compared with a completely new structure, the latter solu-

tion is frequently adopted. In such a case a heavy responsibility falls on the engineer not only to try to achieve some form of visual unity in the final structure but also, to ensure that the existing structure is or can be made capable of withstanding successfully any additional forces which may be imposed during and after the work of reconstruction.

Assessment of existing bridges

During the Second World War, Professor Pippard¹ investigated the strength of masonry arch bridges with special reference to the carrying of heavy war transport loads. The results may not therefore be valid for modern transport conditions. He suggested that the allowable axle load is governed by the span, ring depth and depth of fill at the crown of the arch. Thus for a span of 20 ft, ring depth 13½ in. and depth of fill 2 ft, the allowable axle load would be 17 tons (as compared with 22 tons Ministry of Transport live load).

While the arch part of an existing bridge may be adequate, the remainder of the structure may not. A common fault with masonry arch bridges is the outward movement of the Spandrel walls. However, unless accurate records of previous inspections are available, it may be difficult to estimate the significance of visible cracks. Vegetation may also cause considerable damage, particularly tree roots.

The strength of bridges constructed of iron or steel would appear to be easier to assess than arches. Even here, though tests carried out during the last war showed unexpected reserves of strength for bridge decks consisting of beams embedded in

* Paper presented to the Institution of Municipal Engineers West Midland District Associate Members and Students Section at Stafford on 30 March. Mr. Mills is senior lecturer in structural engineering College of Advanced Technology, Birmingham, and was formerly senior engineering Assistant, Borough of Solihull.

concrete or jack arches. It was suggested by Chettoe² that the increased strength as compared with that of the beams only was given roughly by the ratio:

$$\frac{\text{Overall depth of construction}}{\text{Depth of girder}}$$

Once again, this assessment was intended primarily for military loads.

The most serious enemy of iron and steel bridges is corrosion. Frequent inspection, the painting of exposed metal at reasonable intervals and the avoidance of unnecessary damp conditions are essential. For example, during the dismantling of the wrought iron girders at Damson Lane, Solihull, prior to reconstruction, it was found that severe corrosion had occurred at the connections at the cross girders with the through girders mainly due to the percolation of water between the side of the road and the webs of the through girders.

It was estimated that the reduction in area of the bottom flange of the through girders had increased the bending stresses by over 10 per cent. As the bridge was originally under designed, the maximum dead load stress was found to exceed that suggested for wrought iron in B.S.S. 153.

Records of foundations are rarely available for the older types of bridges and trial pits will be required to obtain even an approximate idea of the depth and overall dimensions of the existing sub-structures. Possible settlement may be assessed by observing the levels of string-courses and assuming that the original lines were horizontal. In the case of masonry arches, uneven settlement may result in cracks developing in the arch itself but considerable relative movement is usually required to do serious damage. Where there are separate abutments as in the beam type of bridge settlement may occur in several ways. The top of the abutment may tilt either inward or outward, the whole of one abutment may settle relative to the other(s), or transverse settlement may occur. The latter type is particularly serious, as it can lead to cracking of the bridge deck due to torsion and is, fortunately, rare.

(1) **Superstructures:** Widening by addition can sometimes be achieved by doub-

ling up and providing dual carriageways on completely separate structures. Several modern examples of this exist in the United States.

Usually, however, the old and new sections abut each other and this method is frequently adopted where a bridge is scheduled as an ancient monument. In such a case, where the elevation must be retained, the normal procedure would be to strip the masonry on the side to be widened, form the additional width in concrete and refix the old masonry on to the new elevation, making good as necessary.

Unless, it is possible to bond the two forms of construction adequately together, a saddle slab should be superposed over the new and old sections of the work. This requirement offers scope for ingenuity where widening and strengthening of masonry arches are carried out. In the reconstruction of Arundel River Bridge,³ widening occurred on both sides and a relieving arch was necessary to strengthen the existing brick arch. In this case, the projection of the relieving arch over the new reinforced concrete arches forming the widening acted as a form of saddle.

The provision of a saddle was not found necessary at Dart Bridge, Buckfastleigh where the widening took the form of flat segmental arches springing from the cutwaters on each side of the existing structure. Nor was one required in the reconstruction of Bonchester Bridge⁴ where the relieving arch was extended over the full width of the widening. The existing old red sandstone was retained to act as part of the shuttering but the elevation on the widened side was not quite the same as the original.

For bridges whose elevational appearance is not of primary consideration, it may be more convenient and/or economic to widen in a completely different style. Sugarloaf Bridge, Gloucestershire, a two-span road bridge over a railway was widened using standard steel sections. The tension flanges of the joists were surrounded in concrete prior to placing in position in order to act as bearings for precast reinforced concrete slabs spanning between them.

Reinforced concrete tee beam and slab construction was used at Lode Lane

Bridge, Solihull. To ensure the minimum of interference with canal traffic, the Contractor elected to precast the ribs of the tee beams on a nearby site and to use mobile lifting cranes to place them in position. An unusual feature was that all the beams differed in length due to the relative skew of the new abutments. The longest beam was 56 ft overall and weighed nearly 19 tons. The saddle slab between the old and new work was in reinforced concrete 10 in. deep spanning on to a mass concrete foundation based in the fill over the existing brick arch. A gap was left beneath the soffit of the slab and the brick wall forming the parapet to the original structure in order to avoid undue concentration of load at this point.

(2) **Widening by cantilevering** may be possible where the existing abutments are of adequate strength or can be strengthened sufficiently. Beams are constructed transversely across the existing abutments to cantilever out on one or both sides.

Great Junction Street Bridge, Edinburgh⁵ is an example of the widening of a masonry arch by this method. The existing structure was considered to be of adequate strength and consisted of a masonry arch having a clear span of 70 ft. The bridge was to be widened from 30 ft to 60 ft and it was estimated that the existing piers could safely carry the increased load. As the abutments of the bridge projected 5 ft each side of the existing spandrel walls, the actual cantilever overhang was only 10 ft 4½ in. The widened sections were carried on each side by reinforced concrete main beams continuous over three clear spans of 17 ft 9 in., 75 ft and 17 ft 9 in. respectively.

The masonry arches of the Blairgowrie Bridge⁶ were, however, suspect and when reinforced concrete cantilever beams were used in widening, the opportunity was taken to span over the arches with prestressed concrete units and thus relieve the masonry super-structure of all but dead weight.

Prestressed concrete cantilever beams were used at Damson Lane, Solihull, to reduce the depth of construction. The main beams 63 ft long were also of prestressed concrete and provision for expansion

was made by the use of cast iron rocker bearing set in pockets above one of the cantilever beams. To achieve this reconstruction, the bridge was completely closed to vehicular traffic for five weeks and a temporary footbridge formed nearby making use of a suitably strengthened sewer pipe bridge. During dismantling of the old structure, some of the prestressed main beams were laid to span across the canal on temporary formwork. When the cantilever beams had been placed in position, these main beams were then lifted into place and used to carry the remaining beams as they were trolleyed across.

(3) **The raising of the soffit of bridges** is a comparatively new development brought about by the electrification of the railways. To provide sufficient clearance, an additional headroom is required of more than one foot in certain cases. Where a road bridge is involved British Railways consults the local authority to find out if any plan that the latter has for the bridge can be carried out at the same time.

During the electrification of the Manchester-Crewe line, two standard methods of raising brick arch underbridges were adopted. One was to construct a reinforced concrete arch immediately above the existing brick arch ring, using it as shuttering. When the concrete has attained its required strength, the brickwork is then removed usually by suitably placed small explosive charges. Alternatively, the existing arch was removed completely and then replaced by a reinforced concrete portal frame.

(4) **The strengthening of superstructures** where no widening is involved can be achieved (apart from complete replacement) by either retaining the existing works and constructing a complete new deck, above or below it, or, where the super-structure is of a ribbed type, inserting additional ribs or beams between those already existing. Examples have already been given of the former type, such as the use of relieving arches and beams.

In certain cases, it may be desirable to retain the existing deck but at the same time, relieve it from live load. One method

of doing this is by the use of precast concrete units placed on top of the existing deck and post-tensioned. Sufficient prestress is applied to give an upward camber to the beams not less in value than the deflection under live load. Where an existing arch must be relieved from all live load, the new structure must be constructed well clear of the old by the use of removable shuttering, for example.

Strengthening by addition has been adopted for several cast iron arch bridges. At Trent Bridge, Nottingham, alternate spaces between the ribs were filled with reinforced concrete. At the same time the bridge was widened using steel arch ribs. To preserve the original appearance of the Waterloo Bridge, Bettws-y-coed, only the three intermediate ribs were encased in concrete. In both cases the ribs were designed to carry the whole of the live load of the bridge without assistance from the cast iron.

The restoration of masonry arches to their original condition may not always be

possible but repair work using guniting can be used to prevent further deterioration. The original structure of Lode Lane Bridge, Solihull, was a brick arch of approximately 22 ft span and built circa A.D. 1800. The east side spandrel walls had suffered considerably from vegetation growth and most of the outer arch ring had fallen on the west face. Hardly any mortar was visible on the arch vault and, in addition, there was a longitudinal crack 10 ft long at about 2 ft from the east face apparently due to outward movement of the spandrel wall. However, this was not considered serious as it was of long standing and the widening involved the re-alignment of the carriageway several feet further away from this face of the arch. During the reconstruction the west side arch was made good, 2 in. guniting applied to the arch intrados in two layers and the east face repointed and partly rebuilt.

(To be continued)

(From "The Surveyor and Municipal and County Engineer 16th April, 1969.")

DEFINITIONS OF HIGHWAY ENGINEERING TERMS

TOUGHNESS (of Road Stone):	The resistance to fracture under shock or impact.
TOUGHNESS INDEX (of Road Stone):	A measurement of the resistance of a stone to fracture under impact.

Masters: (To the servant) "Why haven't you cleaned the fish properly?"

Servant: "Sir, what is the need of cleaning it when it lives in water throughout its life."

ROLE OF LIME IN STABILISED SOIL CONSTRUCTION

By

Dr. I. S. UPPAL*

General

SOIL stabilisation is the process by which the physical properties of soil and soil-aggregate mixtures may be improved or altered by either mechanical treatment or with the addition of chemicals. In the mechanical stabilisation the gradation of the mix as well as the physical properties of binder soil are most important in obtaining a satisfactory stabilised material and, therefore, when the soil of proper grading is not available, it has to be suitably blended with coarser or finer material to bring the final soil-mixture within the desired gradation limits. But when the locally available materials are not fit for use due to their faulty gradation and import of selected materials for admixtures is not economical, the use of additives such as lime, cement, bitumens etc., may be the economical solution.

Amongst the most important requirements of stabilised soil in engineering constructions are:—

- High compressive strength both in dry and wet state.
 - High resistance to softening action of water.
 - High penetration resistance.
- and (d) Low volumetric shrinkage on drying.

Most of the natural soils (except non-plastic ones) can be compacted at a proper moisture content to a hard mass having high strength in dry state, but on wetting with water they become soft and lose strength and give way under slight pressure. It has been observed that even the best mechanically stabilised soil cannot withstand the softening action of water for more than a few hours. This drawback has been

the chief cause for the stabilised soil specifications not being very popular for the pavement construction although such roads cost not more than 50 per cent of the ordinary W.B.M. specifications.

In finding out a solution to this problem the effect of various chemical additives on the properties of stabilised soil mass has been studied by several laboratories in different countries. Amongst the additives tried are Portland Cement; Lime, Bituminous Materials; Calcium Chloride; Sodium Chloride; Surface Active Agents—both cationic and anionic; resins; glues; sodium silicate; calcium acrylate etc. Besides, a number of investigations on the use of various industrial bye-products e. g. molasses, gluten, lignin, jharua, latex, copacite, ground nut husk, oil cake etc., in soil stabilisation have also been conducted and results published in various scientific journals. The results of most of these investigations have, however, remained only of an academic interest due to prohibitive cost of the chemicals needed in field work and only a few materials e. g. cement, lime and molasses have been found really effective and economical for use in field scale.

Use of lime has been found to be more economical and it, therefore, offers a more promising solution for improving the behaviour of soil under wet conditions.

The first use of lime was made by the ancient Romans for the construction of Via Appia with compacted lime-soil mixtures. In U.S.A., lime as a road building material, was first used in 1924 and since then it has been extensively employed in the construction of roads and aerodrome bases by the State Highway Department of Texas. Performance surveys in that State have shown that roads and airports in which

* Research Officer, B & R Research Laboratory, Chandigarh

lime was used were more durable and had greater load carrying capacity than adjacent non-treated sections.

Role of Lime

Reaction of lime with soil water mixtures

The action of lime in soil can be explained by the following three basic reactions:

- The addition of lime alters the water film surrounding the clay minerals and the divalent calcium ion binds the soil particles close together resulting in decrease of plasticity and a more open and granular structure.
- Lime coagulates or flocculates the fine soil particles thus changing the structure of soil.
- Lime reacts with soil components, e.g. alumina and silica forming a cementitious material in situ and this imparts greater stability and strength to the mixture particularly in wet state.

During the last some years considerable amount of experimental work on the 'Use of Lime for stabilisation of Black Cotton Soil of India' and alluvial soils of Punjab has been done on laboratory scale in the Punjab P.W.D. Buildings and Roads Research Laboratory, Karnal and in the Central Road Research Institute, New Delhi. The results of these investigations have been published in the Indian Roads Congress Journal.

During the course of some other investigations the effect of lime alone and in conjunction with some other chemicals and industrial by-products like molasses and gluten on the engineering properties of soil has also been studied and results published. Further investigations have now been carried out more recently with a view to making use of lime for the construction of strong road bases and sub-bases particularly in water-logged areas and encouraging results have been obtained. These results are reviewed in this note. Conclusions drawn from previous investigations on the use of lime in soil stabilisation are also briefly indicated in the following paras.

Changes in Physical Characteristics of Soils due to addition of lime

Recent investigations have confirmed results obtained previously that the addition of increasing quantities of lime generally increase the Liquid Limit of the various soils and tends to reduce the plasticity index. Although the addition of lime up to about 3 per cent, by weight of soil does not materially affect the Plasticity Index, further increase in the quantity of lime definitely lowers the P.I. of soils. The reduction in Plasticity Index is more appreciable in the more plastic soils than in the less plastic ones. Similarly it has been observed that the addition of lime to soil results in greater percentage of coarser fraction retained over 200 mesh. This effect is also more pronounced in the more clayey soils. The results of three soils of Punjab having different soil characteristics are graphically represented in Fig. 1. Like the liquid limit the optimum moisture content of the soil lime mixture also increase with the increasing quantities of lime. These results are also graphically represented in this figure.

Effect of Lime on the Grain Size Distribution of soils

The effect of addition of 1 to 2 per cent lime on the grain size distribution of alluvial soils of Punjab (Silty Clayey in nature) is shown in Fig. 2, from which it will be seen that whole of about 60 to 75 per cent of fine fraction below .01 and .015 mm. size, which the soils contained, was coagulated to a size bigger than these when 2 per cent lime was added to the soil.

Effect of Lime on the Volumetric Changes

The shrinkage of the compacted soils considerably decreases with the increasing proportions of lime. It has been observed that the addition of about 2 per cent lime to silty soil reduces the shrinkage by about 40 to 50 per cent while with further increase in the proportions of lime to about 5 per cent by weight of soil, the shrinkage is reduced by about 75 per cent. Similarly the swelling due to saturation with moisture is considerably reduced by the addition of increasing quantities of lime, so much so that even the addition of 1 per cent lime to

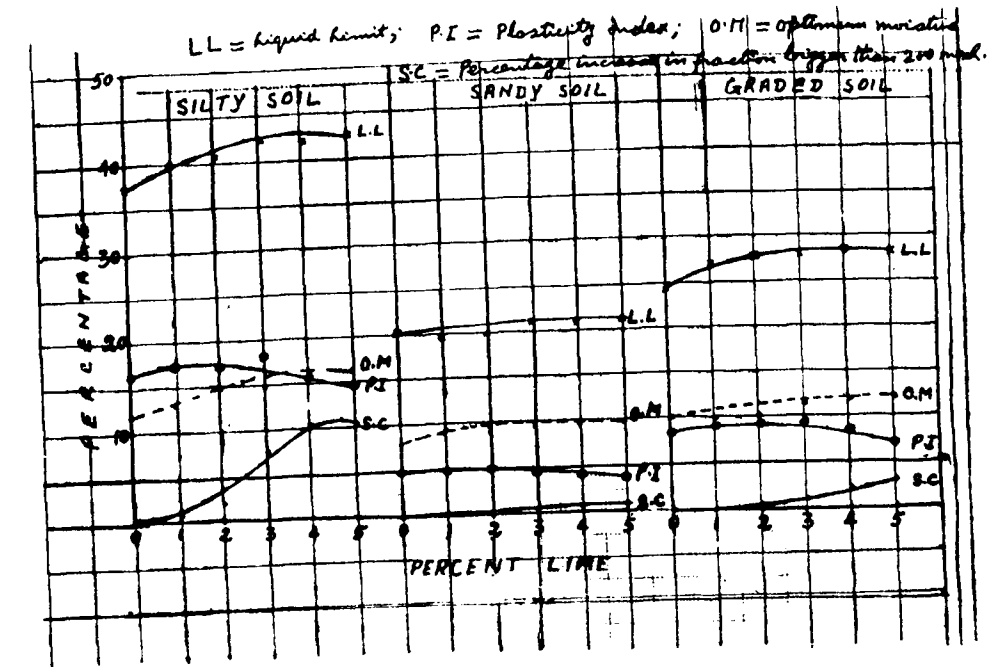


Fig. 1.

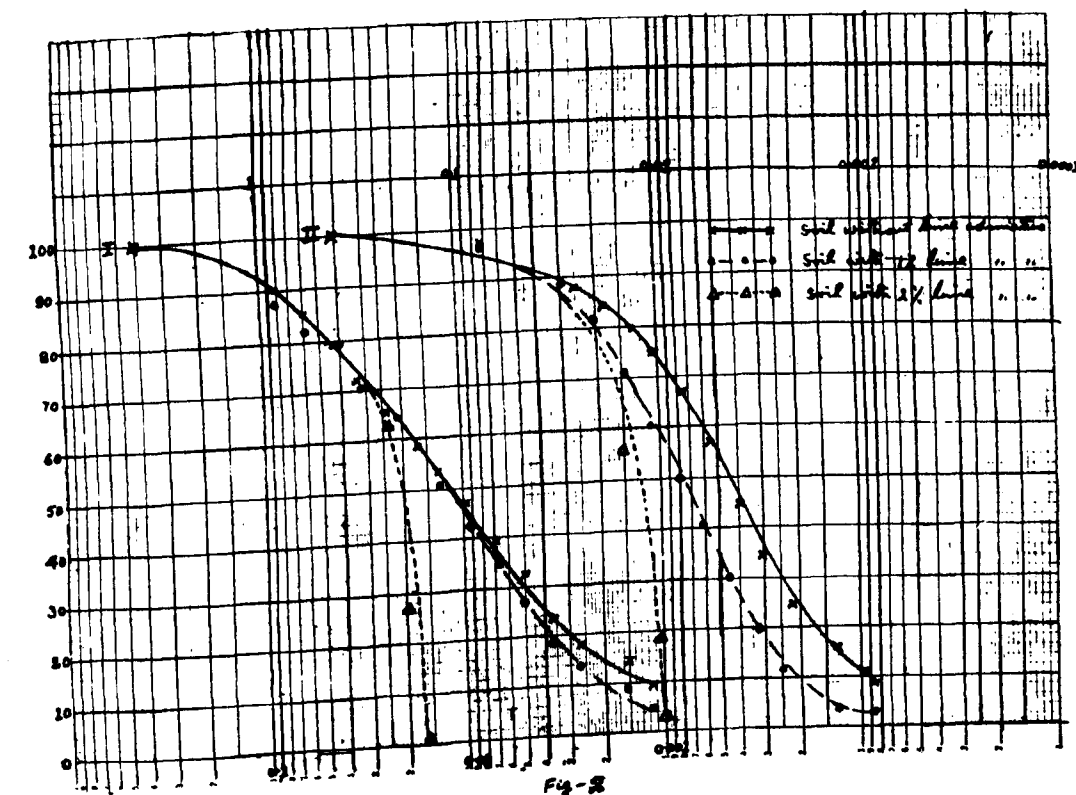
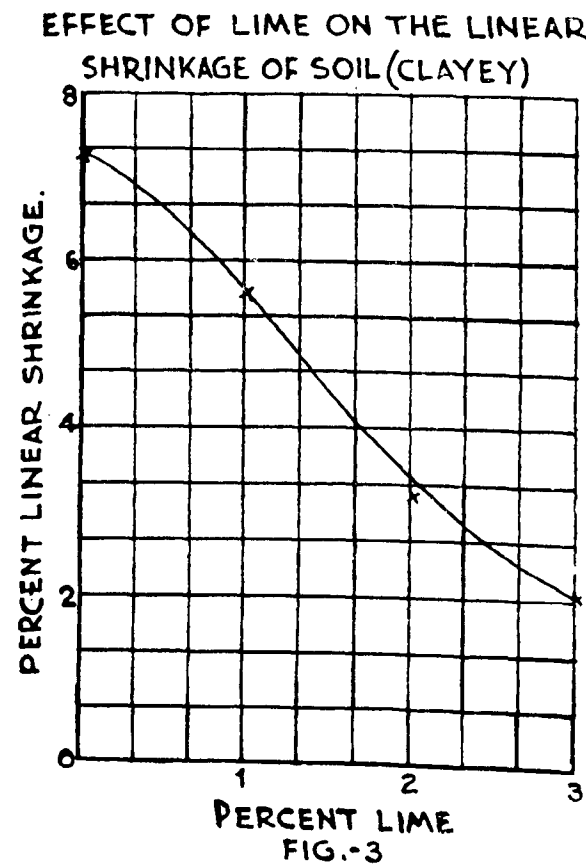


Fig. 2.

a silty-soil reduces the swelling by about 80 per cent. The effect of increasing quantities of hydrated lime on the linear shrinkage of a silty soil with L.L. 41.3 per cent P.I. 19.3 and sand content 11 per cent is shown in Fig. 3.

Effect of Lime on the Density of Stabilised Soil Blocks

The addition of lime to soil in increasing quantities has been generally found to decrease the density of lime soil mixtures and like other properties this effect is also more pronounced in the silty-clayey soils than in the sandy and well-graded soils. The effect of lime on the density of the Silty, Sandy and Well-graded soils is indicated in Fig. 4.



Effect of Lime on the Bearing Capacity of Soils

The Bearing Capacity of the various soils as determined in terms of CBR by un-confined compression test, and by Direct Shear Test methods has been generally found to improve with the increasing quantities of lime upto 3 per cent by weight of soils and further addition of the lime did not materially improve this property any further. Of more significant importance is the effect of lime in increasing the bearing capacity of various soils under wet condition. The improvement in CBR of the three Punjab soils with increasing quantities of lime after soaking the compacted mass in water for four days is represented in Fig. 4. The maximum moisture absorption by such soil-lime mixtures is also indicated in this figure,

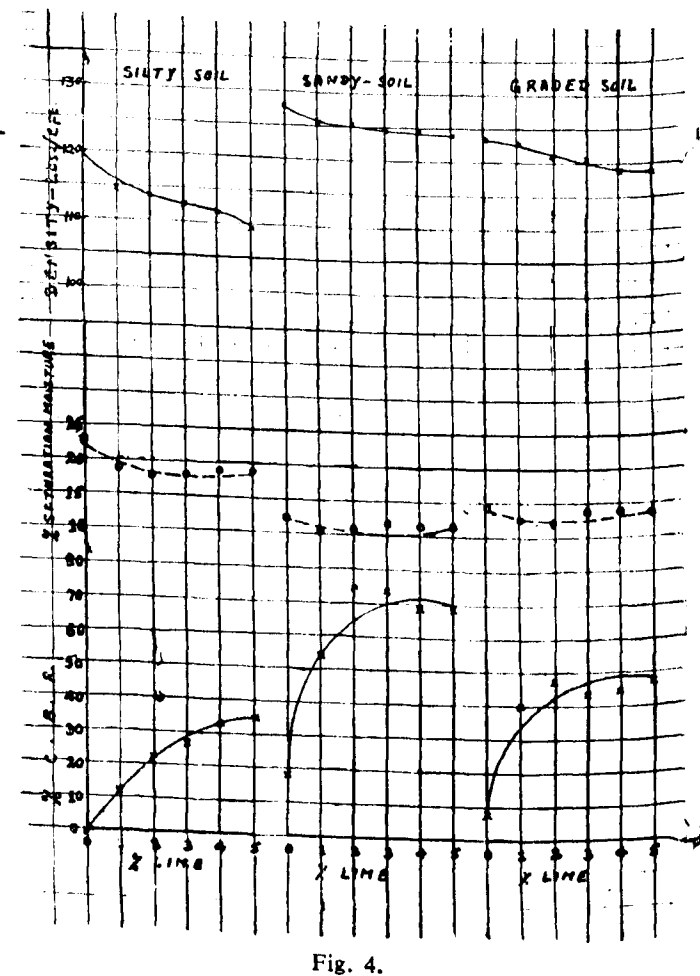


Fig. 4.

which will show that the moisture absorption also generally decreased when even a small quantity of lime was present in the soil. It is interesting to note that although the optimum moisture of the soil-lime mixture increased with the increasing quantity of lime the saturation moisture of such soils decreased in the presence of lime. Also it is interesting to note that although the density decreased with the increasing quantities of lime, the CBR both in dry and wet state of such mixtures increased.

Although the CBR of the soil freshly treated with lime immediately improves considerably yet curing of such mixture for a week is desirable to improve it still further. Also the moisture of compaction for such mixtures is to be properly controlled and should not be much in excess of the optimum moisture if good results are to be obtained. The work done by M/s Mehra and Chadda has shown that if moist curing is done for a fortnight or more the penetration resistance of lime soil blocks, made from almost all the soils, considerably improves and in some cases it becomes more than twice that of the less cured blocks.

Effect of Lime on the Compressive Strength of Soils

Like the penetration resistance and bearing capacity the compressive strength of the soils containing lime increases with the increasing quantity of lime in wet conditions. In the dry state, however, it behaves slightly differently in different soils. It has usually a tendency to reduce the strength when added in small quantities of 1 to 2 per cent and then improves when its proportion in the mixture is increased. Since the addition of lime does not materially affect the compressive strength of soils, in dry condition, this aspect is not of much importance; but its effect of improving the compressive strength and penetration resistance, thereby improving the bearing capacity in the wet conditions is really of very great significance.

Effect of Addition of Lime on the resistance of soil to the softening action of Water

The addition of even small quantities of lime, viz., about 1 to 2 per cent by weight

of soil, considerably improves the resistance of the soil-lime blocks to the softening action of water. The soil block, which normally becomes soft and disintegrates within 15 to 20 minutes of its immersion in water can resist such action of water for a number of hours if only 1.5 to 2 per cent hydrated lime is properly mixed in it. It has been found that if the quantity of lime is increased to 3 per cent or more, by weight of soil, the lime-soil blocks so prepared can remain intact in water without showing any disintegration for a number of days. This effect of lime goes a long way in its use for making non-erodable mud walls and mud plasters and also for making the road bases more stable in wet state.

Two stabilised soil wall pannels of PISE construction each 5 ft high, 3 ft wide and 1 ft thick were built up in the open over a burnt brick foundation. In one of these panels 2.5 per cent of hydrated lime, by weight of soil, was thoroughly mixed, while the other was of ordinary soil. Both these panels were left unplastered and allowed to weather for a year including one full monsoon. After this period it was found that lot of surface erosion had taken place in the panel containing no lime while the one containing lime remained almost unaffected. The condition of these two panels is shown in Photographs in figure 5.

Use of Lime in the Mud Plaster

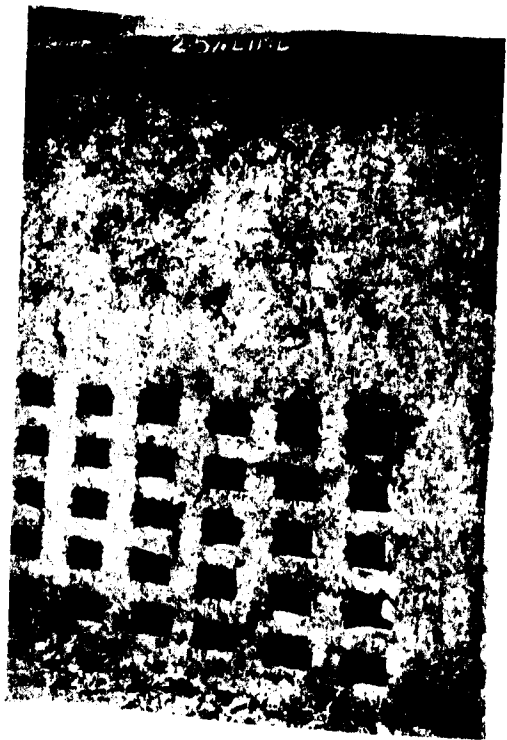
Similarly two panels of unburnt brick walls were plastered with usual mud plaster, one containing no lime and the other containing 2.5 per cent lime and allowed to be exposed to the natural weathering conditions in the open for a year. It was found that after the Monsoon the plaster containing no lime showed considerable erosion and even resulted in disintegration of the top portion of the panel while one containing lime remained intact. The condition of these two panels after Monsoon season, is shown in two Photographs in figure 6. During these investigations it was found that even the cement did not give as good results as were obtained with the use of same quantity of lime. It can, therefore, be concluded from these observations that although lime can not be used for water proofing purpose, it can be effectively used for making the surface non-erodable against the showers of rain.



Fig. 5 Mud wall containing 2.5 per cent lime— Mud wall containing no lime



Mud plaster without lime



Mud plaster with lime

Field Application of Lime for Improving the Subgrades and Flexible Basis of Road

In view of the numerous beneficial effects of lime on the Engineering Properties of soil as enumerated above the use of this material offers a very promising solution for improving the Bearing Capacity of the road bases. It has the quality of increasing the Bearing Capacity of clayey soils under wet conditions. A number of natural soils from the field when mixed with 2 per cent hydrated lime and subjected to CBR Test showed considerable improvement in the Bearing Capacity even at lower densities. The test results of few soils from damaged roads in the water logged area are given in Table-I. It would be seen therefrom that the natural

soils which had a CBR of 2.4 per cent at the field moisture and density showed a CBR of 16 per cent at the same density and moisture when only 2 per cent lime was added to it. At the higher density, however, the CBR still increased. Similarly in the case of other soils the CBR of the soils increased from 1.6 to about 19 and 29 after the addition of 2 per cent lime.

A large number of natural soils from other water-logged areas have also been tested in the Laboratory with similar results. In view of these encouraging results the use of lime can be safely recommended for improving the subgrades of the roads in water logged areas. The alkaline (sodium and potassium) soils, however, require a bit higher quantity of lime than the calcium soils.

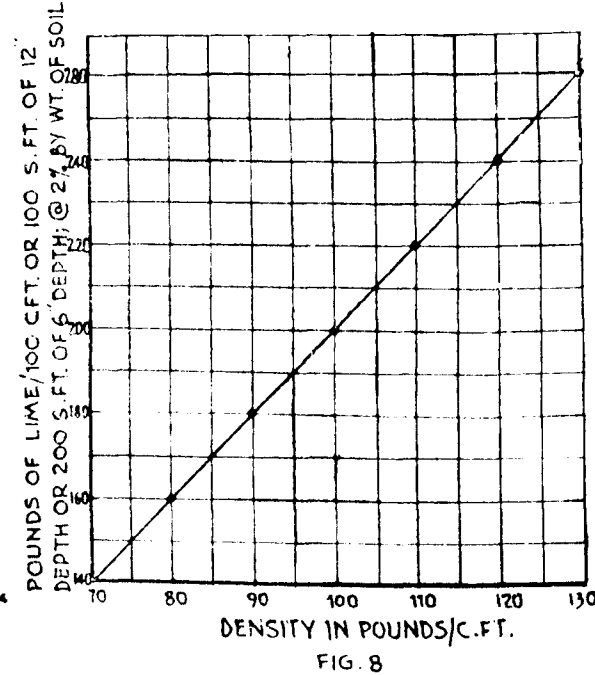
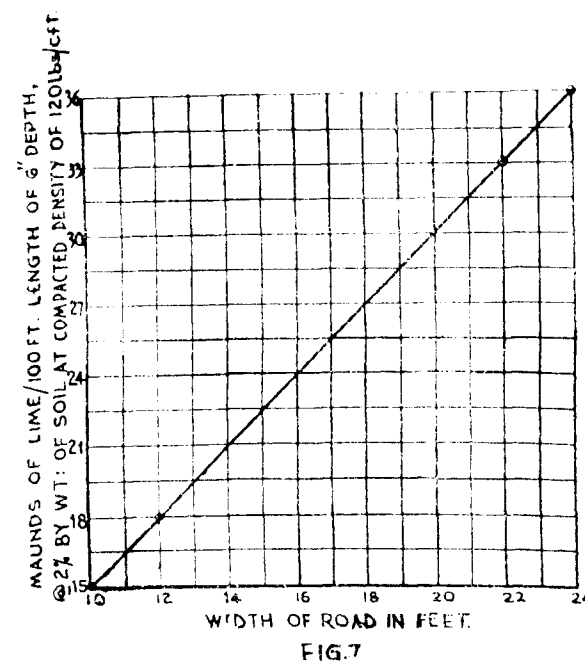
TABLE I
C.B.R. Results with 2 per cent lime and without lime and P.I. per cent sand etc. of samples from Kurali Morinda Road Mile 19/3 to 20/7.

At the time of sampling Date of sampling 20/10/1959

S. No.	Location	Field moisture	Field density gms/cc.	Per cent CBR at field moisture & density	Average field den- sity	Opt. moisture	Per cent CBR at average density O.M. with 2 per cent lime	Per cent CBR at average density with 2 per cent lime after soaking	Per cent moist after soaking	L. L.	P. I.	Per cent sand
1.	Kurali Morinda Road Mile 20/7	18.4	1.8	2.4	1.74 gm/cc (108.5 lbs/cft)	16.0	19.3	16.0	18.5	36.5	16.7	14.2
2.	Kurali Morinda Road Mile 20/4	20.0	1.86	1.76	do.	13.0	29.3	19.3	19.3	34.6	14.9	15.4
3.	Kurali Morinda Road Mile 20/1	23.5	1.58	2.4	do.	16.0	29.3	19.3	22.8	48.1	22.9	4.5
4.	Kurali Morinda Road Mile 19/5	13.6	1.7	6.8	do.	13.0	26.0	17.6	17.2	30.86	10.4	15.6
5.	Kurali Morinda Road Mile 19/3	13.6	1.89	9.6	do.	14.0	22.6	15.2	19.5	28.7	9.5	17.8

The frequent failures and re-construction of roads particularly in water logged areas are presenting big problems for the road engineers and although the raising of such roads to above the highest flood level, is the permanent remedy yet it is not always

possible to do so in the case of every road. Under the circumstances the best and the cheapest alternative appears to be to dig out about 12 to 18 in. of the sub-grade below the road crust and improve its Bearing Capacity by mixing thoroughly requisite



quantity of slaked lime and re-compacting the soil-lime mixture properly before building up the crust. This method of improving the sub-grade is actually being tried on some of the roads in Punjab and the results obtained, so far, are quite encouraging. Even if the raising of the road is done it would be desirable to lay at least a 6 in. compacted layer of stabilised soil-lime mixture below the hard crust to increase the Bearing Capacity of the sub-base.

Economics

Lime treatment is also not uneconomical. Two charts shown in figures 7 and 8 have been drawn for the case in calculating the quantity of lime for the use in such constructions. It would be seen therefrom that for a 22 feet wide road base only 33 mds. of lime per chain length is required for 6 in. compacted depth. If this depth of lime-soil-mixture is increased to 12 in. the quantity of lime at 2 per cent, by weight of soil, will come to 66 mds. or say worth Rs 200/- only i.e. Rs 2/- per ft length of 22 feet wide and 12 in. thick crust. This price compares favourably with that of sand required for grading the soil and gives much better results. The other chart shows the quantity of lime in lb required (at 2 per cent by weight) per 100 cu. ft. of soil at different densities.

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HERE AND THERE

1. OIL PRODUCTION

● ACCORDING to a recent survey, world oil production rose from 280 million metric tons in 1938 to about 935 million metric tons in 1958. The survey forecasts an annual production of 1,500-2,000 million tons in the next twenty years.

and consumption figures are estimated at 8,900 and 140,000 barrels per calendar day and proved reserves are placed at 300 million barrels.

* * *

In Saudi Arabia, the first-ever plant to refrigerate liquid petroleum gas is being erected at Ras Tanura. The unit is expected to be ready by August 1960 and the petroleum gas will be shipped to other parts of the world by tankers. The project is said to be the latest development towards the utilization and conservation of petroleum gases in the Middle East.

(From 'Stanvac Magazine' Volume 6, No. 3).

According to published reports, the petroleum industry reached new levels of production and consumption during the year 1958. World production and consumption are estimated at 18,158,940 barrels per calendar day and 19,084,000 barrels per calendar day respectively. The total proved reserves of petroleum are placed at 264,393 million barrels India's production

2. NATIONAL SPENDING FOR HIGHWAYS

Country	Reported for 1959 (Dollars)	Forecast for 1960 (Dollars)
United States	10,964,750,000	11,500,000,000
Canada	1,191,710,000	1,350,000,000
West Germany	960,000,000	1,000,000,000
France	642,600,000	750,000,000
Great Britain	478,550,000	550,000,000
Japan	398,834,800	450,000,000
Italy	320,000,000	350,000,000
Australia	311,314,200	350,000,000
Brazil	200,000,000	250,000,000
Sweden	170,924,000	195,000,000
India	170,750,000	200,000,000
Switzerland	140,040,000	150,000,000
Venezuela	114,582,500	150,000,000
Finland	111,600,000	115,000,000
Austria	105,567,400	120,000,000
Norway	100,009,000	110,000,000
Union of South Africa	92,500,000	95,000,000
Mexico	85,480,000	95,000,000
New Zealand	74,257,920	78,000,000
Philippines	68,709,000	75,000,000
Argentina	65,406,433	75,000,000
Yugoslavia	65,000,000	70,000,000
Denmark	61,622,400	65,000,000
Cuba	52,030,000	55,000,000
Netherlands	51,422,883	55,000,000
Algeria	50,000,000	60,000,000
Turkey	—	55,000,000
Iraq	—	50,000,000

From "World Construction," April, 1960

3. INTERNATIONAL ROAD FEDERATION

● THE deputy chief executive of the London Office of the International Road Federation, Mr. W. G. Kennedy, left on April 14th on a tour of six Far Eastern countries, in five of which it is proposed to set up road federations.

In Hong Kong preparatory work has already been carried out and the present visit is designed to put on a firm basis the formal establishment of a local road committee. It is also intended that a similar organisation will be set up in Singapore.

In Thailand, Malaya and Burma the possibility of forming national road associations in the near future will be investigated and all sectors of the community approached for support. In the former two countries considerable interest, official and otherwise, has already been shown.

As part of his programme Mr. Kennedy will also attend the zonal meeting to be organised by the United Nations Economic

Commission for Asia and the Far East in Dacca, East Pakistan, in June, 1960, when the central sector of the projected Trans-Asian Highway will be discussed. The major gaps in the proposed through route fall within this area.

The deputy chief executive also intends to hold discussions with the United Nations Economic Commission for Asia and the Far East Headquarters in Bangkok on the need for collecting essential transport statistics and the importance of establishing uniform traffic regulations throughout the region. A further matter to be raised with the Commission will be the proposal to hold a Middle East regional meeting to develop a road network running from Ankara in Turkey to Teheran in Iran, to link up the European International Main Traffic Artery System with the Trans-Asian Highway. At present these two systems are not connected.

(From: 'British Road Federation Bulletin', May, 1960).

4. INTERSTATE HIGHWAY BRIDGE RAISED

● THE nation's first highway bridge modified to provide greater vertical clearance for trucks carrying missiles was raised on Interstate 94 near Lansing recently.

Using hydraulic jacks, workmen raised the partially completed deck of a bridge under construction to increase the clearance from 14-ft 6-in. to 16-ft 3-in.

Michigan State Highway Department engineers said total weight of the prestressed concrete beams and diaphragms that formed the base of the deck was nearly 500 tons.

The 24 beams were tied together to form solid units in four sections. Each section—from the abutment to the first pier on each side and two center sections—was raised separately.

Because the beams were tied together with concrete diaphragms, it was essential to raise all beams in each span simultaneously.

After the beams were raised, concrete bolster blocks were cast on top of the

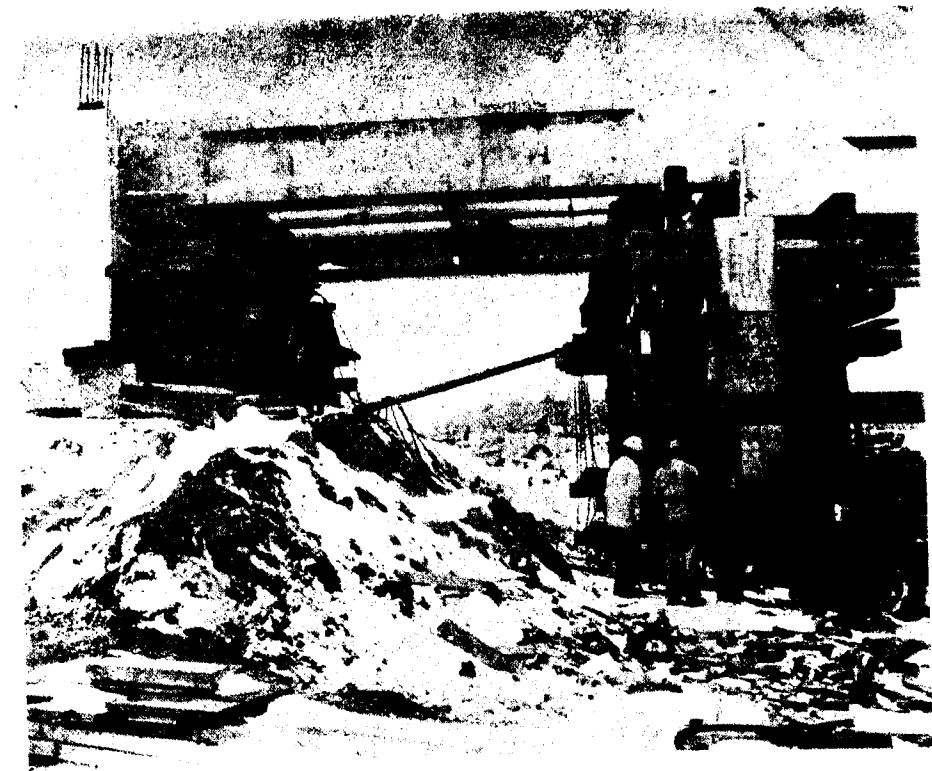
piers and abutments to support the deck at the higher elevation.

The U.S. Bureau of Public Roads in Washington said Michigan was the first state to raise an expressway grade separation since the federal regulation was issued in late January.

The federal order, issued at the request of the Defence Department, requires that overhead structures on rural sections of the National Interstate and Defence Highway System provide a minimum of 16ft clearance.

Michigan is providing an extra three inches' clearance to allow for future resurfacing of the expressways and also because snow on the highway would reduce the clearance.

The Michigan State Highway Department changed the design of all bridges to be placed under contract as soon as the federal regulation was issued.



Interstate Route 94 Bridge Near Lansing

At the same time, it made a survey of bridges under construction to determine which ones could be modified before completion.

Howard E. Hill, Managing Director of the Highway Department, said that increasing the clearance during construction of the 210 feet long bridge would save "quite a bit of money".

The additional cost of providing greater clearance for the bridge near Lansing was

about 18,000 dollars, Hill said.

The Bureau of Public Roads has reached no decision yet on a plan to increase the clearance of structures already built which have less than 16 ft clearance.

Michigan has about 275 completed bridges which may be affected by the new regulation.

(From 'American Highways', April, 1960).

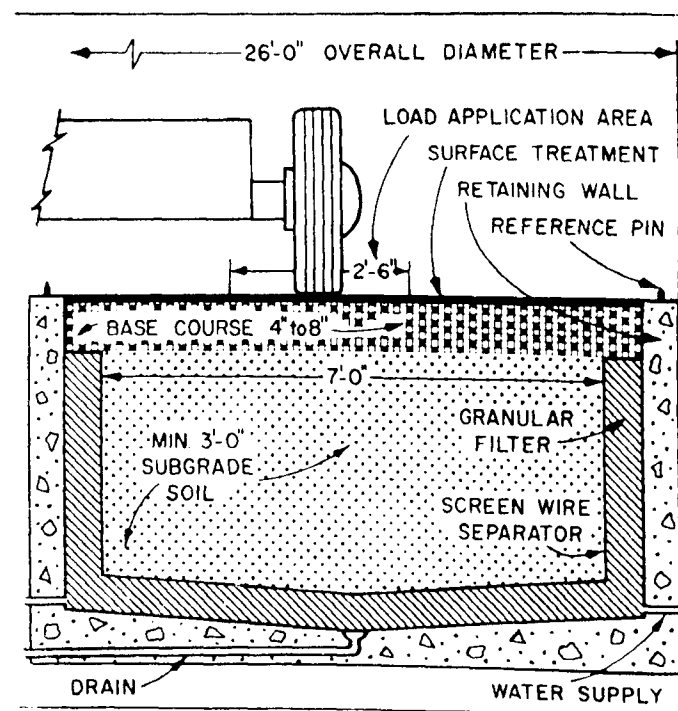
5. MINIATURE TEST ROAD PLANNED

● A HIGHWAY test track 26 ft in diameter will be built sometime this spring at the University of Illinois. On this diminutive test road, road materials will get approximately 1 year's in 1 week.

First tests will be on new low-cost materials for secondary roads and city streets.

Industrial sources have pledged 13,200 dollars a year for 5 years to support the project. Testing is scheduled to begin not later than Sept. 1.

Two truck wheels at ends of a beam pivoted in the middle of the test track will spin along the 50 ft of highway at speeds from



3 to 25 m.p.h. with loads varying from 1,700 to 3,000 lb per wheel. Automatically moving in and out, they will cover a patch 2½ ft wide. Traffic in a day will equal that of 50 days or more on an average secondary road. Operation of the test unit will be halted for adjustment and lubrication 4 hours out of every 24.

The test track will be divided into six sections, one consisting of the standard crushed-stone base of the Illinois Division of Highways, and others of experimental construction. Sub-soil will be the same under all. Water content in the sub-soil will be varied at will to simulate actual field conditions.

Basic information will be sought to set construction standards for low-cost sec-

ondary roads using two newly introduced materials. One is a slag, lime, fly-ash mixture on which Professor George W. Hollon has been doing research for 4 years. Professor Hollon is in charge of the test track. His mixture is now being field tested on several county secondary highways in northern Illinois by the county highway departments of Cook and Lake counties.

The first 3 years of work with the test track will be devoted to Professor Hollon's mixture. During the next 2 years tests on the use of lime to stabilize roadways are scheduled.

A sectional view of the circular test track is shown in the accompanying illustration.

(From "Better Roads", April, 1960)

6. EXPRESSWAY FOR JAPAN

● THE World Bank has made a loan equivalent to 40,000,000 dollars to Japan for the construction of a 45-mile expressway from Amagasaki to Ritto, linking the Osaka metropolitan area with that of Kyoto.

This is one of the most heavily populated and industrialized areas of Japan. A fast, safe highway will reduce travel time, relieve congestion and reduce the cost of freight and passenger traffic.

The loan was made to Nihon Doro Kodan (Japan Highway Public Corporation) according to the International Bank for Reconstruction and Development. This is a government corporation established in 1956 to construct, operate and maintain toll roads, tunnels, bridges and ferries throughout Japan.

The development of transport facilities has seriously lagged behind other sections of the Japanese economy. The railroads are overloaded and the roads are inadequate to handle rapidly growing traffic. Only 10 per cent of the 93,000-mile road system is paved and most of the main highways serving industrial areas are narrow and winding and run through the centers of towns.

Despite the poor roads the volume of traffic has been increasing at average annual rates of 15 to 20 per cent for trucks and buses and even more for automobiles. Construction of modern roads started in 1952 and Japan now intends to spend about 2,800,000,000 dollars during the period 1958-1963 in a program to improve or reconstruct existing roads and to build toll expressways in certain important industrial areas.

The Amagasaki-Ritto Expressway is the first section of an 118-mile expressway that the corporation plans to build from Kobe to Nagoya. The area traversed by the Amagasaki-Ritto expressway has a population of 8,700,000 and contains about 57,000 factories and workshops. Industrial output includes the whole range of Japanese manufactures, from iron and steel to electronic equipment. There is also considerable agricultural production. Half the population of the area is concentrated in a narrow zone facing Osaka Bay. This area accounts for three-fifths of the industrial out-put of the whole region.

The railroads are being used to capacity, and despite poor roads and heavy congestion, trucks carry about three-quarters of all short-haul high-value goods produced in all parts of the Kobe Nagoya area.

The expressway will be a four-lane divided limited-access highway that will bypass all towns en route. In general it will parallel the existing highway and the rail road, but to avoid densely populated areas and rice-growing lands, the greater part of it will be built through adjacent foot-hills, thus requiring long tunnels.

Steel bridges and concrete viaducts will be constructed to cross several large rivers and their flood areas, viaducts will be built where the expressway traverses urban districts and areas zoned for future urbanization. A substantial number of overpasses will be needed to cross intersecting roads and railway lines. The standards will be similar to those of expressways in other countries. The design speeds range from 74 m.p.h. in flat rural country to 50 m.p.h. in the mountains and urban areas. The expressway will reduce the average travel time between Amagasaki and Ritto from 3 hours to 1.

The total cost of the Amagasaki-Ritto Expressway is estimated at 47,200,000,000 yen (131,000,000 dollars in U.S. money). The bank's loan will cover about 31 per cent of the total costs; the balance will be met in part from the corporation's revenues, but mainly from grants from the Japanese government, loans from funds under government control and borrowings on the Japanese market to be guaranteed by the government. The expressway is expected to repay its cost from tolls in 25 years.

(From "Better Roads", April, 1960).

7. VALLIPURAM CAUSEWAY

● THE Palar River crosses the road connecting Mahabalipuram—a place of archaeological interest and tourist centre, and Tirukalikundram a place of religious impor-

tance, and the Great Southern Trunk Road connecting Madras with the southern districts of the State. Without a bridge or a causeway at this site, tourist traffic pro-



ceeding from Madras via Mahabalipuram had to make detour via Chingleput, involving an extra length of 10 miles. Apart from its importance as facilitating through traffic a suitable structure at this crossing was a necessity for the needs of the local traffic.

Various alternatives were investigated. A bed level causeway, even though providing a hard surfaced crossing, would have been subject to frequent interruption to traffic. On the other hand, a high-level bridge would have cost not less than Rs 25 lakhs. Therefore, a high-level causeway with its crest at 90.25 ft, i.e., a few feet above the ordinary flood level, was finally decided upon. By this arrangement, it was felt that there was not likely to be any interrup-

tion to traffic except in the case of extraordinary high floods.

The causeway, as constructed, in June 1955, has a level portion of 1,980 ft and sloping portions of 300 ft on the Tirukalikundram side and 160 ft on the Nelvoy side. The length of the causeway is 2,500 ft of which vented portion is 630 ft. On the southern side of the river, where the bed has a deep channel, 56 vents, 36 consist of 4 units of 9 box culverts measuring 10 ft by 8 ft each. The remaining vents are 10 ft by 9 ft each, for which open foundations with cement concrete piers and simply-supported slabs are provided. The lineal waterway of 560 ft provided by these vents is sufficient to pass the normal summer discharge of the river. The roadway over the causeway has a width of 22 ft.

Customer: "Do you have anything for grey hair?"

Conscientious druggist: "Nothing, sir, but the greatest respect."

CURRENT LITERATURE

ABSTRACTS

BULLETIN 239 PHYSICAL AND CHEMICAL PROPERTIES OF CEMENT AND AGGREGATE IN CONCRETE HIGHWAY RESEARCH BOARD 2101 Constitution, Washington D.C.,

THIS 65-page bulletin contains three papers presented at the 38th Annual Meeting of the Highway Research Board and one paper presented informally at a conference session for discussion and review.

"Relationship of Pore-Size Distribution and Other Rock Properties to Serviceability of Some Carbonate Aggregates," by Carl L. Hiltrop and John Lemish, presents data whose development may ultimately lead to a description of a physical "poor" aggregate.

"Correlation Between Chemical and Mortar Bar Tests for Potential Alkali Reactivity of Concrete Aggregates," by Bernard Chaiken and W. J. Halstead, shows the necessity for use of both tests to characterize some aggregates.

"Silicification of Carbonate Aggregates in Concrete," by Ramon E. Bisque and John Lemish, shows more conclusive data on this theory than presented in a related paper last year. Substantiating data are claimed to show that silica is introduced into some carbonate aggregate from the cement paste.

"Cement-Pozzolan Reactions," by E. J. Benton, reports on studies undertaken to develop information which will eventually lead to establishment of better criteria for pozzolan, mix proportions and cement type to achieve optimum results.

HIGHWAY ACCIDENT STUDIES BULLETIN No. 240 HIGHWAY RESEARCH BOARD 2101 Constitution, Washington, D.C.

THIS 56-page bulletin contains five papers presented at the 38th Annual Meeting of the Highway Research Board, as follows:

"Statistical Determination of Effect of Paved Shoulder Width on Traffic Accident Frequency," by R. C. Blensely and J. A. Head, reports on research by the Oregon State Highway Department in the use of statistics to analyze the difference between the average accident frequency on sections with narrow paved shoulders (4 ft or less) and on sections with wide paved shoulders (8 ft or more).

"Factor Analysis of Roadway and Accident Data," by John Versace, is a further analysis of data presented by Schoppert in 1956, seeking to make apparent additional relationships among the roadway features while compressing the results into a small number of more universal motions.

"Accident Analysis of an Urban Expressway System," by A. F. Malo and H. S. Mika, applies to a typical urban expressway system analytical techniques developed for statistical studies of accident data on the Pennsylvania Turnpike.

"Interchange Accident Exposure," by S. M. Breuning and A. J. Bone, shows that for intersections, at least, conventional statistics are rather misleading because the exposure to accidents is not proportional to the distance travelled.

"Inventory Speed Responses and Prior Traffic Records as Predictors of Subsequent Traffic Records," by Harry W. Case and Roger G. Stewart. Results of this pilot study indicate that several of the associations between driving speed as reported by the individual, prior traffic records, and subsequent traffic records are much greater than would be expected by chance.

**LIST OF "INSDOC TRANSLATIONS" AVAILABLE IN THE
CENTRAL ROAD RESEARCH INSTITUTE LIBRARY, NEW DELHI**

- ROESSINGER (F.)**
General Discourses on different methods of prestressing concrete.
Insdoc Trans. No. 1411.
Trans. from French from "Bulletin Technique de la Suisse Romande, 1950, 76, 225-37".
5131
- ROHNER (F.)**
Non-destructive testing.
Insdoc Trans. No. 816.
photo copy "Schw. Archiv fur Angewandte Wissenschaft und Technik 1948, 11 (10), 289-293".
3471
- ROMANI (L.)**
Attempt at Dimensional analysis of the Resistance to Rolling of Pneumatic tyres.
Insdoc Trans. No. 1433.
Trans. from French from "Bull. Mensuel de documentation de l'U.T. A.C. no 75, 167-76".
5197
- ROTH (F.)**
New Method for the determination of the binding properties of binding materials employed in bituminous cold application and their transformation on storage
Insdoc Trans. No. 1448.
Trans. from German from "Strasse und Tiefbau 1950, 4, 190-2".
5047
- SAAL (R.N.J.) & Van der poel (C.)**
Visco-Elastic Properties of Asphaltic bitumen.
Insdoc Trans. No. 2241.
Trans. from French from "II Congress International de L'Asphaltic".
7265
- SAURLER**
Raising of individual plates in concrete road surfaces.
Insdoc Trans. No. 1319.
Trans. from German from "Strasse und Autobahn, 1 (7), 9-11".
4952
- SCHEUERER (A.)**
Determination of the adhesive strength and the progress of hardening of bituminous binders for road building.
Insdoc Trans. No. 869.
Trans. from German from "Bit. Teers Asphalt Peche 1952, 3 (2), 29-35".
3731
- SCHWARZ (H.)**
Calculation of the mineral composition of Portland cement.
Insdoc Trans. No. 1410.
Trans. from German from "Schweizer Archiv 1950, 16, 308-16".
5199
- SCHWARZ (F.)**
On the medical examination of drivers of motor vehicles.
Insdoc Trans. No. 1610.
Trans. from French from "Zeitschrift fur Verkehrssicherheit 1951, 2 (5/6), 195-206".
5578
- SEYWALD (L.)**
Controlling of concrete track plates.
Insdoc Trans. No. 1318.
Trans. from German from "Strasse und Autobahn 1951, 2, (11), 362-365".
5008
- SIEDEK (P.)**
On the bearing capacity of the sub-soil of roads.
Insdoc Trans. No. 1416.
Trans. from German from "Strasse und autobahn 1951, 2, 67-71".
5125
- SOCIETE DU VIAGRAPHIE**
Study of the irregularities of road surfaces.
Insdoc Trans. No. 2263.
Trans. from French from "Etude des irregularities de la surface des chaussées".
7446
- STANGE (K.)**
Valuation of Mixers with the help of statistics methods.
Insdoc Trans. No. 1885.
Trans. from Chemie-Ingenieur Technik 26 (3), March 1954, 150-55".
6418
- STOLNIKOV (V.V.)**
Electron microscope studies on the action of surface active reagents in the process of hydration of portland cement".
Insdoc Trans. No. 1404.
Trans. from Russian from "Zhurnal Prikladnoi Khimii 1950, 23, 682-8".
5198
- TAVASCI (B.)**
Structure of a mortar made of lime and Segni pozzuolan.
Insdoc Trans. No. 839.
Trans. from Italian from "Cemento 1947, 41, 106-118".
3559

- THOENES (D.)**
Phenomena of uncovering in the system consisting of stone, water & asphaltic bitumen or tar (pitch).
Insdoc Trans. No. 2437.
Trans. from French from "Bull. Ass. per. Cong. Belge de la route 1953", 23, 17-35.
8721
- TROBS (Heinrich)**
Development and present position of the production of road binders based on brown coal tar in the people's own tar processing works, Rositz.
Insdoc Trans. No. 2849
Trans. from German from "Freiberg Forsch 1954, A 23, 69-89".
10569
- VAN DER WEEL (N.)**
On the mechanism of determination of the silicic acid content of soluble & insoluble silicates.
Insdoc Trans. No. 1396.
Trans. from Dutch from "Chemische Weekblad 1951, 47, 845-8".
5485
- VASENIN (F.I.)**
Nature of heat liberation in the synthesis of calcium silicates.
Insdoc Trans. No. 1403.
Trans. from Russian from Zhurnal Prikladnoi Khimii 1948, 21, 389-95".
5127
- VIVALDI (R.)**
Cement of today & that of the Romans of more than 20 centuries ago.
Insdoc Trans. No. 857.
Trans. from Italian from "Industria Italiana del cemento 1950, 201, 13-17".
3688
- VON STEIN (W.)**
Control of traffic signals and safety of traffic.
Insdoc Trans. No. 1611.
Trans. from German from "Zeitschrift fur Verkehrssicherheit, 1954, 2, 21-37".
5594
- WACLAW (F.)**
Properties of cement raw materials and their influence of the burning of cement.
Insdoc Trans. No. 1316.
Trans. from German from "Zement-Kalk Gips 1952, 5 (4), 91-102".
5009
- WALTHER (H.)**
Micro-structure & Properties of deformation of lignite tars and pitches, II.
Insdoc Trans. No. 1731.
Trans. from German from "Chemische Technik, 1955, 7, 471-2".
5698
- WALZ (KURT)**
Protection of concrete road coverings against destruction by scattering salts.
Insdoc Trans. No. 1445.
Trans. from German from "Strasse und Autobahn 1950, 1 (9), 1-5".
5167
- WASSERFUHR (H.)**
Modern road building as an out-let for lignite-distillation tar and pitch.
Insdoc Trans. No. 2896.
Trans. from German from "Braunkohle 1935, 31, 209-216".
9618
- WENN (B.)**
Investigation of Crushed stone aggregates for resistance to impact and compaction.
Insdoc Trans. No. 1436.
Trans. from German from "Strasse und Autobahn 1951, 2 85-9".
5134
- YUNG (V.N.)**
Influence of alkalis on the properties of calcium silicates.
Insdoc Trans. No. 1729.
Trans. from Russian from "Tsement 1951, 17(6), 9-13".
5944
- ZAMAKHAER (M.S.)**
Specification of the width of the carriageway of motor roads.
Insdoc Trans. No. 2703.
Trans. from Russian from original.
9177
- ZIPKES (B.)**
Behaviour of road surfaces in regard to traffic safety.
Insdoc Trans. No. 858.
Trans. from German from "Strasse und Verkehr 1950, 36 (2), 1-12".
3766
- ZIPKES (E.)**
Road Rollers,
Insdoc Trans. No. 1327.
Trans. from German from "Zement Kalk Gips 1951, 4.".
5011
- ANONYMOUS**
Bitumen, Coir Felt: A new kind of sound-insulation material.
Insdoc Trans. No. 2007.
Trans. from German from "Bitumenteere Asph. Peche und Verwandte Stoffe 1954, 5, 252-253".
6806
- ANONYMOUS**
Cycle path paving with an appendix containing provisional directives of July 1943, for execution of carpet pavings using tar as binder.
Insdoc Trans. No. 2321.
Trans. from Danish from "Vejkomiteens Skrift Nr. 18, 1-22".
8910
- ANONYMOUS**
Danish highway code III classification of roads.
Insdoc Trans. No. 2320.
Trans. from Danish from "Danish Highway code". 6-9.
8909

(Continued on page 52)

**LIST OF PUBLICATIONS ADDED TO THE ROADS WING LIBRARY,
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1. **Annual Reports (Technical) of the Central Board of Irrigation & Power, India, 1954 & 1955.**
2. **Strassenbau, Von. A.Z.** by Alfelder Eisenwerke Carl Heige Kom-Ges. Alfeld/Lehne.
3. **Punjab Public Works Department & Roads Branch—Annual Report of the working of Building & Roads Research Laboratory, Karnal 1956-57.**
4. **Report by the Railway Board on Indian Railways for 1958-1959 Vols. I, and II.**
5. **Theory of Structures 1940** by Longmans Green & Co., London/New York.
6. **Building Regulations for Reinforced Concrete** by American Concrete Instt.
7. **Basic Road Statistics 1948 & 1955** British Road Federation London.
8. **Specification for the use of Rammed Cement Soil in Building Construction**, Indian National Society of Soil Mechanics and Foundation Engineering.
9. **Moments in Simple Span Bridges Slabs with stiffened Edges.** A report of an investigation Vol. XXXVI August 1, 1939, 14097 by University of Illinois.
10. **Le Betonage D' Hivere Theore Et Methods** by Dunod, Paris, 1958.
11. **Piles Culees Et Cintres Des Ponts**, by Robinson, Dunod, Paris, 1958.
12. **Klothoiden Taochenbuch fur Entwurf and Abstechung** by Krenz, Bauverlag Bauverlag GmbH Wiesbaden, Berlin.
13. **Pearpsaktive im Ingenieur ban Insbeson dere Imstrabenban** by Ranka Publisher Bauverlag GmbH Wiesbaden Berlin.
14. **Der Neuzeitlicher Strabenbau, Aufgaben and Technik Vierte Neubearbeitete Auflage** by Nemmn H. Spingar Verlag Berlin/Gollingen/Heidelberg 1959.
15. **Strassenplanung Mit Klothoiden** by Osterlon & Published by Bauverlag, GmbH, Wiesbaden, Berlin.
16. **Standard Australian Glossary of terms used in Road Engineering** by Standard Association of Australia.
17. **Frames & Arches** by Leontovich and published by McGraw Hill Book Co., New York.
18. **Air Photography applied to surveying** by Longman Green & Co., London.
19. **Open Channel Hydraulics** by Chowe and Published by McGraw Hill Book Co., New York.
20. **Practical Prestressed Concrete** by Preston & Published by McGraw Hill Book Co., New York.
21. **Highway Engineering Handbook.** Handbook .do
Public Administration Service, 1313-East 60th St., Chiacago.
22. **Conducting a Home Interview Origin Destination Survey (Procedure Manual).**
23. **Origin Destination & Land use (Procedure Manual)** by Nation Committee of Transport.
24. **Conducting a comprehensive parking study (Procedure Manual).**
25. **Maintaining Accident records.**

26. **Recommended Standard Warrants, and objections for Transport Services & Facilities.**
27. **Standards for Street Facilities & Services (Procedure Manual).**
28. **Modernizing Laws and Ordinances (Manual Procedure).**
29. **Measuring Traffic Volumes (Manual Procedure).**
30. **World Economic Survey 1958** by United Nations. Deptt. of Economic & Social Affairs, New York, 1959.
31. **IS-806-1957—Code of Practice for use of Steel Tubes in general Buildings Construction** by Indian Standards Institution, New Delhi.
32. **All India Civil List Manager, Publication, Delhi.**
33. **Census of India—Report Vol. I 1959** Manager of Publications, Delhi.
34. **British Standard 3148: 1959 “Tests for water for making concrete.”**
35. **Victoria Country Road Board Forty Sixth Annual Report for year ended 30th June 1959.** by A. C. Brooks, Government Melbourne.
36. **Civil List Indian Administration Service and Indian Postage Service** Manager of Publications, Delhi.
37. **Fifth Irrigation & Power Seminar Srinagar 23rd to 25th June 1958 Vols. I and II** by Central Water & Power Commission new Delhi.
38. **Economic Survey of Asia and the Far East 1959**, United Nations Publication.
39. **Traffic Control and Road Accident Prevention**, cheaper Edition with supplement incorporating recent Legislation by Champan and Hall, London.
40. **Statistical Year Book 1959 Annuaire Statistique Eleventh issue Onxieyme Annee.** United Nations Publication.
41. **Report of the Soil Research Laboratory Highways Department Guindy Madras-25** for the period from April 1954 to March 1955 by Govt. of Madras.
42. **Report of Soil Research Laboratory Highway Deptt. Guindy Madras-25** for the period from April 1955 to March 1956. -do-
43. **Highway Research Station Guindy, Madras—Annual Report for 1956-57.**
44. **Resurfacing and widening old Concrete Carriage-ways with Concrete** by Ninth National Belgian Road Conference, 1959.
45. **Mathematics for Engineers Part II including differential and integral Calculus, Spherical trigonometry and mathematical probability**, 5th Edition Catalogue No. 167/4.

WISDOM IN BRIEF

“DAILY, I grow to honour facts more and more; theory less and less.”—Carlyle.

BUDGETS AND ADMINISTRATION REPORTS

UTTAR PRADESH CIVIL WORKS BUDGET FOR 1960-61

The following extracts relating to civil works have been taken from the Uttar Pradesh Budget Publication for the year 1960-61.

Revenue

Heads	Actuals 1958-59	Revised Estimate 1959-60	Budget Estimate 1960-61
(Rs in lakhs)			
(a) Rent of buildings	4.46	4.04	4.04
(b) Ferry receipts	23.56	22.00	22.00
(c) Tolls on roads	...	11.00	13.00
(d) Recoveries of expenditure	10.61	5.00	5.00
(e) Miscellaneous	22.25	21.25	31.83
(f) Receipts from Tehbazari and projection fees levied by local bodies on State Roads	0.02	0.02	...
(g) Toll on bridges	9.36	...	...
(h) Subventions from the Central Government for Buddha Jayanthi Road works and for unemployment relief schemes for road projects	...	23.22	15.71
(i) Subventions from Central Road fund (Reserve)	1.03	4.49	12.37
(j) Subvention from the Government of India for Development schemes included in the 2nd Five Year Plan	73.95	105.67	116.81
Deduct—refunds.	(-) 1.89	(-) 1.20	(-) 1.00
Total...	143.35	195.49	219.76

Expenditure on Civil Works met from Revenue

ORIGINAL WORKS

Buildings	18.90	14.58	16.87
Communications	53.23	39.48	30.69
Miscellaneous	1.25	3.64	0.16
REPAIRS			
Buildings	16.25	16.43	17.88
Communications	307.60	308.32	311.36
Miscellaneous	2.88	3.10	7.17
Tools and Plant	4.59	4.47	4.54
Suspense	9.08	92.29	90.41
Transfer to the State Bridge fund	...	11.00	13.00
Capital Outlay on Civil Works met from revenue (Plan)	34.00	105.67	116.80
Recoveries—Adjusted in the accounts in reduction of expenditure	(-) 31.84	(-) 110.09	(-) 105.70
Total...	415.94	488.89	503.18

Outlay on Civil Works outside the Revenue Account

Heads	Actuals 1958-59	Revised Estimate 1959-60	Budget Estimate 1960-61
(Rs in lakhs)			
ORIGINAL WORKS :			
Buildings	268.97	393.53	533.90
Communications	299.70	345.04	381.56
Miscellaneous	14.23	14.03	3.98
Tools and Plant	6.40	8.10	9.38
Suspense	2.18	301.23	290.93
Recoveries—Adjusted in the accounts in reduction of expenditure	(-) 56.32	(-) 435.60	(-) 555.37
Total...	535.16	626.33	664.38

Revenue form Roads:

Receipts under the U.P. Motor Vehicles Taxation Act	...	220.00	240.00
Receipts under the Indian Motor Vehicles Act	211.73	18.30	20.33
Taxes on Sale of motor spirit	57.63	51.13	50.12
Deduct—refunds	(-) 0.87	(-) 1.30	(-) 0.80
Total...	268.49	288.13	309.65

(A brief review with reference to Civil Works)

THE total revenue of the staff for the year 1960-61 is estimated at Rs 13089.68 lakhs against Rs 12250.57 lakhs (revised estimates) for the year 1959-60 and Rs 11723.22 lakhs (actuals) for the year 1958-59. The corresponding figures of expenditure are Rs 13323.23 lakhs, Rs 12250.57 lakhs and Rs 11613.75 lakhs respectively for the years 1960-61 (Budget estimates) 1959-60 (Revised estimate) and 1958-59 (Actuals). Total revenue expenditure on Civil Works is estimated at Rs 503.18 lakhs for 1960-61 while the corresponding figures for the revised estimate for 1959-60 and actual for 1958-59 are Rs 488.89 lakhs and Rs 415.94 lakhs respectively.

There is a provision of Rs 342.05 lakhs (original works and repairs) on communications in the current year from the revenue account and the corresponding estimates for the years 1959-60 (revised estimates) and 1958-59 (actuals) are Rs 347.80 lakhs and Rs 360.83 lakhs respectively.

Total expenditure on Civil Works outside the Revenue Account for the year 1960-61 is estimated at Rs 664.38 lakhs, revised estimate for the year 1959-60 is Rs 626.33 lakhs and Actuals for the year 1958-59 is Rs 535.16 lakhs. Expenditure on Buildings and Communications from the main items of expenditure.

LIST OF APPROVED WORKS ON NATIONAL HIGHWAYS

S. No.	Job No.	Name of work	Amount (Rs in lakhs)
ANDHRA PRADESH			
1.	17	Works each costing less than 2 lakhs.	8.20
ASSAM			
2.	2296-AS-40	Widening Gauhati Shillong Road (N.H. No. 40) for two lane traffic i.e. from Umsan Lem Naya Bungalow (section 10) mile 39th to mile 45th.	3.07
3.	2297-AS-40	Widening Gauhati Shillong Road (N.H. No. 40) for two lane traffic (section III) mile 32 to 38.	5.96
4.	2323-AS-37	Remetalling and surfacing certain portions of miles 152 to 179 of Assam Trunk Road N. H. No. 37 in Dergaon Sub Division.	2.89
5.	2327-AS-39	Remetalling and surfacing miles 26-30 of Numali-garh Dinapur Road N.H. No. 39 in Barpathar Sub Division.	4.95
6.	2329-AS-31	Improving the surface condition of N.H. No. 31 from mile 109 to 115 under Kokraghar Division.	3.72
BOMBAY			
7.	2294-BM-8	Providing additional two minor bridges on Hariata-Kenera-Bareja section of N.H. No. 8.	2.27
8.	2306-BM-8A	Construction of a bridge across the Nallah in mile 43 on Bagodra-Deopura section of N.H. No. 8A.	3.36
9.	2319-BM-8A	Providing C.D. works on Limbeli-Saiyala-Dolia section of N.H. No. 8A.	3.35
10.		Five works each costing less than 2 lakhs.	2.86
DELHI			
11.	2331--DLH-2	Improvement to the Junction of Mathura Road and Okhla Road, N.H. No. 2.	0.11
HIMACHAL PRADESH			
12.	2301-HP-22	Construction of an explosive magazine at Phagu on H. T. Road N.H. No 22.	0.07

S. No.	Job No.	Name of work	Amount (Rs in lakhs)
MADHYA PRADESH			
13.	2304-MP-26	Construction of a high level bridge across the Sonar river in mile 30/5 of Sagar-Narasimhpur road N.H. No. 26.	3.53
MADRAS			
14.	2287-MD-7	Widening the road crust to two lanes in miles 261/0 to 276/1 of B.C.C., N.H. No. 7.	4.92
15.	2288-MD-47	Asphaltic concreting 22 ft wide Trivandrum-Nagercoil Road in miles 47/6 to 54/3+60 ft, N.H. No. 47.	3.14
16.	2293-MD-7	Forming a diversion at Karimangalam in mile 173/7 to 175/7; Krishnagiri Salem section of N.H. 7.	1.60
MANIPUR			
17.	2295-MN-39	Earth work in Hill cutting and metalling the widened portion to improve the sharp curves and slipped portions.	4.17
MYSORE			
18.	2292-MY-4	Widening the culverts on Madras-Cannanore road National Highway No. 4 mile 29/4 to 62/0 in Kolar Division.	0.45
ORISSA			
19.	2330-RS-42	Reconstruction of Pucca culverts on Cuttack-Sambalpur Road on N.H. No. 42 miles 82/0 to 124/3.	1.69
PUNJAB			
20.		Two works each costing less than 2 lakhs.	0.63
RAJASTHAN			
21.	2332-RJ-8	Construction of N. H. No. 8 Jaipur-Delhi Road (New alignment) Shahpura Paota Kotputli section.	7.90
22.	2336-RJ-8	Widening formation to 38 ft and providing shoulders including carpetting in Udaipur-Nathdwara Road miles 2/0 to 29/0) N.H. No. 8 excluding Ghat Section.	5.28
23.		3 works each costing less than 2 lakhs.	3.22

S. No.	Job No.	Name of work	Amount (Rs in lakhs)
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24. 2935-EP-24 Widening to two lanes from Hapur to Garmukh-
teshwar of N.H. No. 24 in Meerut District including raising of foundations where necessary.

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|-----|-------------|--|------|
| 25. | 2322-B | (Construction of a diversion road and a temporary level crossing near the junction at B. & K. loop line in Eastern Railway and Berhampur-Raghunathganj section of N.H. No. 34. | 0.53 |
| 26. | 2300-B(1-31 | (Construction of protective works against erosion near Raidak Bridge at 15th mile on N.H. No. 31 in Cooh-Behar District. | 4.22 |

ANONYMOTS	ANON.
(Continued from page 45)	
Instructions for the planning of cycle paths.	
Inside Trans. No. 1567.	
Trans. from German " (original)".	5200
ANONYMOTS	ANON.
Ville de Paris-Appareatus for the measurement of coefficients of friction of surfaces.	
Inside Trans. No. 1481.	
Trans. from French, from original.	5140

Spout for distributing fine gravel for partial	1953, 95-96, "Kautsesides, Acetromones, 25 (278) March	4512
uses, mounted on light type trucks.	Trans. from French from "Rev. Gen.	
Inside Trans. No. 1168.		
Bitumen-Coir Kelt: A new kind of sound	Trans. from (German) from "Bitumen- Theor. Asph. Peché und Verwandelte Stoffe 1954, 5, 252-253.	6806

"For twenty long and wonderful years," mused the gentleman at the bar, "my wife and I were deliciously happy."

"Then what happened?" asked the butler.

“ 7th 11 ”

79

the way ahead.....on modern highways

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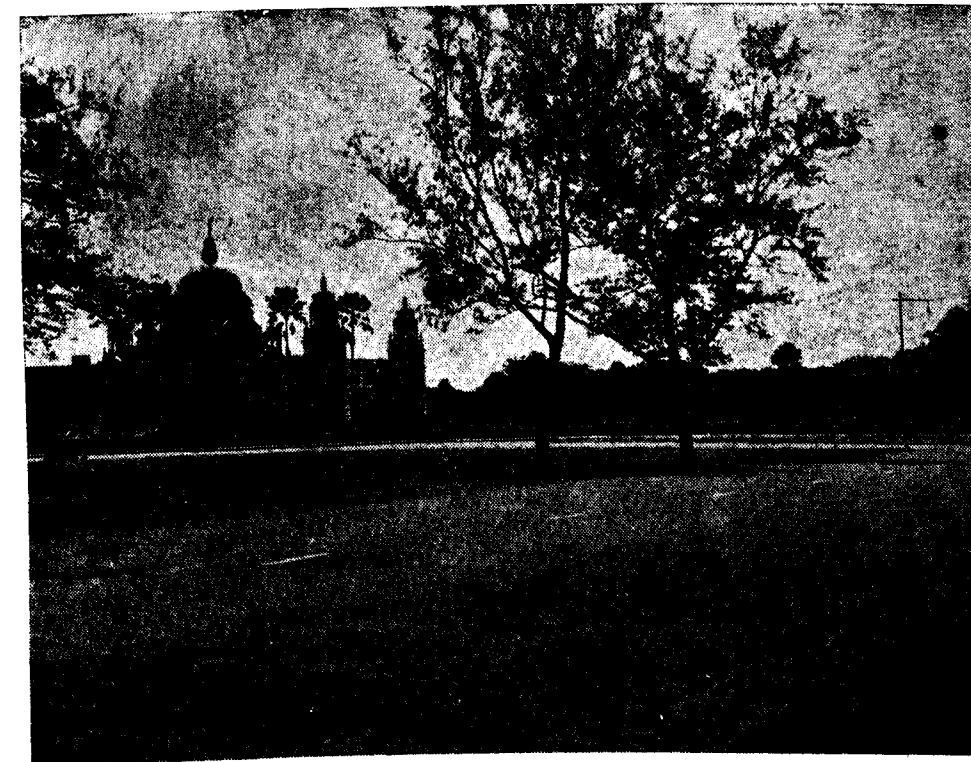
Mont Road, Madras... Paved with Galtex 50/40 Asphalt by the Madras Corporation

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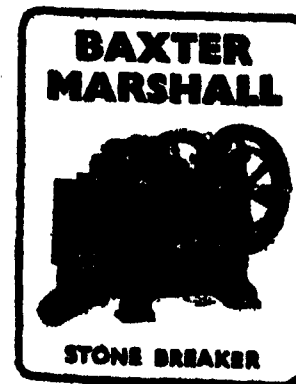
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