TRANSPORT-COMMUNICATIONS

MONTHLY REVIEW

JUNE 1960—No. 158

INDIAN ROADS CONGRESS, NEW DELHI.

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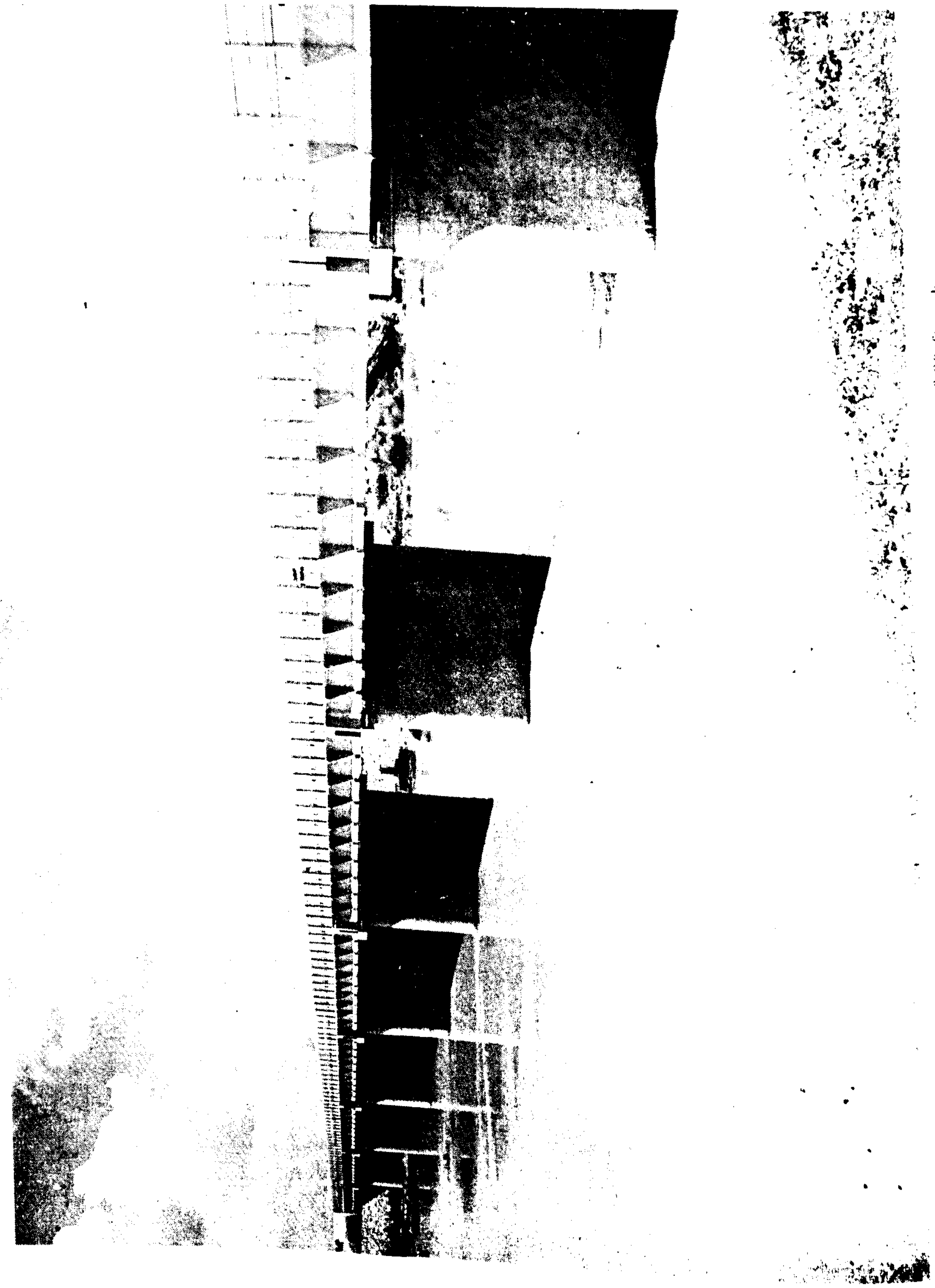


BEIN BRIDGE ON N.H. 1 (PUNJAB) Length 722 ft—eight spans of 90 ft each.

TRANSPORT-COMMUNICATIONS MONTHLY REVIEW

A REVIEW OF
ROAD ENGINEERING, DEVELOPMENT & TRANSPORT

JUNE 1960

SOME ASPECTS OF KEEPING HIGHWAYS UP-TO-DATE

IN the design, construction and maintenance of modern highways it is necessary to attain a high standard of safety and a good riding quality at high speeds.

As a matter of course the riding quality of a new road surface is excellent and our understanding of skid resistance is quite sufficient to construct road surfaces that are skid resistant. However, these excellent qualities of the new road surface are affected by the intensity of the traffic and by the size of the wheel loads.

It is a matter of primary importance to know the rate of decline and to take measures in good time to keep the road in the best possible condition.

This is the reason why the State Road Laboratory of The Netherlands, which is a part of "Rijkswaterstaat", maintains a continuous and careful check on the quality aspects mentioned above.

A programme of systematic periodical measurements is carried out on all state roads.

Measuring of the Riding Quality

For this purpose the French apparatus "Viagraph" is used (Fig. 1). This is an instrument fitted with eight wheels in a line. In

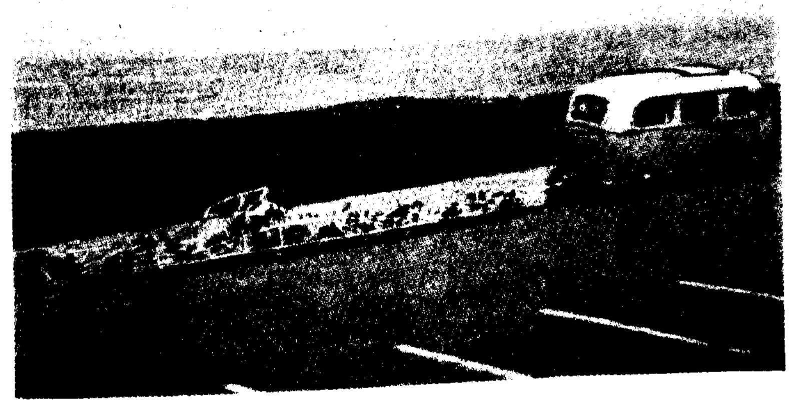


Fig. 1. Viagraph.

the centre a feeler (ninth) wheel serves the purpose of measuring the deviation of the height of the road surface in that place from the average height of this surface under the eight wheels.

The apparatus is towed at a speed of 5 km/h. The feeler wheel follows a waveline which is recorded in a diagram. This waveline is an excellent indication of the riding quality of the road.

By a standardised method this waveline is elaborated in the office and the deviation percentage is computed. The results are put into a drawing, which is sent to the engineer in charge of the measured road sections (Fig. 2).

Measuring of the Skid Resistance

What is the skid resistance of a road surface? Skid resistance is the capacity of the combination " road, tire and vehicle " to absorb and transform the kinetic energy of the vehicle.

When the brakes are applied without locking the wheels, energy transformation takes place in the vehicle (heating of the brakes), in the tire carcass (deformations) and in the contact area between tire tread and road surface.

When the wheels are locked energy transformation only takes place in the contact area between tire tread and road surface.

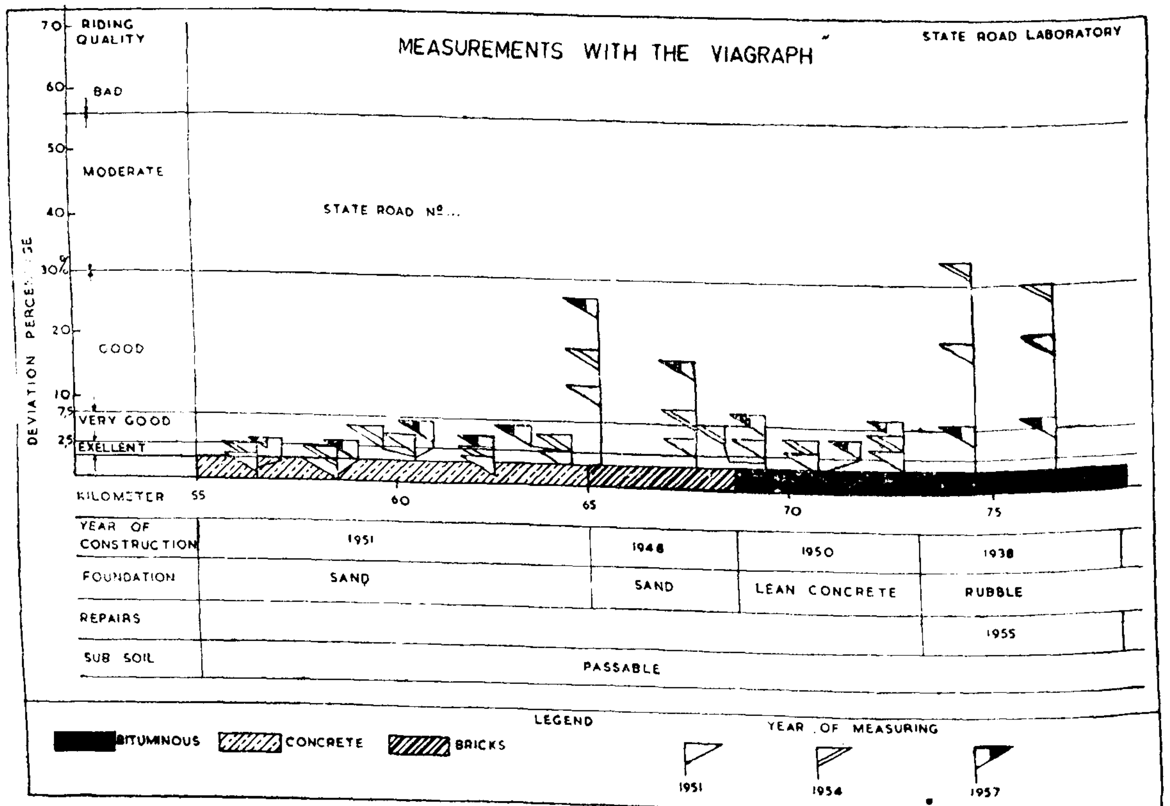


Fig. 2. **Report of the results of Viagraph measurements.**

As can be seen in Fig. 2, qualifications regarding the riding quality are given to the different percentages of deviation. All state roads are measured once in three years. Every road shows a decline in riding quality, one faster than the other.

Consequently, a higher braking effect is attainable when the wheels are not locked.

Dry and clean roads are always very skid resistant, so only wet road surfaces need testing.

For qualification of the skid resistance the equation of Coloumb F = fN (F = friction force, f = friction coefficient, N = normal load) is used.

When a towed vehicle is used for measuring the skid resistance, the towing force is equal to F and can be measured.

The friction coefficient is independent of the normal load, and can be computed if F and N are known.

But the towing force is dependent on the method of braking. When the wheels are not locked the highest towing force will be measured, and consequently the highest f.

However, this is not the only complication. Experience has shown that f is dependent on the speed and also on the temperature. With increasing speeds on wet roads a decreasing f will be found. It is possible that one road surface is qualified as skid-resistant when f is measured at a speed of 20 km/h and as slippery when measured at a speed of 100 km/h, while another kind of road surface proves, to be skid resistant at both speeds.

To determine qualifications for the different degrees of slipperiness or skid resistance it is inevitable to look for a relation between skidding accidents and the measured friction coefficient at the place where these accidents occur.

Use of a Towed three-wheeled Trailer

For measuring purposes the State Road Laboratory uses a towed three-wheeled trailer (Figs. 4 and 5).

In the centre between the outer wheels the third (smaller) wheel is made to rotate by a transmission with an adjustable fraction of the rotating speed of the outer wheels. This third wheel can be lowered or raised.

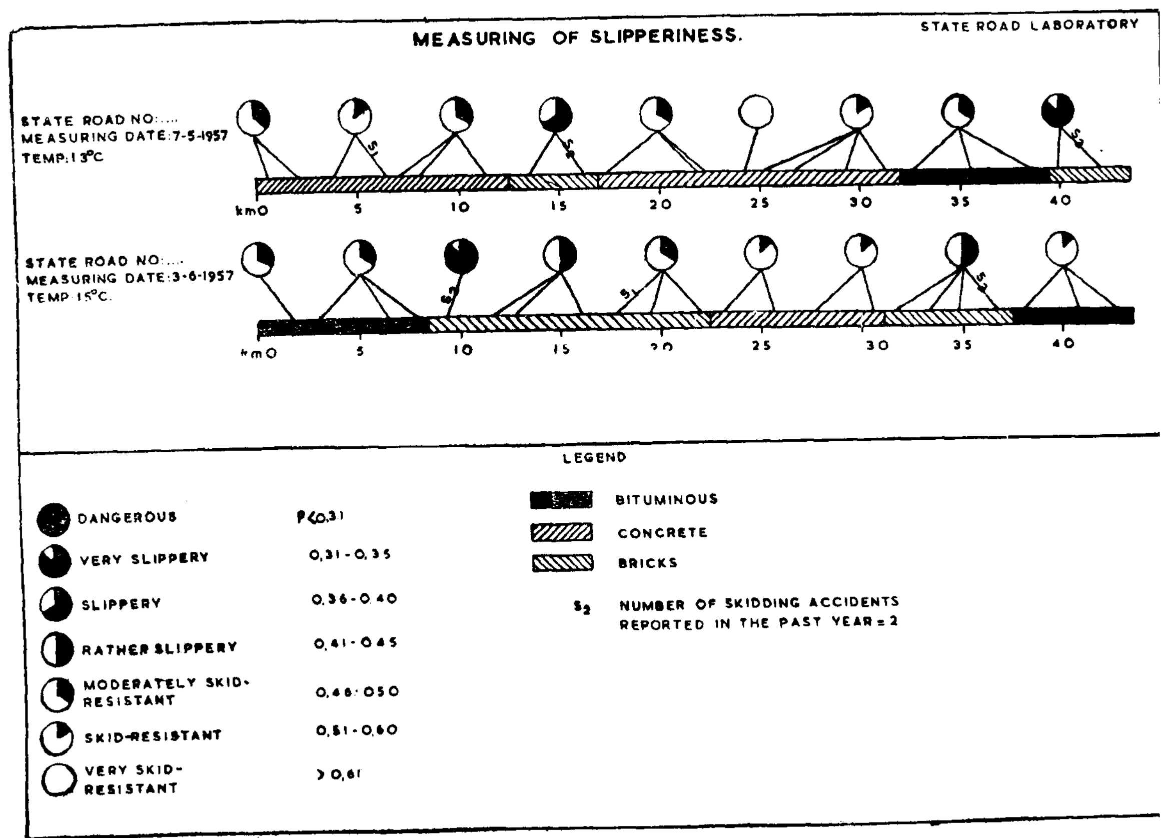


Fig. 3. **Report of the results of skid resistance measurements**

Fig. 4.
Apparatus for measuring skid resistance

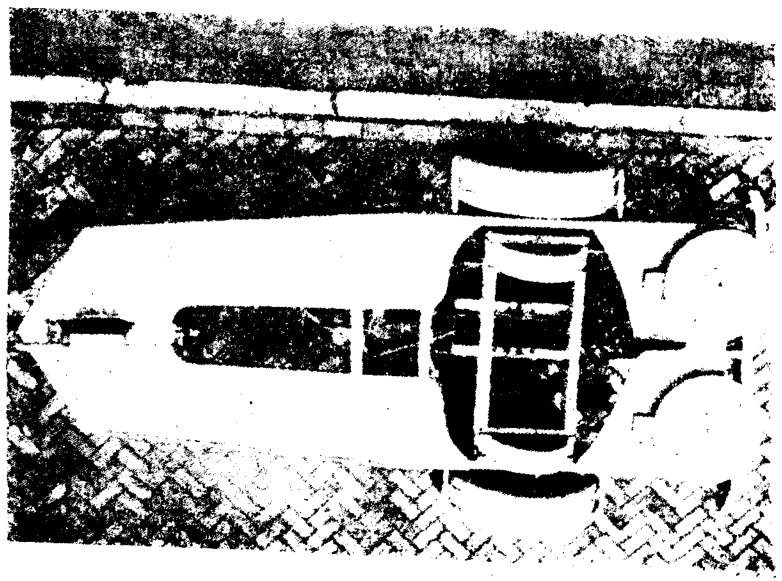


Fig. 5.
Apparatus for measuring skid resistance

Two kinds of measurements are possible with this instrument. When the third wheel is raised, the outer wheels can be braked until the wheels are locked. An operator in the towing vehicle manipulates the brakes. The towing force is measured and registered and the friction coefficient for locked wheels is computed. During each test water is sprayed in front of the tires.

When the third wheel is lowered it rotates too slowly for the forward speed. Consequently, it rolls and slides. This is an imitation of braking without locked wheels.

Of course water is sprayed in front of the tire. The towing force of this wheel with retarded rotation is registered as a continuous line. The friction coefficient f computed from the results of these tests proves (as could be expected) to be much higher than the f computed from the results of tests with locked wheels.

On the strength of many tests it has been proved that there exists a fairly good correlation between the results of both measuring methods, on the understanding that the f found with the wheel with retarded rotation is a certain percentage higher than the f found with locked wheels. At 20 km/h this percentage is about 35 and at 50 km/h it is about 50.

Qualifications for Skid Resistance

As a result of an investigation into the skid resistance of road surfaces on which skidding accidents had occurred it was possible to determine qualifications for skid resistance. These qualifications are:

Measuring with *locked wheels* at a speed of 20 km/h

$f > 0.60$	very skid resistant
$f = 0.51 - 0.60$	skid resistant
$f = 0.46 - 0.50$	moderately skid resistant
$f = 0.41 - 0.45$	rather slippery
$f = 0.36 - 0.40$	slippery
$f = 0.31 - 0.35$	very slippery
$f < 0.31$	dangerous

Measuring with the *wheel with retarded rotation* at a speed of *50 km/h*

$f > 0.65$	very skid resistant
$f = 0.56 - 0.65$	skid resistant
$f = 0.51 - 0.55$	moderately skid resistant
$f = 4.46 - 0.50$	rather slippery
$f = 0.41 - 0.45$	slippery
$f = 0.36 - 0.40$	very slippery
$f < 0.36$	dangerous

Every year in midsummer all State roads are tested for skid resistance. Midsummer is chosen because f decreases with increasing temperatures and it is necessary to know the worst possible condition of the road surface.

The results of these tests are incorporated in a drawing (Fig. 3), which is sent to the highway administrators.

(*From "The Way Ahead," Volume VII, Number 2*).

DEFINITIONS OF HIGHWAY ENGINEERING TERMS

YIELD (OF CONCRETE) The factor obtained by dividing the volume of the mixed concrete as laid and measured in situ by the volume of the coarse aggregate used. Sometimes expressed as the volume of concrete per unit quantity of binder.

YIELD POINT The upper limit of elasticity of a material.

MEASURES TO INCREASE TRAFFIC CAPACITY OF CITY STREETS

By

R. NICHOLAS, B.SC., M.I. MUN. E., M.I.C.E., M.T.P.I.,

City Surveyor and Engineer, Manchester*

IN preparing the paper, the author was interested to realise the extent to which his ideas for the future have altered or 'advanced.' The present emphasis on the urgent need to assist traffic movements and improve traffic safety by all means, other than the construction of new urban roads of modern design, has of course arisen from two causes, one being that the rate of increase of traffic has been substantially greater than we expected at the time when we were preparing our development plan highway proposals, and the other that we have been slow in using the powers contained in the Road Traffic Act, 1956, which empowers some local authorities to make Orders creating one-way streets, prohibiting or restricting waiting or loading and unloading of vehicles. Undoubtedly the application of these powers can increase the capacity of our city road system.

Traffic growth Estimates

The 1950 Ministry Memorandum suggested, in certain cases, that an increase of 40 per cent over 1938 would be adequate. In Manchester this was attained by about 1954. The Ministry's present published estimate of future traffic growth is 75 per cent over 1954 values for rural areas but provided no estimate for urban areas. The smaller use made since the war of vehicles licensed may have resulted from the inadequacy of our road system, particularly in urban areas.

In ideal circumstances one-way schemes can of course be applied over a large area, but small scale one-way street systems can be used to relieve very heavily used junctions, wherever the existing road system will enable a one-way system to be operated round blocks of existing property.

Obviously one-way streets are always objected to by transport undertakings on the grounds that greater mileage is involved but research will disclose whether the time saved may not be a more important factor.

The possibility that one-way systems might be operated at peak hours only might well be worth considering, the main difficulty of course being to devise a system of movable signing.

In regard to kerb parking restrictions, the application of these so that they prevent loading and unloading of commercial vehicles at peak hours may make it worth while providing lane marking on many of our streets which could then take four lanes of traffic, that is two in each direction. Lane marking in such streets is quickly disregarded if the use of the kerb lane cannot be guaranteed.

Increased traffic capacity can of course be obtained by substituting vehicular operated traffic signals for fixed time signals, with lane marking on the signal approaches and complete peak hour parking prohibition.

Tidal flows

The large scale linking of traffic signals may not necessarily increase traffic capacity, except where this can be combined with one-way movement.

Traffic capacity can be increased where tidal flow arises if the number of traffic lanes available for morning and evening movement can be varied.

Traffic capacity can, of course, be increased, particularly in one-way streets, where a narrowing of footpaths enables a further traffic lane to become available.

Traffic flow can be improved by pedestrian control, including, of course, the provision of guard rails.

* Shorthand version of paper given to the Institution of Municipal Engineers Biennial Spring School in London, in March 1960.

Much has been heard recently of traffic engineering as if it were some new subject and figures have been published of the large staffs which were employed by cities in the U.S.A. The problems and the solutions in that country are obviously not the same as ours, and certainly neither the police nor local authorities have been given much encouragement to employ successfully the kerb parking restrictions permissible under Section 33 of the Road Traffic Act, 1956.

A concentration of police in peak hours in the central area of Manchester during the Christmas shopping period has shown what can be done. Indeed during that time no traffic congestion arose, whereas in previous years serious hold-ups have taken place.

It is quite evident that traffic wardens and a ticket system would ensure compliance with kerb parking restriction regulations and thereby secure the advantages of applying these regulations and so ensure a more ready acceptance of them.

So far as traffic engineering is concerned, in Manchester a traffic engineering section has been established in my department within the planning organisation, and the section is responsible for all research work relating to parking problems, immediate measures of alleviation, interim measures and ultimate highway planning solutions.

As part of this process, regular studies are made of traffic movement through all main roads in the city by using a van in which a dictaphone is installed. The assistant responsible for the research uses the dictaphone and stop-watch to record movements between specified junctions, while a motor-cyclist outrider is employed who is required to go forward and investigate the cause of any delays which may arise.

One way of increasing the capacity is to install parking meters and thereby prevent this parking accommodation being used by the long-term or all-day parker.

The profits from the parking meter scheme have to be used towards the cost of providing off-street parking. In this connection it is surprising to find that the profits after paying all charges relating to the provision and operating of the parking meters then become liable for income-tax. It may be that no local authorities pay income-tax at the present time, but such a possibility could arise.

Off-street parking

Off-street parking might be attractively arranged at suburban stations where these are provided with frequent local services which terminate in the business area. Otherwise, the provision of fringe parking areas may well prove unattractive. Indeed, where there is considerable demand gor development purposes, and, therefore, multi-storey parking would have to be used, the small saving arising from the use of cheaper land would not enable the parking fee to be reduced to an attractively low level.

The best position for off-street parking is on the innermost ring enclosing the city centre. Off-street parking could be placed underground—under open spaces or sites which are to be developed above ground level—in multi-storeyed buildings, either ramp or mechanical types, and perhaps best of all in the lower floors of composite buildings. Examples can be seen on the Continent where the first floor of the building covers the whole of the site and is used for car parking purposes and above this on stilts is placed the tower of flat slab block or offices.

As to the future, I am convinced that there will have to be new roads provided to relieve present congestion and so absorb traffic from the present road system.

It should be possible in the larger urban areas to effect a considerable relief of existing congestion and enable the present road system largely to continue in use until it can be improved in the process of redevelopment, if two or even three radial roads and one ring road within the area are converted to urban motorway or expressway standards.

This would not only involve pedestrian segregation but also complete building segregation. In addition, there would be complete segregation at all junctions.

Roads designed in this way would, of course, greatly reduce traffic accidents.

(From "The Surveyor and Municipal and County Engineer", March 5, 1960).

200 MILLION POUNDS PROJECT FOR BRIDGE ACROSS THE CHANNEL

Proposed Structure from South Foreland to near Calais: Five-lane Highway, Rail Tracks and Cycle Lanes.

A project and priced estimate for the construction of a bridge across the Channel, from the South Foreland near Dover to a point just South-West of Sangatte, near Calais, a distance of 21 miles, which has been prepared under the direction of the Compagnie Francaised' Entreprises, has been submitted to the Channel Tunnel Study Group on behalf of that Company, in association with Dorman Long (Bridge and Engineering) Ltd., and Merritt-Chapman and Scott Corporation of America.

The cost is stated to be of the order of 200 million pounds and a feature of the project is the use throughout of large standardised elements for both the superstructure and substructure. The bridge would provide a central five-lane highway, two railway lines and two lanes for cycle and motor-cycle traffic.

Technical Characteristics

The following information on the technical characteristics of the bridge proposal is given by Dorman Long (Bridge and Engineering) Ltd., in a statement on the project, which also includes a list of advantages of bridge over tunnel:

The Proposed line of the bridge crosses the Straits at the narrowest point, a distance of 21 miles from the south Foreland near Dover to a point just south-west of Sangatte, near Calais. Rail connections with existing routes can be made within five miles of the bridge terminal on the French side and just over two miles on the English side.

Considerable investigations of the foundation conditions on the sea-bed have already been carried out. If subsequent investigations of the route proposed show any diversion to be advisable, this can readily be accommodated. The elevation of the land at both ends of the bridge greatly facilitates the bridge approaches.

The bridge terminals in both England and France will lie in open country permitting the development of terminal facilities and connections to existing routes without great cost.

The whole design of both substructure and superstructure has been prepared with a view to site construction of the largest possible units with the minimum of delay by standardised mass production methods and making use of the heaviest equipment.

Traffic Facilities

The bridge is designed to provide the following facilities.

A central five-lane highway 49 ft wide.

Two rail-road tracks, one on each side of the highway located directly over the bridge girders.

An overhanging sidewalk 13 ft wide on each side for cycle and motor-cycle traffic.

The design has been prepared in accordance with British and French national loading standards and specifications.

On economic grounds for the conditions prevailing, a span of 740 ft between pier centres has been adopted throughout the crossing with the exception of two pairs of wider navigation openings, situated on the sea routes on either side of the Varne Bank.

A minimum headroom of 170 ft at high water is available under the ordinary spans and 230 ft in the navigation openings. The normal spans are of alternate rigid cantilever and suspended span construction.

On the proposed bridge location the piers are situated in the following depths of water:

- 18 piers in depths between 0 ft and 65 ft.
- 35 piers in depths between 65 ft and 100 ft.

- 45 piers in depths between 100 ft and 130 ft.
- 44 piers in depths between 130 ft and 165 ft.

Their construction would involve no difficulties greater than those which have already been successfully overcome.

The successive construction of a very great number of piers of the same design and in increasing depths of water will permit the development and adjustment of the fabrication and placing technique adopted as the work proceeds towards the deeper water.

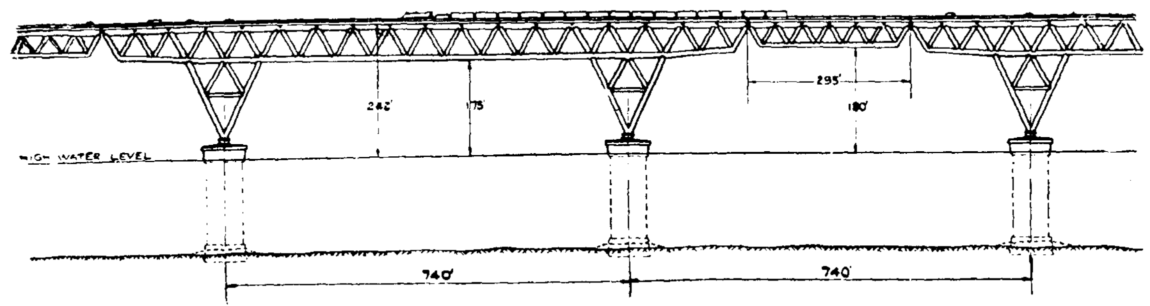
Construction of Piers

The piers are of uniform section, approximately elliptical in form. They consist of heavy precast rings of reinforced concrete superimposed on one another, with socket-type joints. The lowest ring which forms the foundation on the channel bed is filled with a grouted rockfill mass after setting in place. The remaining rings are filled with sand or other suitable granular material to provide the required stability. The whole pier will be anchored to its base by cables set in conduits formed in the walls of each ring and grouted in place. The upper ring will be covered with a concrete slab some 50 ft above sea level upon which the legs of the steel superstructure are supported.

The steel superstructure comprises cantilever truss spans 1,180 ft long overhanging the standard 740 ft openings. Their ends are connected by 295 ft suspended spans. The depth of the cantilever spans is sharply accentuated over each pier to form a support. The spans rest upon alternate fixed and expansion bearings on the pier caps.

The members of the truss spans of the superstructure are of circular tubular construction built up from steel plates by welding. The magnitude of the project and the large amount of repetition involved makes such a form of construction economic. The tubular form has outstanding advantages in efficient use of material and reduction of wind resistance and greatly simplifies the problems of maintenance. The dimensions of the tubes permit ample space for access and maintenance and for the accommodation of services, if required. The outside diameter proposed for the chord tubes is 11 ft 9 in. and for the web members 6 ft 6 in.

The design of the bridge deck is based upon the orthotropic slab principle. The forms of the deck members are proportioned in such a manner as to induce deflection of the wind currents with a view to the protection of vehicles using the bridge. Wind-tunnel experiments with this object in view are proceeding.

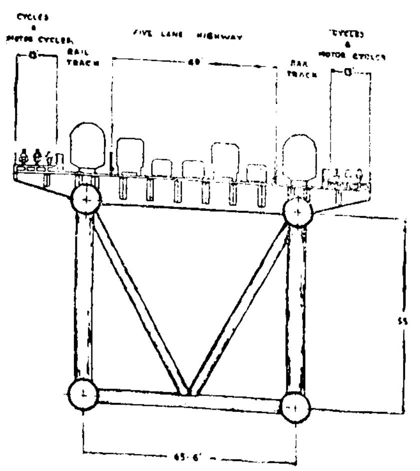


Channel Bridge—typical elevation

Mass Production of Units

The design has been prepared with a view to the prefabrication of the pier ring segments and assembly of the superstructure units in work-yards to be established on both sides of the Channel. This work would be carried out under the best conditions for mass-production, with all necessary handling facilities. The work-yards would be provided with effective connections to the adjacent road and rail systems and with launching facilities on the foreshore to suitably protected basins from which the necessary floating-out operations can be executed. All necessary social, welfare, medical and technical services would be provided.

The pier ring segments would be floated out from the work-yard basin to their permanent sites with the aid of buoyancy tanks or 'camels'. At these sites they will be placed in position with the aid of 'De Long' type pontoon platforms fitted with their own generating plant and all necessary hoisting, compressed air and maintenance equipment. These platforms consist of large pontoons by which they can be floated from one site to another, with



Channel Bridge—typical cross-section

retractable legs or spuds which can be forced down to the sea-bed and by means of which the platforms can be raised from the water above the influence of wave action. The platforms will be serviced by vessels converted for the transport of all necessary materials for the construction of the piers.

Complete spans of the bridge superstructure will be assembled in the workyards, rolled out on slipways and transported on specially designed pontoons to the bridge site where they will be deposited by the falling tide upon the completed piers.

The total weight of structural steelwork involved in the structure is approximately 800,000 tons.

Advantages of Bridge over Tunnel

The bridge solution to the problem of a Channel crossing offers many advantages:

(1) From the aspect of amenity a bridge has every advantage over a tunnel. An underground journey of 25 miles is not a subject for pleasant anticipation.

(2) The bridge solution obviously provides the greatest safety to its users. The hazards of fire or ventilation failure are inherent in all long tunnels and become of major significance in a tunnel 25 miles long, sloping downwards at both ends.

(3) Road and rail and cycle traffic of all kinds can be accommodated on a bridge structure without any interruption or check to the flow of traffic.

(4) Either steam, diesel or electric means of propulsion can be used for the railway traffic.

(5) The largest vehicles which can be accommodated on the roads of either country may pass freely on the bridge.

(6) No interruption or re-handling of goods or passenger traffic is involved beyond that enforced for police or customs purposes.

(7) Terminal installations can be reduced merely to the requirements for toll collection and customs facilities.

(8) The work involved in bridge construction can be most widely divided among many firms and interests, whereas that of a bored tunnel is concentrated upon the few workers who can operate at the tunnel faces.

(9) The first cost of a bridge cannot be simply compared with that for a tunnel. The true comparison lies between the unit cost per ton, per passenger, car or vehicle crossing the channel, with proper allowance for future developments with either solution, after taking due account of the cost of maintenance.

(*Continued on page 28*)

RECENT DEVELOPMENTS IN HIGHWAY BRIDGE DESIGN

By

C. S. Chettoe., B.S.C., M.I.C.E., and P.F. Stott, M.A., A.M.I.C.E.

(*Continued from May T.C.M.R.*)

Steel Bridges

Although steel as a material of bridge construction has been in use for a long time the last few years have seen advances in steel making which have made more generally available higher quality materials.

There is now a guaranteed yield point for mild steel. This has led to minor changes in B.S. 153.

Considerable attention has been focussed on the danger of brittle fracture in mild steels by the failure of a large bridge in Canada. Certain steels show a change in character at low temperature, losing their ductility and becoming brittle. In this condition the material is liable to cracking starting at points of high stress concentration such as connections, and welding or metallurgical defects, and propagated in such a way as may become catastrophic in welded structures. Where the danger exists the use of a notch ductile steel to B.S. 2762 is desirable especially for thicker members.

High tensile steel has become more easily available generally to B.S. 548, and to B.S. 968 in weldable quality. The use of these steels has now become economical for medium as well as long spans [12].

The use of low alloy steel has not progressed as fast as some have hoped. B.S. 15 includes two copper bearing steels of which one with 0.20 per cent to 0.35 per cent copper gives reasonable resistance to corrosion. In the high tensile range there are steels such as Corten with even better resistance.

In the field of corrosion generally and of protective treatments considerable developments have taken place, due to a great extent to the work of Hudson [13] and his colleagues at the British Iron and Steel Research Association.

Details are better designed for accessibility and painting than formerly. The welded box sections and tubes now coming into common use have obvious advantages in this connection.

Preparation of surfaces by shot or grit blasting is now widely adopted and is much more satisfactory than scraping and wirebrushing. Sprayed metal coatings of zinc or aluminium are recommended and are generally used where steelwork is not easily accessible or is in exposed situations and/or salt-laden atmospheres. Paint coatings have improved and intervals between painting have correspondingly increased.

Following improvement in steel making and design techniques the basic stress for mild steel has been increased to 9 tons per square inch with many variations in actual stresses according to circumstances, but with a general factor of safety of 1.7 on yield stress. The absolute maximum combined stress allowable must never exceed 14 tons per sq. in. for mild steel with comparable stresses for high tensile steel.

Fatigue is now more satisfactorily covered in B.S. 153. In the old standard it was provided for where reversal occurred by the addition of half the minor stress to the major in members, and the whole of the minor stress was added to the major for joints. Tables are now available giving a factor K to be applied to the basic permissible stress. This factor depends on the ratio of minimum to maximum stress, the number of stress repetitions, the quality of the steel and the method of fabrication. It therefore covers the effect of fluctuation of stress without reversal. No allowance is made for fatigue in compression members.

Advances in the design of struts, trusses, plate girder flanges, webs and stiffeners affect stresses as well as other matters. These, set out in the new B.S. 153, are based on first principles, recent research and consideration of the latest practice in other countries.

The most radical developments in steel bridge design and practice have taken place in connection methods. High strength bolts[14] are now frequently used. There are German and American Codes of Specifications for them, but no Standard in this country as yet, though the British Standards Institution is considering design and field practice. These bolts grip the plates tightly together, but do not completely fill the holes as fitted bolts do. They therefore do their work entirely by tension and friction, and not by shear and bearing. Numbers are normally the same as those of the rivets which would be required for the joint, but they are cheaper to install—about 25 per cent and there are many other advantages. They require less labour, can be used in tension, are noiseless to fit, easy to tighten and do not work loose. They can be used both for assembly and for final tightening.

Present practice is therefore moving in the direction of using these bolts for site connections, while welding is increasingly used for shop work. Among developments in welding have been greater radiographic inspection in suitable cases, minimum area welds to reduce distortion, and larger electrodes. Tests for welders are laid down in B.S. 2645.

Before the war, small steel bridge decks were usually built of R.S.J.'s in concrete, or steel girders and jack arches. Reinforced concrete decks in association with steel girders were also used, and the main girders were sometimes cased in concrete to reduce maintenance costs. This increased dead load, and the condition of the embedded steel was not always safeguarded. Present day practice continues the use of R.S.J's in concrete, using the greater range of joists and beams now available and even what are called castellated beams (i.e., with holes in the webs); and for rather larger spans, steel girders carrying reinforced concrete decks monolithic with them. In all these cases, where provision is made for interaction between the two materials, they are treated as a composite member for purposes of calculation. There is a German specification for composite design, and steps are being taken to initiate a Code of Practice for this country.

In the past, plate girders were not much used for spans above 100 ft, and continuity tended to be limited to three spans. Trusses were used for longer spans, and arches also in appropriate circumstances. A tendency, very apparent in bridges and viaducts on the German autobahn, developed before the war in the direction of extending continuity over a number of plate girder spans, fixed at one end and free at the other. This involved considerable movements over the intermediate piers, which were taken up by elastic movement of the piers or by roller bearings. It may now be said to have become a standard practice; in many cases, however, we see a main crossing with three or five continuous spans and an approach viaduct on each side having shorter spans. Examples are the Queenhill Bridge, Worcestershire, now under construction and the Neath Viaduct[15], South Wales.

Recent developments in methods of calculation and design aided by special local conditions have led to the construction of some remarkable steel continuous girder bridges in Germany.

The superstructures of these bridges have been designed as single units subject to bending and torsion from loading asymmetrically disposed transversely, and consist of a series of girders connected by diaphragms supporting a deck monolith with them. There may be also a steel plate soffit so that the complete superstructure consists of a box. All these German bridges—of which there are four—are constructed across the Rhine and are three-span continuous. The one at Speyer (Fig 4.) is a good example[16]. Three of them have centre spans in excess of 600 ft. They are quite spectacular in appearance but it is doubtful whether such large spans are economically possible in general. Special circumstances obtain on the Rhine, as very large units can be fabricated in the Ruhr and floated up the river to the particular site.

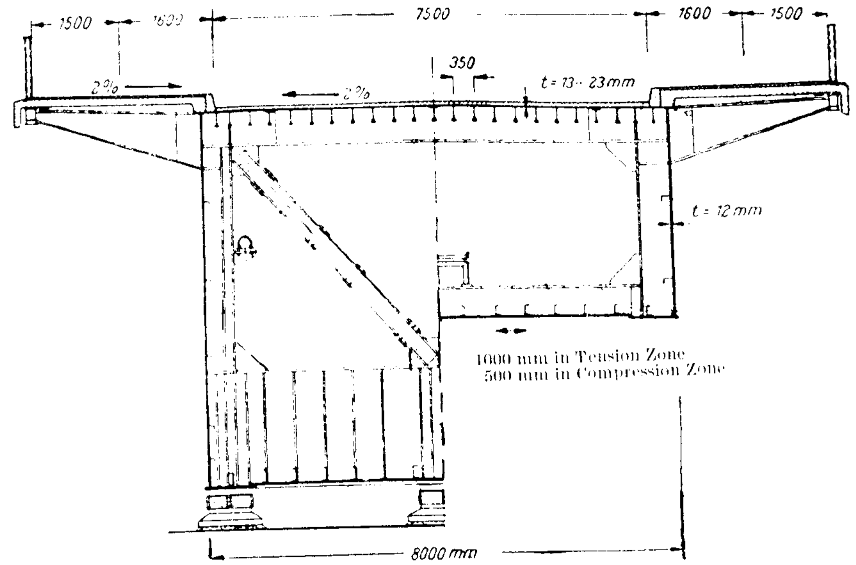


Fig. 4. **Cross section of Speyer Bridge**

This general type—continuous with curved soffits, or with constant depth over long viaducts—has become very popular, and has largely ousted the truss bridge. This is, no doubt, largely on account of its better appearance. Truss bridges, however, are still being built for fairly large spans; an example is that at Aukland, New Zealand, with a maximum span of 800 feet.

Steel arches have been built comparatively recently for spans as low as 300 ft; but are not likely to be used much for moderate spans in future. Suspension bridges, again, have been used for short spans (as at Chelsea) but are more appropriate to spans over 1,000 ft.

The development of the monolithic type of deck above described (in Germany called "orthotropic") has led to the evolution of some new and rather surprising types of bridge which derive from the self anchored suspension bridge. The best looking is probably the Nordbrucke at Dusseldorf. The main part of the bridge has three spans; the deck is carried by three parallel cables on each side supported by a pair of single pylons unbraced across the roadway. Another development is an even starker bridge about to be constructed at Humburg, with two pylons only in the middle of the roadway and three cables fanning out in a vertical plane. It has affinities to the much larger and perhaps uglier Severin bridge at Cologne, which is asymmetrical with one pier in the river and a single pylon of inverted V-shape. It is a relief to turn from these to the Rodenkirchen suspension bridge whose span of 1,240 ft is rather beyond our range.

The deck details of these bridges are of interest. The roadway usually consists of a steel plate on which two layers of asphalt are laid; sometimes steel strips welded to the plate are employed as retainers for the asphalt. Alternatively, a concrete deck on which the asphalt is laid may be cast on a supporting plate and linked to it with shear connectors. The former type is very suitable for large bridges or opening bridges which require a light deck. The most recent developments in decking include the substitution of a thin coating of resinous paste to the plate deck in place of the asphalt, and the use of open steel grids in places where the small openings in the deck do not constitute a hazard.

Where a reinforced concrete deck is associated with continuous deck girders and is to act compositely with them, bridges or viaducts have sometimes been "prestressed" in order to put the deck into initial compression by jacking down the supports after construction. This method has been used in two notable German bridges—the Werra* and Wuppertal viaducts—both of which were constructed to a convex profile but after-

* Zeetzen, "Reconstruction of the River Werra Autobahn Bridge near Hedemunden", Roads and Road Construction, September, 1953.

wards jacked down to a sagging curve tangential to the falling approaches. The Wuppertal viaduct, in the Ruhr, is of novel type. It has a steel trough section internally braced, with a deck of concrete.

Concrete Bridges

Recent developments in the design and construction of concrete bridges have been largely in the field of prestressed concrete. Before proceeding to consider prestressed techniques it may be appropriate to review the present situation of design and construction in reinforced concrete.

In the general run of bridges reinforced concrete has now been much lessened in its application by competition from prestressed construction. For spans over 50 ft and up-to 500 ft or more, prestressed concrete is now almost invariably adopted. For spans of the order of 50 ft or less reinforced concrete may still be competitive where special conditions operate: but there seems no doubt that when the element of repetition enters, such as where a number of bridges of the same size are to be built over a motorway, *in situ* reinforced concrete construction even with simple and repetitive shuttering may not compete in price against precast prestressed beam units.

It is reasonable to ask whether the change in method which has largely taken place from reinforced to prestressed design is due to the inherent cheapness of the new construction which employs so much higher stresses than were earlier considered appropriate, or whether some of the fault lies in the stagnation of techniques of design in reinforced concrete. In general it is the combination of high strength concrete working to high stresses which has given the impetus to prestressed construction, but there remains a certain field in which it is possible that an opportunity has been missed of advancing the application of reinforced concrete with such a combination.

In the opinion of the authors, and subject to safeguards in the drafting of regulations, reinforced concrete using high tensile deformed bars would show considerable advantages. It is envisaged that the calculation of strength would be on the basis of ultimate load theory, and that an over-riding check would be applied to ensure that the crack widths occuring in service would be within safe limits when corrosion was considered. The valuable work which is incorporated in the Swedish tentative standard specifications[17] gives a promising starting point for the development of regulations incorporating this attitude to design. Such an advance in design technique could only be made satisfactorily if every aspect of a structure in which it was to be adopted was rationally investigated and due allowance made for stress effects. For instance, specific allowances would be desirable for settlement of foundations where this would induce stresses in the deck structure.

Even though reinforced concrete bridges as such are less common in these days, secondary members in reinforced concrete are still vital parts of bridge structures. There has been a tendency to adopt prestressing as an end in itself, to be used whenever feasible, and this has given rise to a large family of bridges stressed transversely as well as longitudinally. While some of these applications are well justified it is now coming to be realised that reinforced concrete transverse members can be in many cases equally effective in action and more convenient and economical in construction.

The great developments in the design of prestressed concrete bridges have been the result of advances in technique in a number of related fields.

First, reference must be made to the increasing body of knowledge about the fundamental properties of the materials of construction and in particular of the properties of concrete. Seen in retrospect it is rather strange and not at all easy to understand why the use of concrete under appreciable stress as a structural medium has gone on for so many years in this century without there being available really comprehensive data on its basic properties. It is only now that research workers are bringing our basic knowledge into step with the demands of current practice. Field observations on concrete structures, difficult though they are, are still required to throw light on the real behaviour of full size structures as contrasted with the behaviour which would be inferred from laboratory experiments. We possess, however, valuable information on creep which derives from the work of Ross[18] and others; and the practical aspect has been assisted by such observations as those of Finisterwalder[19]

Developments in high tensile steels and owledge of their properties have also ·atly affected the progress of prestressed ıcrete. The strengths of standard grades wires have been improved by manufactuıg techniques and the long term creep aracteristics have been evaluated. The oduction of high tensile bar and the meturgical techniques associated with it have vanced to a point where a satisfactory ındard can be guranteed. The newcomer ıong stressing tendons is high tensile wire :and. Originally developed by American ire rope manufacturers its introduction ıd use in this country has been stimulated , new methods of anchorage design not volving the socketing technique deriving om wire rope practice. The introduction this new material affords an illustration the difficulties of work in these spheres here rapid development in use outstrips ısic research on the properties of the aterial. Only now, some time after inial production of such strands, satisfactory ·idence of the magnitude of long-term ·eep effects in the material is becoming vailable.

A review of the current use of prestressing techniques in bridge design is perhaps est introduced by consideration of specific xamples which themselves point to inte-esting and significant features of present onstruction.

The Ascot Road four-span motorway bridge on the Maidenhead by-pass illustrates the present development of short span bridges. A section of the deck is shown in Fig. 6. Prestressed beams of inverted T-shape made by the Hoyer system of prestressing on long line beds are placed side by side and the composite deck slab completed by concrete infilling placed over and between them. Transverse strength is provided by stressing tendons threaded through ducts formed in the T-beams and in the infilling concrete. This type of construction is economical and gives a pleasing appearance, and can be adapted for bridges with varying degrees of skew.

For structures of greater span than this simple bridge including spans of 100 ft and perhaps more, composite construction is still an economical proposition (Fig. 7). In these longer spans the design resembles the familiar composite steel joist and slab designs and behaves in very much the same manner but the joists are in this instance of prestressed concrete. Transverse strength in such bridges can be provided by transverse stressing as stated earlier but practice is now tending to favour transverse beams of reinforced concrete as being equally effective in promoting load distribution. Multi-span structures of this type have been made continuous for live load conditions by incorporating reinforcing steel in the slab over the supports, this section then functioning as a reinforced concrete beam in effecting the continuity.[20]

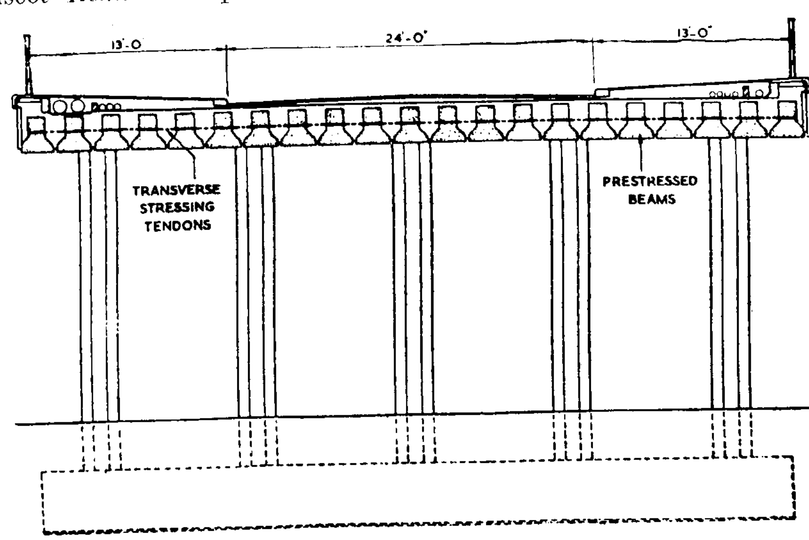


Fig. 6. Ascot Road Bridge, Maidenhead By-Pass. Spans: 32 ft., 46 ft., 32 ft. Skew angle 10 degrees

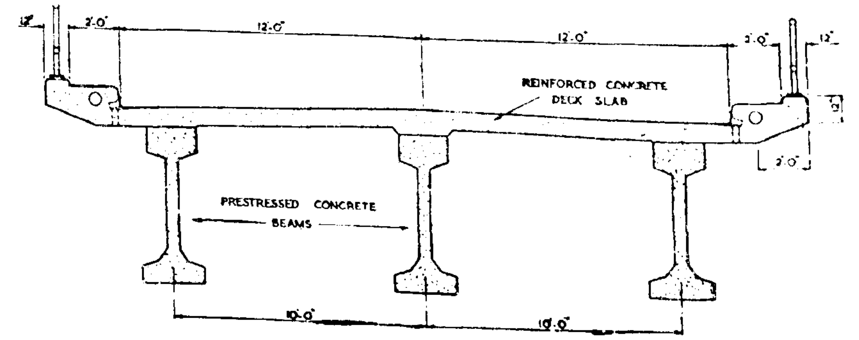


Fig. 7. **Cross section Jackadgery Bridge, New South Wales. Two spans of 95 ft and seven of 105 ft**

The development of larger concrete bridges in which most of the superstructure is prestressed is illustrated by the cross section shown in Fig. 8* of the Narrows Bridge at Perth in Western Australia. Here precast concrete "I" beam units of varying section are used as the main structural members and the transverse diaphragms are lightly prestressed. The section shown here draws attention to the use of stressing tendons external to the main concrete section. After initial stressing these are surrounded by concrete to prevent corrosion. It is worth remarking at this point on the articulation of large concrete bridges. The Narrows Bridge, while erected in the form of cantilever construction with suspended spans at shore and centre spans, is made continuous for live load by stressed connections. It then expands as a single unit, being anchored at one abutment, and having an expansion joint only at the other. This arrangement is typical of many of the present generation of large concrete bridges, and is also sometimes used for steel bridges as previously mentioned.

Other methods have been used with success for long span bridges and many designs incorporate main members of box section, their efficient structural use of material combined with their great torsional stiffness making them attractive. The Rhine bridge at Worms[21] and Koblenz[22] are instances where sections of this type have been used in combination with a cantilever technique of construction using bar tendons, while the new Clifton Bridge at Nottingham[23] was partly constructed in a similar manner using wire cables.

Arches are frequently used in suitable circumstances for spans up to 800 ft or even more.

The greatly increased use of concrete in bridge construction has focussed attention on the problems of surface finish. There is now general recognition of the need for careful consideration of finish, but some recent work in this country still compares unfavourably with corresponding practice in Germany and elsewhere.

The main types of finish available are:

(a) *Generally "as cast".*

Under this head come various types of shuttering arrangements, e.g.:

(i) Plywood or other smooth finish.
(ii) Board marks forming a pattern.
(iii) Steel shutter marks forming a pattern.
(iv) Horizontal or vertical marking or grooves at construction joints.
(v) Patterned plastic shutter Linings.

(b) *Special surface treatments*:

(i) Rubbing down from shutters to give a smooth finish.
(ii) Bush hammering.
(iii) Shot or grit blasting.
(iv) Scrubbing to expose aggregate (for small or precast members).
(v) Transferred aggregate (see below).

With exposed aggregate treatment such as those under (b) above, special aggregates and cements are sometimes used.

Some countries, e.g., Sweden, have always favoured a smooth finish, for which very good concrete is essential, and on the whole this method has been gaining ground on the Continent. Narrow board marks are effective in some circumstances—for example on the recent Ludwigshafen flyover. Elsewhere a smooth finish with rather crude and coarse grooves or rectangular

* See "Roads and Road Constriction," December 1959, p. 365.

pannels has been used as on the Bingen Bridge. A faint indication of rectangular pannels (steel shutter marks) as on the Tancarville Bridge near Le Havre, is often better.

For precast blocks and sometimes *in situ* work also, transferred aggregate methods depending on the placing of special aggregate on the moulds have been developed. These, for bridges, may be best suited to large-scale work (Fourth Bridge piers) where they are not seen from close quarters. Bush hammering, scrubbing and shot blasting are probably the best methods of treatment for general use, though the others may all be satisfactory in special circumstances. Quite light bush hammering or shot-blasting are often most suitable as these methods should not crack or split the aggregate itself. The advantages of bush hammering is that it can give some variety to the appearance of concrete depending on the aggregate used. Large-scale work, especially if not closely seen, does not necessarily need bush hammering.

Fences and Parapets

While there is little new on which to comment the trend towards lightness in construction and appearance of steel and concrete bridges has emphasised the general suitability of open steel, iron or aluminium fencing. Vertical balusters are needed to provide protection for pedestrians but for bridges carrying motorways horizontal rails alone are adequate. Concrete parapets look heavy and are very susceptible to cracking. If they are used, special precautions are necessary, generally including the forming of joints as critical sections.

A reasonable guide to design is given in B.S. 153, but more strength than is there recommended may be needed in special cases such as elevated roadways where a vehicle crashing through the parapet might fall on densely trafficked streets below. In these instances a design of the type developed in Sweden[24] may be desirable, in which the top rail is designed as a continuous member strong in tension and capable of holding a vehicle even if the vertical standards yield under impact.

Bearings and Expansion Joints

Considerable development has taken place in the forms of bearing available for use in bridges. The most striking has been the introduction of rubber bearings, the mass of rubber sometimes incorporating steel wire or plate reinforcement. These bearings can be designed for pressures of the order of 600 lb/sq. in. for normal use with shearing angles of 10 degs. or upwards according to circumstances. The capacity of these bearings to permit movement in any direction in a horizontal plane is particularly advantageous in the case of skew or curved bridges where movement parallel to the abutments as well as along the length of the span is required.

Steel bearings have been introduced in Germany and elsewhere in which alloy steel case hardened to a considerable depth is employed for those parts in which high contact pressures develop. Bearings of this type are much smaller and often simpler and cheaper than those made in the materials envisaged in B.S. 153. They are particularly suitable for use in locations where high capacity in small compass is required as in suspended span seatings and in bearings at heavily loaded columns where space is limited.

Roadway expansion joints employing rubber sections have been developed of late years. For small movements a rubber strip can be glued between steel or concrete faces; for large movements a joint formed of a number of rubber-steel sandwiches in series has been proposed. One interesting all-steel joint has been developed by the German firm of Demag for large movements; in this design a train of cast steel blocks rises over a segmental former to cover the varying gap in the loading.

Acknowledgments

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(Continued on page 28)

SURFACE DRESSING

By

G. P. JACKSON

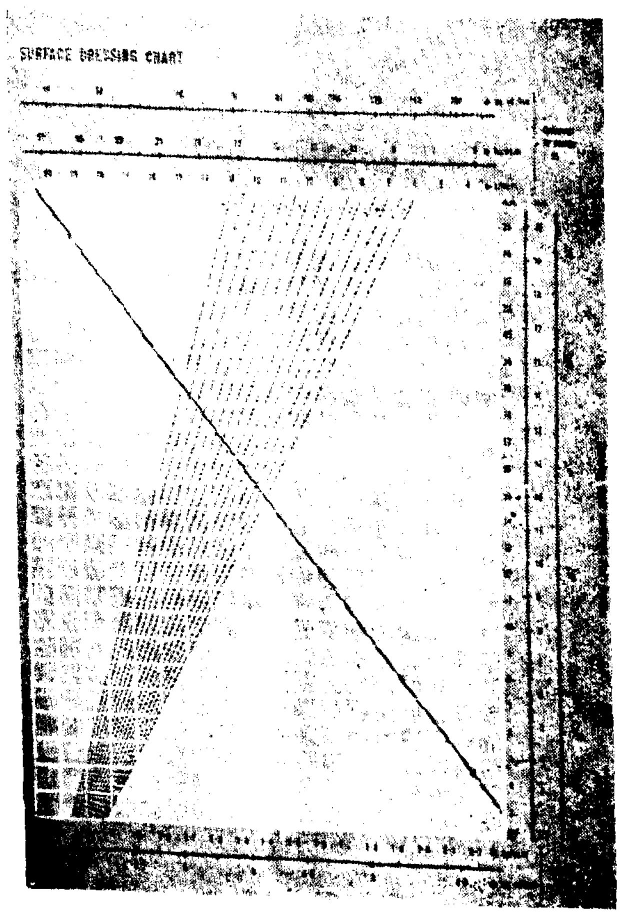
Shell International Petroleum Co., Ltd.

IN surface dressing work the selection of the correct application rate for the binder and chipping cover material is of great importance, and the method described in this article has been worked out in an endeavour to assist engineers in determining the correct rate of applications. It is based on a study of various existing surface dressing formulae from many different countries, but it is emphasised that it can only be considered as a general guide and that much still depends on the experience of the engineer in charge of the work and his knowledge of local conditions.

The top horizontal scale on the chart, with which is associated the single diagonal line running from the top left-hand corner to the bottom right-hand corner of the chart, gives the chipping application rate. The basic scale is in litres per square metre, and above that are scales giving application rates in kilograms per square metre and square yards per ton, based on a loose density of the chippings of 1.35, which is considered to be a fair average. This application rate also gives a 10 per cent allowance for whip-off.

The vertical scale on the right of the chart gives the average least dimension of the chippings to be used as cover material. The basic scale indicates the size of chipping in millimetres as determined by sieves with a round mesh opening. The next two scales give the size of chipping in millimetres and inches, respectively, based on square mesh sieves.

The bottom horizontal scale, with which are associated the diagonal factor lines running from the bottom left-hand corner to the top centre of the chart, gives the binder application rate in kilograms per square metre and below that in square yards per gallon. These scales are based on the use of a medium heavy cutback, i.e., M.C./R.C. 4 to M.C./R.C. 5 or equivalent. If lighter cutbacks are used then the quantity of binder required will be slightly more, i.e.,



up to about 0.1 kg./sq.m. for an R.C. 2 type cutback. On the other hand, if a straight-run bitumen is used, the quantity of the binder required will be about 0.1 kg./sq.m. less.

Method of Use

1. The chart is based on the principle of the average least dimension of the chippings used as cover materials. For most practical purposes where the chippings are not too flaky, this can be taken as the average size of the chippings.

2. Before being able to determine the binder application rate, it is necessary to consult the table first and to determine which factor line should be used.

3. To determine the binder application rate, read across from the average least dimension of the chippings to be used as cover material until intersecting the appropriate factor line. Then read down to the bottom scale on the chart which will give the correct binder application rate.

4. To determine the chipping application rate, read across from the average least dimension of the chippings to be used as cover material until intersecting the single diagonal line, then read up to the top horizontal scale on the chart which will give the correct chipping application rate.

Factors Affecting Binder Application Rates

Traffic volume	(Commercial* vehicles per day)	Factor
Very light	0–15	+2
Light	15–45	+1
Medium	45–150	0
Medium heavy	150–450	−2
Heavy	450–1500	−4
Very heavy	1500–4500	−6
Type of old surface		
Very lean bituminous surface		+4
Lean bituminous surface		+2
Average bituminous surface		0
Rich bituminous surface		−1
Very rich bituminous surface		−3
Type of aggregate		
Flaky		−2
Well shaped cubical		0
Round or dusty		+2
Climatic conditions		
Wet and cold		+2
Wet		+1
Temperate		0
Dry		−1
Dry and hot		−2

* Vehicles exceeding 3 tons loaded weight.

Example One

Average least dimension of chipping $= \frac{1}{2}$ in.

Factors:	Heavy traffic (800 vehicles/day)	−4
	Rich surface	−1
	Well shaped chippings	0
	Temperature climate	0
	Total	−5

Binder Application Rate: 1.05 kg/sq.m.
$5\frac{1}{4}$ sq. yd./gall.

Chipping Application Rate: 17.3 kg./sq.m.
69 sq. yd./ton

Example Two

Average least dimension of chippings $= 3/8$ in.

Factors:	Very light traffic (10 vehicles per day)	+2
	Very lean bituminous surface	+4
	Round gravel	+2
	Dry climate	−1
	Total	+7

Binder Application Rate: 1.25 kg./sq.m.
4.3 sq. yd./gall.

Chipping Application Rate: 13.5 kg./sq.m.
90 sq.yd./ton

Acknowledgment is made to the important poineer work in the use of the conception of the average least dimension done by Mr. F. M. H. Hanson, D.S.O., O.B.E., the well-knowh New Zealand highway authority.

(From "African Roads & Transport', January/February, 1960)

HERE AND THERE

1. NEW TYPE BRIDGE ABUTMENTS

● THE development of sub-structures has not kept up with the general development of the science of bridge-building, says an article in *Acta Technica Academiae Scientiarum Hungarica*. Recognising this fact, the author submits for consideration some new solutions for abutments.

For shorter spans, a foundation based on a common caisson considerably reduces the costs of the structure, and the building of arches and other constructions which are sensitive to the deflections of the supports becomes possible even under the most unfavourable soil conditions. Foundations with caissons whose edges face each other could be economical, especially in the case of skew bridges.

The utilisation of shell constructions for abutments may also be advantageous. The abutment of wedge-shaped ground plan and its modified form are new type solutions. In this solution the shifting and tipping forward of the abutment can be avoided by the proper selection of the wedge inclination.

Finally the vantage point of an abutment shaped like a ship's bow complements the advantages of a cellular light abutment. The proposals are merely solutions in principle, the detailed investigation or rather testing of which would be expedient.

(From: "African Roads and Transport", January/February, 1960)

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2. MILWAUKEE EXPERIMENTS WITH SULPHITE LIQUID ROAD BINDERS

● "BOILED down to bare essentials it has become apparent that a new field exist for a really low cost, quickly constructed temporary street, not competitive with permanent such as the excellent portland cement concrete, asphalt and tar pavements presently available."

Mr. R.A. Burmeister, Materials Engineer, City of Milwaukee, Wis., makes this observation. After pointing out that residents in newly developed areas want roads of post-war standard that have to be provided on 1939 vintage funds.

Writing in "Public Works", Mr. Burmeister details some of the efforts Milwaukee has made towards resolving this problem of low cost temporary surfacing.

Milwaukee has been experimenting, says Mr. Burmeister, with sulphite liquid road binders which are "chemically classified as mainly lignin sulfonate and are chemical by-products of the sulphite wood pulping process."

Milwaukee started with sulphite liquids in 1956 and, after preliminary field trials, commenced to evolve a specification.

The specification for the sulphite liquid contains two principal items: (1) The sulphite liquid shall contain not less than 10 percent solids by weight; and (2) a cylinder made of sandy soil and bound with the sulphite liquid shall have double the strength of a similar cylinder wherein the soil is bound only by water. Soon after the specification was prepared a laboratory evaluation test of sulphite liquid was made. The subject was a sandy loam. This was moistended and placed in a cylindrical brass moulding having an internal diameter of 4.0 inches and a height of 4.6 inches. Placement was in three equal layers and each layer was compacted by receiving 25 blows from a $5\frac{1}{2}$ pound rammer dropping free from a height of 12 inches. (Proctor Method, ASTM D 698.) By repeating this test with various moisture contents it was found that the optimum moisture content was 9.2 per

cent by weight and the maximum density was 129.2 lb/cu.ft.

Three cylinders of soil so made were then placed in an oven at 160°F for 42 hours. Three cylinders of soil were similarly made and oven dried but instead of using water they were made with sulphite road binder liquid in such amount as to produce $2\frac{1}{2}$ per cent sulphite solids by weight of the oven dry soil. The cylinders were then dry tested in compression. The untreated soil cylinders had a strength of 420 lb./sq. in. while the sulphite liquor treated soil cylinders had a strength of 1,455 lb./sq. in. In other words, the sulphite treated soil was $3\frac{1}{2}$ times as strong as the untreated soil mixture. Thus it became apparent that sulphite liquor had road binding qualities. It should be remembered, however, that the test specimens were baked which gave them higher strengths than attainable in the field.

Table 1 shows approximate mileage of the various types of pavements within Milwaukee City limits.

This article concerns itself primarily with the building and maintenance of two types of temporary pavements from Item 7, Table 1:

TABLE 1

Road Types and Mileage

Item		*Mileage**
1.	Asphalt ...	680
2.	Asphaltic Concrete ...	43
3.	Tar Macadam ...	176
4.	Tar Road Mix ...	63
5.	Portland cement concrete	158
6.	Brick ...	19
7.	Temporary, various types	132
	Total ...	1,271

(a) Starting with a subgrade properly shaped, crowned and rolled to a specified line and grade: a 4 inch layer of crushed stone (1 to 3 ins. in size) is added in one lift and then rolled. Then $\frac{3}{4}$ in. crushed road gravel is added in sufficient quantity to fill the voids in the crushed stone and provide a 2 in. thick layer of crushed road gravel above the crushed stone making a total thickness of 6 ins. Filling up voids is accomplished either by water flushing or rolling with a wobble wheel roller. The final 2 in. thick layer of $\frac{3}{4}$ in. crushed road gravel is rolled with a six-ton roller. Sulphite liquid is then applied.

(b) In case of an old gravel road or a subgrade not built to formal line or grade such as may occur in newly annexed areas, the following procedure is used. If the old gravel road is in poor condition, the material is sacrificed and enough $\frac{3}{4}$ in. gravel is added to build up to an effective thickness of upto 6 in. If the old gravel road is in good condition, the $\frac{3}{4}$ in. crushed gravel may be added only in those areas that need correction, such as pot holes, ravelled areas, etc. If little or no surfacing exists on the subgrade the $\frac{3}{4}$ in. crushed gravel is added to give an effective thickness of upto 6 in. Sulphite liquid is then applied.

In 1956, there were, 1,747,060 gallons of 10 per cent solids concentrate and 288,813 gallons of 25 per cent solids concentrate of sulphite liquid applied to 70 miles of streets at an average of 2.3 applications. The 10 per cent solids concentrate required 14,500 gallons in individual applications per mile of street and the 25 per cent solids solution was applied at 6,300 gallons per individual application per mile of street.

There were 6,313,676 gallons of 10 per cent solids concentrate used in 1957, on 118 miles of street at an average number of applications of 4.15. Total gallons per mile of street were 53,365 or 12,859 gallons per mile in individual applications.

Last year 3,951,500 gallons of 10 per cent solids concentrate of sulphite liquid treated 120 miles of streets at an average number of applications 5.72. The number of gallons for individual applications were 5,745 per mile of street or 32,927 gallons per mile for all applications.

All streets were treated on the surface only; scarifying, windrowing, mixing, spreading and rolling as practised on stabilisation projects were not done. Most streets treated had gravel surfaces. The number of applications varied depending mainly on traffic intensity and, to a lesser degree, on surface texture and weather.

(From: African Roads & Transport,' January/February, 1960)

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* Mileage is computed by using actual square yards of road divided by an average of 35.5 ft.

3. ROAD ACCIDENT STATISTICS

State	No. of accidents	Persons killed	Persons Injured
1. Andhra Pradesh	1,553	279	1,303 (57)
2. Assam	638	147	275 (57)
3. Bihar	1,723	367	1,234 (58)
4. Bombay	7,459	634	6,988 (58)
5. Kerala	1,443	220	1,587 (58)
6. Madhya Pradesh	1,419	247	1,126 (57)
7. Madras	6,539	466	3,823 (58)
8. Mysore	2,014	267	1,442 (57)
9. Orissa	859	109	649 (58)
10. Punjab	551	261	520 (58)
11. Rajasthan	388	19	155 (57)
12. Uttar Pradesh	662	286	581 (58)
13. West Bengal	14,515	417	7,680 (57)
14. Jammu & Kashmir	123	26	N.A. (57)
15. Delhi	2,658	125	1,002 (58)
16. Himachal Pradesh	62	15	103 (58)
17. Manipur	17	1	21 (57)
18. Tripura	63	13	110 (59)
19. Andaman & Nicobar	5	1	2 (59)
TOTAL	42,691	3,900	28,601

N.B. Figures with brackets indicate the latest year for which the information has become available.

4. NEW DEVELOPMENTS IN ROADWAY LIGHTING

Appendix B

(From Report of Progress in Street Lighting 1955–1958 by J. M. Waldram, Chairman Committee W–3.3.1 C.I.E. International Commission on Illumination).

"The following table indicates the ranges of mean illumination and mean luminance adopted in the various codes under review ...Nearly all codes pay special attention to glare, which is regarded as a particularly important blemish upon an installation, and in most cases advocate some form of cut-off lighting."

TABLE I

Country	Mean Illumination Lux	Mean Illumination lm/ft²	Mean Luminance cd/m²	(Brightness) ft L.
Finland	3-9 (mod. pedestr. traffic	0.3-0.9	0.3-0.85	0.09-0.25
France	2.30 (on dark surfaces)	0.15-1.5	Not less than	0.5-0.15
Germany	0.5-16 or 20 (on dark surfaces)	0.05-1.6 or 2	0.03-1 or 1.3	0.01-0.3 or 0.4
Gr. Britain			0-5,1 or 2 [illegible]	[illegible]6-0.31 [illegible] 0.6
Netherlands				
Spain	0.5-0.8 to 9-12 5 classes	.05-.08		
Sweden	3.7-5.1; max. 10	0.37-0.5; max. 1.	0.35-0.5, max. 1 (Calculated)	0.11-0.15, max. 0.3
Switzerland	Not less than 6	Not less than 0.6		
U.S.S.R.	Min. illumination 0.2-6	0.02-0.6		

NOTES: (Luminance is our photometric brightness as we apply it to the brightness of pavement and objects.

"Not less than 0.5-0.15 foot lamberts" as pertaining to the Code of Public lighting for France should be of interest in revising our U.S.A. Recommended (ASA) Practice.

Suggest consideration of the phrase "not less than" instead of minimum, at any position on the traffic-used roadway and minimum in service at any service at any time, etc.)

(material in parenthesis inserted by Charless Rex.)

(*From "Traffic Engineering," March 1960*)

5. FLEXIBLE BASES FOR ROAD CONSTRUCTION EXPERIMENTS IN WARWICKSHIRE

● DURING the past few years a considerable amount of experience has been accumulating in the use of bituminous mixtures for the bases of flexible roads. In Italy and Germany in particular, this form of construction is considered as being past the experimental stage, and many miles are being laid each year. Various specifications are used, mostly of the dense asphalt or bitumen macadam type, but with a lower bitumen content than is normally recommended in British Standards for surfacing materials.

An interesting series of test sections is being laid at the present moment on A.

4091; the Moxhall-Tamworth road near the County boundary with Staffordshire. The major improvement on this road includes the construction of a new carriageway and formed an excellent opportunity therefore for comparisons of materials and thicknesses on a uniform subgrade and sub-base.

There are 12 sections, each 80 yds. long, having bases of lean asphalt–B.S. 594 asphalt, tarmacadam and lean concrete, in three thicknesses. The formation level 3-in. thick, with a wearing suface of 1-in. of rolled asphalt. The normal construction, followed at either end of the trial length is a 12-in. lean concrete base surface with 5-in. bituminous macadam and 1-in. fine cold asphalt.

This series of trials is an integral part of a full-scale research programme, such as the Road Research Laboratory sections on A.1 at Alconbury Hill, and is in the nature of a trial or demonstration under contract

The total thickness of base is built up in 3-in. layers

remains unchanged, the sub-base of coarse fly ash, normally 6 in. thick, varies on each section as required so as to obtain the test thicknesses of the bases. The three bituminous bases are being laid to thicknesses of 6 in., 9 in. and 12 in., and surfaced with 1-in. of rolled asphalt; the lean concrete is to be 6-in., 9-in., and 12-in., surfaced with B.S. 594 type base material, conditions. Checks are, however, being made as a matter of routine so that there will be precise knowledge of the materials as laid and the road will be kept under close observation.

(From "The Surveyor and Municipal and County Engineer", 26 March, 1960)

6. 40 M. P. H. SPEED LIMIT—RESULTS OF EXPERIMENT IN LONDON

● THE Minister of Transport, Mr. Ernest Marples, this week laid before Parliament the report (H.M.S.O., 6d.) of the Departmental Road Safety Committee on the results of the 40 m. p. h. speed limit experiment in the London Traffic Area.

The main facts which emerge from the report are that on roads which previously had no speed limit, the 40 m. p. h. restriction caused a reduction in speeds and there was a fall in accident rates; while on roads previously subject to the 30 m. p. h. limit, the raising of the limit to 40 m. p. h. caused no appreciable change in speeds or accident rates. In the latter case, the higher limit was more realistic and consequently encouraged a better standard of enforcement.

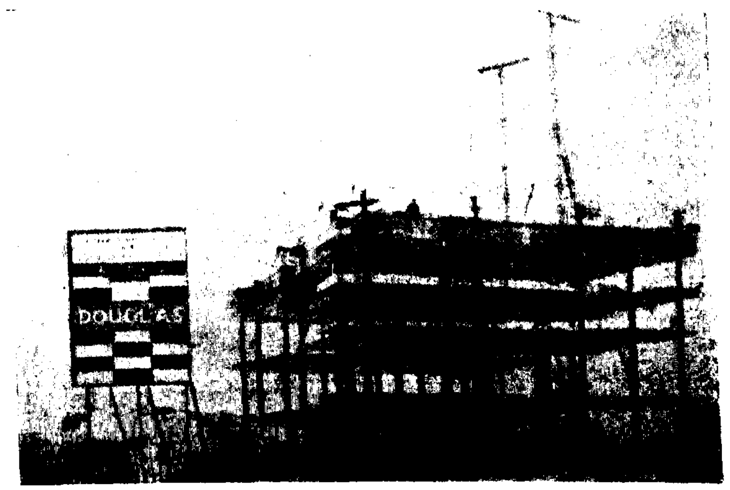
After time for consideration of the Report, Parliament will be asked for the affirmative resolutions needed to bring into force those parts of the Road Traffic Act, 1956, which will enable the 40 m. p. h. limit to be applied to suitable lengths of road throughout the country.

(From "The Surveyor and Municipal and County Engineer", 26 March 1960)

7. LIFT-SLAB BUILDING METHOD ON BIRMINGHAM FLATS

● THE lift-slab building method is being used for the construction of three blocks of nine-storey flats for the City of Birmingham Corporation. The 50-ton floors are made at ground level, with Fablon 250 gauge polythene film acting as a separation medium and a damp-proof membrane. In bad weather this operation is being carried out under giant tarpaulin.

When they are ready, the floors are lifted into position by the hydraulic jacking system. As each floor reaches the appropriate level, it is welded into position.



As this method is more independent of the weather than the more traditional building methods, the firm anticipates that, apart from a saving in materials of about five per cent, a contract taking 15 months by normal methods can be finished in 12 by using the lift-slab construction method.

(From "Highways and Bridges and Engineering Works," March 30, 1960)

8. COLOURED LINES AS ROAD ROUTE GUIDES?

● THE Lord Mayor of Portsmouth has suggested to Portsmouth Accident Prevention Council that the city should adopt a system of coloured lines to guide motorists to different parts of the city. There would be signs at entry points reading "Follow the blue line for the Guildhall," or "the red line for the Dockyard." Most drivers, one assumes, would follow any line indicating available parking space.

(From "Modern Transport", April 30, 1960)

9. NEGLECT OF ROAD SYSTEM

● DEPLORING the paucity of good roads, he said: "Even where the highways have been built they are usually narrow, and often badly surfaced: frequently their bridges are weak and their foundations inadequate. There is only one adequate road in all India, the Grand Trunk Road from Delhi into the Punjab. The result is accidents and low load limits; both are dangerous, both waste capital. Sometimes, indeed, the load limits are lower than even the bad roads make necessary. Thus, Bombay State has an average pay-load carrying limit of 130 maunds, whereas its neighbours with no better roads permit 200; not only are freights in Bombay State unnecessarily higher as a result, but also lorries have to reload when they get across the State border, with much consequent delay, damage and expense."

(From "The Automobile Magazine of India," April 1960)

(*Continued from page 12*)

(10) Since the financing of the project is inevitably subject to the guarantees of the British and French Governments, it would seem that its benefits should be as widely distributed as possible and not confined to the users of rail traffic only to the detriment of commercial and private road users.

(11) Only an open uninterrupted highway can permit the full development of tourist and commercial traffic between England and Continental Europe through France.

(From "The Surveyor and Municipal and County Engineer," 9 April 1960)

(*Continued from page 19*)

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(From: "Roads and Road Construction", February, 1960.)

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ABSTRACTS

HIGHWAY LAWS—1959; Bulletin No. 237, Highway Research Board, 2101 Constitution, Washington, D.C.

THIS 29-page bulletin contains the 1959 Report of the Committee on Highway Laws, together with four papers as presented at the 38th Annual Meeting of the Highway Research Board, as follows:

"An Attorney General Looks at Highway Law," by Duke W. Dunbar.

"Codification of Federal-Aid Legislation," by Clifton W. Enfield.

"Revision of Highway Law in Illinois," by John A. Shaneman.

"A summary Discussion of Proposed Revision in Minnesota Highway Laws," by Paul A. Skjervold.

EXPERIMENTAL CONTINUOUSLY - REINFORCED CONCRETE PAVEMENTS: PROGRESS REPORTS—1959; Bulletin No. 238, Highway Research Board, 2101 Constitution, Washington, D.C.

THIS 104-page bulletin contains seven papers presented at the 38th Annual Meeting of the Highway Research Board, January 1959.

Two of these papers, "Progress Report on Continuously-Reinforced Concrete Pavements in Pennsylvania," by F. C. Witkoski and R. K. Shaffer, and "Observations on the Behaviour of Continuously-Reinforced Concrete Pavements in Pennsylvania," by I. J. Taylor and W. J. Eney, report the experience of the Pennsylvania Department of Highways with two two-year old continuously-reinforced pavements carrying traffic volumes of 7,500 to 8,500 vehicles per day, together with the instrumentation and analysis of the same projects.

Four other papers report on testing and theory of continuouly-reinforced slabs as investigated at Purdue University, as follows:

"Laboratory Research on Pavements Continuously Reinforced with Welded Wire Fabric," by M. J. Gutzwiller and J. L. Waling.

"Stresses and Deflections in Concrete Pavements Continuously Reinforced with Welded Wire Fabric," by M. J. Gutzwiller and J. L. Waling.

"Crack Formation in Continuously-Reinforced Pavements", by M. J. Gutzwiller and J. L. Waling.

"Mechanics of Continuously-Reinforced -Concrete Pavements", by M. M. Miller, Jr., and M. J. Gutzwiller.

Another paper, "Bond and Transflexural Anchorage Behaviour of Welded Wire Fabric," by William Zuk, reports on the interaction measured by pull-out tests between concrete in slabs and cold-drawn welded wire fabric reinforcement.

AN OVERPASS FOR THE ORLY BRANCH OF THE SOUTHERN FREEWAY OVER THE NATIONAL HIGHWAY NO. 7. (FRANCE) De L' Institut Technique Du Batiment Et Des Travaux Publics January, 1960.

Bridge n°10, built as part of the program for the extension of the Airport of Orly now in progress, will provide an overpass for the Orly branch of the Southern freeway over the National Highway nr. 7.

This curved structure of prestressed concrete has a central span of 176 ft and 2 lateral spans of 126 ft.

The design requirements make this structure of interest in a number of respects:

1. Narrow limits imposed by the longitudinal profile of the National

(*Continued on page 31*)

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3686

(Continued from page 29)

Highway nr. 7 and of the freeway.

2. The clearance of the National Highway nr. 7 freed to the maximum by the substitution of a curved structure for a skew structure and by the use of reduced intermediate supports, each composed of a single column.

3. Aesthetic considerations dictated by a privileged situation.

The execution confronted the builder with delicate problems:

— The complex shape of the formworks;

— The high density of the reinforcements and cabling;

— The high strength required of the concretes.

The use of prestressed concrete provided the solution to the technical problem. While respecting the architectural character that the Management of the air port was anxious to give to this structure that will in a sense form the entrance portal to the new air port of Orly.

Any man who thinks he's more intelligent than his wife is married to a smart woman.

LIST OF APPROVED WORKS ON NATIONAL HIGHWAYS

S. No.	Job No.	Name of work	Amount (Rs in lakhs)
		ANDHRA PRADESH	
1.	2232-AH-7	Reconstruction of a bridge at mile 11/7 of Hyderabad Nagpur Section on National Highway No. 7.	0.38
		BIHAR	
2.	2260-BR-28A	Construction of bridge in the 5th mile of Motihari-Sagauli Road.	1.95
		BOMBAY	
3.	2233-BM-4	Widening miles 98/0 to 107/0 of Bombay-Poona Road, National Highway No. 4 to two lane traffic.	3.00
4.	2234-BM-8A	Widening of culverts on Dolia-Bamanbore Section of N.H.No. 8A.	2.14
5.	2236-BM-3	Reconstruction of the sykes bridge with its approaches-across the Tapti River in mile 141 of Bombay-Agra Road, N.H. No. 3, in West Kandesh District.	4.07
6.		Seven works each costing less than 2 lakhs.	5.58
		HIMACHAL PRADESH	
7.	2221-HP-22	Widening 6 ft thick to full width miles 83/0 to 84/2 of Hindustan-Tibet Road Section of Narkanda to Rampur—N.H.No. 22.	3.09
8.	2222-HP-22	Metalling and black-topping H.T. Road—N.H. No. 22—Miles 30/0 to 39/0 soling and first wearing coat.	2.25
9.	2223-HP-22	Construction of cross drainage structures and road side drains on Hindustan-Tibet Road—N.H. No. 22—Section Sanjauli to Narkanda Miles 38/0 to 39/0.	4.37
10.	2250-HP-22	Metalling and Tarshing in miles 83/6 to 84/4 of Hindustan-Tibet Road, National Highway No. 22 (Soling and first Wearing coat).	0.36
		JAMMU AND KASHMIR	
11.		Eleven works each costing less than 2 lakhs.	8.51

S. No.	Job No.	Name of work	Amount (Rs in lakhs)
		KERALA	
12.	2220-KR-47	Improving Ernakulam Alwaye Road (from Ernakulam Municipal Limits to CK Taluk Boundary) N.H. No. 47.	3.35
13.	2224-KR-47	Improvements to N.H. No. 47, Trivandrum Quilon road miles 40/0 to 43/0.	4.14
14.		Two works each costing less than 2 lakhs.	2.06
		RAJASTHAN	
15.		Two works each costing less than 2 lakhs.	2.27
		MADHYA PREDESH	
16.	2228-MP-3	Widening of National Highway No. 3 (Agra Bombay Road) Indore South from mile 15/8 to mile 41 in Madhya Pradesh.	2.91
		MANIPUR	
17.	2229-AS/39	Cutting of Blind Corners on Pallel Moret Road.	0.50
		MADRAS	
18.		Two works each costing less than 2 lakhs.	1.97
		UTTAR PRADESH	
19.	2225-UP-24	Raising and widening National) Highway 24 (Ghaziabad-Hapur Section in Meerut District.	23.23
20.	2247-UP-2	Construction of a diversion to byepass Tait village in mile 794-795 of Bombay-Delhi Road, N.H. No. 2 in Mathura District.	3.99
21.	2253-UP-28	Acquisition of land for byepass at Faizabad in Miles 77-81 of Lucknow Gorakhpur Road, National Highway No. 28.	0.39
		WEST BENGAL	
22.	2249-BG-2	Flood damage repairs (caused by the floods of Sept.-Oct. (1959) to G.T. Road N.H. No. 2 within Bardwan Division from mile 53¼ to 149¼.	9.30
23.		Two works each costing less than 2 lakhs.	0.74


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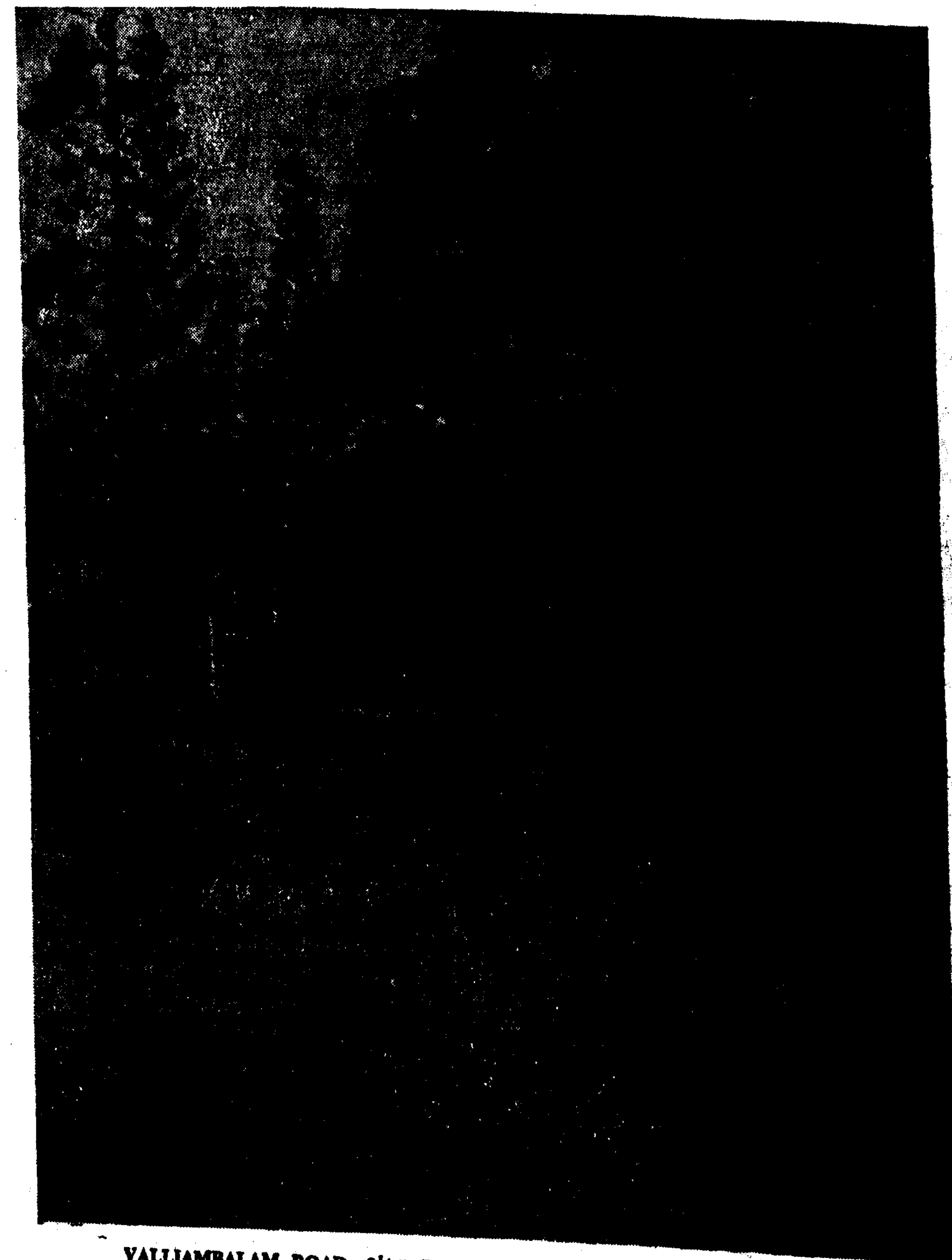

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