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NOVEMBER 1958—No. 139

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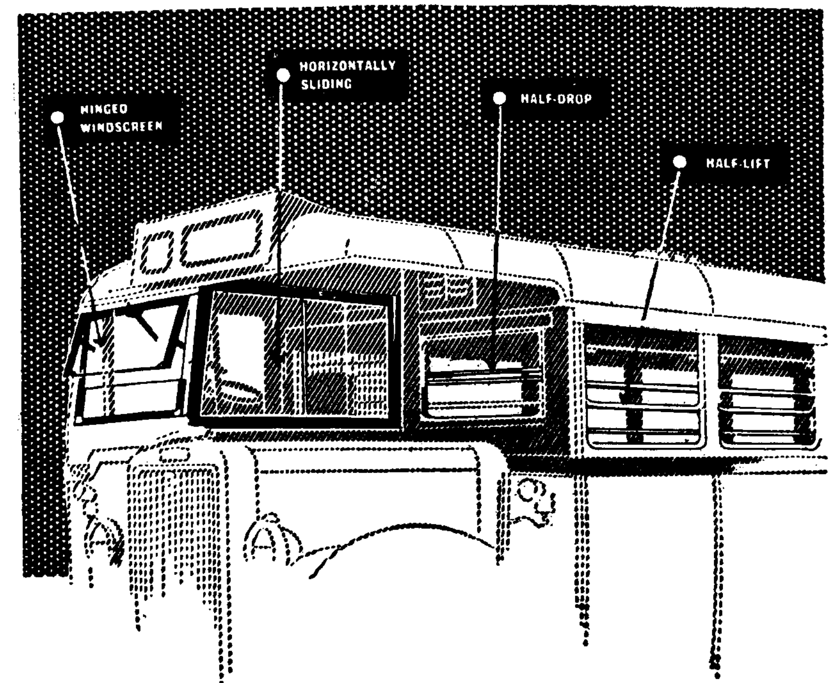

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Transport - Communications Monthly Review is published on the 25th of each month by the **Indian Roads Congress, New Delhi.**

This Review is sponsored by the Roads Wing of the Deptt. of Transport, Ministry of Transport and Communications, but the Government of India accept no responsibility for any views or opinions expressed.

Subscriptions. Annual subscription including postage is Rs Fourteen. Single copy including postage is Re one and annas four.

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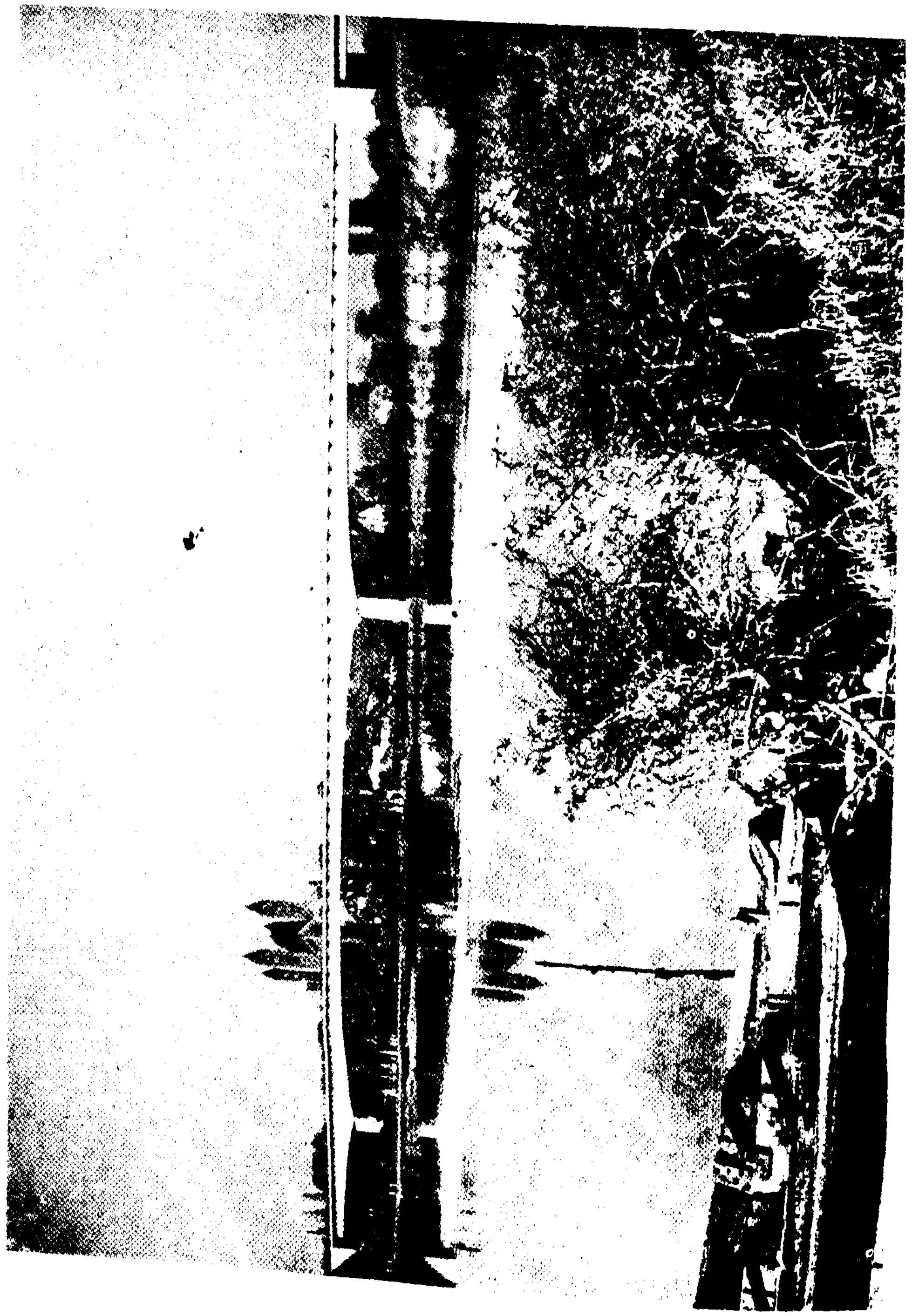

THE BRIDGE OVER RHEIN AT SPEYER

(Photo from "Strasse und Autobahn August 1958.")

TRANSPORT-COMMUNICATIONS MONTHLY REVIEW

A REVIEW OF
ROAD ENGINEERING, DEVELOPMENT & TRANSPORT

NOVEMBER 1958

ROAD WORKS AND THE NATIONAL ECONOMY

By

S. S. MORRIS, B.SC. (ENG.), M.I.C.E., M.ASCE,

M. I. MUN. E., M.T.P.I, City Engineer of Cape Town*

THE vital arteries through which pulsates the life-blood essential for a country's sound and effective development are its means of communication and transport; and with the phenomenal increase in vehicular traffic, roads have become a paramount feature in any transport system.

No country attuned to the importance of an effectively expanding economy can afford to neglect its roads. South Africa, standing as it does on the threshold of great industrial, commercial and agricultural opportunities, can certainly not afford to do so—not only the roads that connect the coastal plains with hinterland, nor those which link one province with another or one town with another, but even the urban thoroughfares upon which local communities depend for their normal commercial, industrial, cultural and recreational activities.

The benefits that accrue from major road construction are no longer conjectural. They have been carefully determined by comprehensive studies both in the United States and Great Britain as well as in certain European countries. Scientific investigation has proved conclusively that savings in fuel, in maintenance of vehicles and in the reduction of man-hours otherwise wasted in travelling, alone more than compensate for the money spent on construction. There are, of course, other substantial benefits not so precisely calculable but still very real. New areas are opened up for domestic and industrial development: property values are substantially enhanced; facilities are provided for bringing to remote and rural areas opportunities for a fuller and better life; in times of threatened war, measures for the defence of the country, both civil and military, are substantially aided; and perhaps most important of all, the growing toll of accidents is materially reduced. Road construction has in fact to-day become one of the most urgent and important of public works.

Need for accelerated programme

Outstanding features of South Africa's post-war development have been the rapid

* Part of an Address given to the annual general meeting of the South African Road Federation (Cape Region).

urbanisation of its population and the unprecedented growth of its secondary industry. Almost every major city now has a population two or even three times greater than it had pre-war. To meet these extraordinary increases in population and to cope with the accelerated growth of industry, local authorities have been compelled to commit their limited financial resources to the vital services essential for the maintenance of public health and the provision of adequate power. For example, many cities have spent millions of pounds on water and power supply projects.

Despite the country's growth and expansion, however, the urban road pattern has, on the whole, remained largely unaltered, yet car ownership per capita has increased and the volume of motor traffic is much greater than it has ever been. The future will bring an even more intense growth of vehicular movement. Latterly there has been a limited amount of new urban road construction, but everywhere it has been on a small and unimaginative scale. The time has come when city roads must be considered as a priority among public works.

The importance of major urban and rural road construction was appreciated in the United States some years ago; in the past decade hundreds of millions of dollars have been spent on the construction of expressways, freeways, turnpikes and tollways, and in the next 15 years expenditure extending to many billions of dollars is envisaged as part of what has been called the 'Presidential Road Program'. Great Britain, very much in arrear through neglect of new road construction, has now begun urgent construction of a motorway system linking her principal towns. As always, when once aroused, the British are moving with characteristic thrust and speed to make good their present deficiencies.

South Africa, if it is to keep abreast of the times, must likewise face up to its road responsibilities. The next ten years should see a complete transformation in our approach to major road problems. In Cape Town, if present programmes are brought to fruition, the effects will be far-reaching.

Road Works Counter to Depression

Unfortunately, however, there loom on civic horizons certain ominous clouds. We hear more and more nowadays of the economic difficulties that are allegedly besetting—we hope only temporarily—not only South Africa, but most of the free world. Reports cannot be ignored of the recession or 'saucer in the curve of business activity' as it is sometimes euphemistically called, even though it is admittedly mild compared with the depression of the thirties. Sterling and foreign exchange difficulties continue to confront Great Britain; the struggle to save the franc remains as urgent as ever; and here in the Union the imbalance of imports and exports and shortage of capital for development are among the problems creating concern among financial authorities.

Emphasising the deterioration of the financial climate that has settled over the country, the Minister of Economic Affairs and the Union Treasury have gone so far as to instruct local authorities to curtail, and indeed wherever possible even delete, non-essential projects from their development plans. How unfortunate it is that whenever the economic barometer falls, public works are the first activities singled out to reef their sails to meet the threatened storm.

Yet the classic, and indeed one might say accepted, method of dealing with economic setbacks should surely be precisely the reverse. America's depression of the nineteen thirties was successfully combated by Franklin D. Roosevelt's policy of 'pumppriming'—that is, initiating public works projects not only for the benefit that they themselves would provide, but also for their side effects in aiding business recovery. Each project, the theorists held (and practice indeed later confirmed), would not only place unemployed men on payrolls, but these payrolls would benefit retailers in the area, and this in turn would assist wholesalers and manufacturers; at the same time orders for materials, equipment and plant would release the brake on industry.

Since the Roosevelt era checks and balances have been built into the system of free enterprise and the cyclic depressions that were once a feature of the economic

system no longer pose so great a threat. But even though it may not be essential to adopt a policy of 'make work' and embark on public works whose benefits are intangible, or will only be harvested in the distant future, it still remains desirable to utilise those public works which can immediately assist the nation's economic development as a fly-wheel smoothing the temporary ebb and flow of business activity.

There are many categories of public works which can be justified on the grounds of immediate urgency. As pointed out, however, roads must surely take pride of place among these. When economic difficulties become apparent, road construction should be accelerated rather than curtailed. Moreover, the general attitude to road schemes needs re-evaluation: Old-fashioned, slow-moving concepts of not only road layout, design and construction, but of road finance—concepts rooted in the horse-cart and ox-wagon eras—must be replaced by a dynamic and vigorous approach consonant with the accelerated tempo of the streamlined and jet-propelled atomic age.

The pattern of road planning

In all countries, and in almost every city, the pattern of road planning reveals an underlying unity of approach; although particular solutions, of course, vary to suit local conditions and topography.

A common fundamental concept is the use of freeways of expressways; that is, roads built in the fashion of a railway line in which local needs are subordinated to the principal objective of carrying traffic speedily and uninterruptedly from origin to destination. Frontage access to such roads from private garages, shops, etc., is rigidly precluded. Intersections with other streets are either completely eliminated or provided only at long intervals; spacing is generally not less than a quarter of a mile—preferably, indeed usually, it isconsiderably more. Intersections, too, are almost invariably by means of bridged overpasses or underpasses, so that there is no conflict of crossing traffic.

The free flow thus provided permits substantial increase in load carrying capacity of these arteries. Normally, a properly designed throughway can carry about five times the volume of traffic conveniently handled by an ordinary main road of similar width. Of paramount importance, however, is the fact that by obviating conflict in opposing streams of traffic and by eliminating marginal interference, road safety is very considerably improved. Statistics confirm that the accident rate per vehicle mile drops very markedly, and even though there is a tendency for the accidents that do occur to be of a rather more severe nature, the fatality rate per vehicle mile is still markedly improved—on average about half to one-third of that found on the ordinary main road.

It is understandable, therefore, that the freeway should have become the basic unit in modern highway planning; and national highways are now regarded as a network of freeways connecting major cities and bypassing the smaller towns and villages en route.

Traffic studies show that large cities are frequently major generators of traffic; as the size of a city increases, the proportion of bypassable traffic decreases, although there nearly always remains a fairly substantial volume of traffic that does not wish to enter the city itself.

Of the traffic that does enter a city the largest proportion is bound, not for suburban areas, but for the city core—the central business district.

Formerly, road planners were satisfied merely to connect national roads to outer ring roads circumscribing cities at about a five or ten-mile radius. Recent traffic studies, however, have shown clearly that this is inadequate. To serve the motorists' needs effectively, traffic on national roads must be given the opportunity, not only of circumferentially bypassing a city, but also of being led right into its heart.

Problems of the Central District

It would be impracticable, however, to bring high capacity freeways carrying heavy additional volumes of traffic directly into an intensively developed and already congested business area without making special provision to link these to the existing street system.

Freeway traffic must be provided with facilities adequate to allow motorists to proceed easily to any part of the central city; at the same time bypass of the congested centre must be afforded for inter-suburban traffic.

There are two solutions to this problem: the first is the cross-town expressway; usually this has to be carried for considerable distance, either on viaduct or in deep cut, on a grade different from that of the city itself, so that local traffic can proceed unhindered. This is invariably a most expensive solution: For example, the most expensive road in the world, costing tens of millions of pounds per mile length, is Boston's Elevated Central Artery. Not only are structural costs heavy with cross-town expressways, but expenditure on land acquisition is even more formidable. Expense, moreover, is not the only implication often the problems of congestion are rendered even more acute at the ramps required to connect the expressway with existing street systems.

The alternative solution, and one which is now universally accepted, is the provision of an inner ring-road circling the central business district as tightly as possible. In almost every major city there exists a belt of low-value, or even blighted property surrounding the central business district. Land acquisition costs in such areas can be reduced to reasonable proportions but, even more important, traffic is kept away from an already congested area.

Parking in the Central District

Just as railway traffic must be provided with railway stations, so too must motor traffic have suitable terminal facilities. It is irrational, to say the least, to pour millions into expressways leading to the city if the motorist, once having got there, can then find no place in which to park.

In all cities, the parking problem has become acute. Normal kerbside parking spaces have become grossly insufficient in the centres of most large cities; and everywhere, in spite of strenuous efforts by traffic police, the all-day parker tends to pre-empt the few spaces that are available; so that the short-term parker, that is the shopper or the business visitor, finds nowhere to park.

Yet it is precisely the latter group which forms the clientele of the business district and provides its *raison d'être*. It is, too, studies reveal, by far the larger group numerically. Both equity and economic common sense, therefore, demand that the short-term parker receive preference.

This is the primary reason why highway authorities all recommend the installation of parking meters—a measure which makes enforcement of parking regulations relatively simple and which enables the short-term parker to gain the required preference over the long-term parker.

Installation of parking meters is, by itself, however, not enough. Additional parking spaces must be made available by construction of new off-street parking facilities.

To cater for the needs of long-term parkers, parking lots not necessarily right in the core of the city can prove adequate; for maximum effectiveness they may, and preferably should, be placed adjacent to the inner ring road so that traffic can be afforded easy access to and egress from the parking lots.

The short-term parker, however, as many traffic studies have also revealed, is unwilling to walk—and actually resists walking—any considerable distance from parking place to destination. To cater for him, multi-storey parking garages must be built preferably as close as possible to the heart of the central business district, within reasonably easy reach, say 200 to 300 yards, of the principal shopping thoroughfare.

In most towns it is not practicable, because of high land values, to plan the inner city ring with so tight a radius round the city core that the parking garages necessary can abut directly on it; although in at least one town—Fort Worth—a celebrated, albeit extremely costly scheme has been prepared on just such a basis. Generally, parking garages

will be required well within the ring and high standard access roads to them must be provided if congestion is to be obviated.

Planning in Cape Town

In Cape Town's highway planning all the principles enunciated above have been followed. Indeed, as long ago as 1951, the Author submitted to the council a comprehensive scheme for redeveloping the central city area, in which these principles were embodied even before they were accepted elsewhere. The implementation of these plans, however, through force of circumstances takes a long time; they must, therefore, be carried out stage by stage, over a period of years.

Planning is, of course, merely the first stage of any project. The best of schemes are valueless if they remain merely blueprints pigeon-holed for action only in some distant millennium when financial conditions will permit.

Fortunately, both the city and provincial councils have realised the desirability, and indeed urgent necessity, of pressing ahead expeditiously with major schemes of construction.

If any road development schemes at all worth while are to be accomplished in Cape Town, success can be achieved only by a bold and imaginative approach to the problem and by expenditure on what at first glance may appear to be a lavish scale, but which in the long run will prove a sound and indeed even profitable investment. This vital fact has been appreciated, not only by the city council and the Cape Provincial Administration, but also by the ratepayers of Cape Town. By approving recently all but one of the features of a 10,000,000 pounds ten-year road programme, the green light has at last been given to a number of the city's vital road construction schemes.

(*From "The Surveyor and Municipal and County Engineer", September 20, 1958.*)

THE CIVIL SERVANT

The civil servants are men who passed a written examination with distinction in early manhood, and thereafter led a life sheltered, regimented, secure, governed by rules, safe from external criticism sacrosanct even from the indignity of being called to give evidence in a court of law. They acquire a characteristic mentality, address and appearance and, above all, a characteristic style of writing. They are of unimpeachable integrity, of cast-iron conservatism; they are self controlled, suave and courteous; they are admirably equipped to dampen ardour, to quench zeal and to stifle enthusiasm; but they cannot lead.

Because they are themselves regimented they want everyone regimented.

Because they are graded and catalogued they want everyone so.

Because they are anonymous they want us to be impersonal.

Because they are sheltered they want us to be hid.

But, gentlemen, we do not want it so. It is not suitable to our great profession that it should be so.

THE USE OF LATERITE IN HIGHWAY CONSTRUCTION

A. T. DEVASSY, B.Sc., B.E. (Civil), M.E. (Highways)*

Origin

LATERITE is a sandy clay stone containing oxide of iron. It is a metamorphic rock coming under the scientific classification of an Argillaceous stone and found extensively on the West Coast of India. It exists mainly on the wind ward toe of the Western Ghats. It is found in varying depths; the weathered outer crust is formed of closely knit grains, dark coloured and extremely hard in texture (nearly approaching Heametite). As you go deeper the laterite gets softer and clayey 12 to 20 feet below the top crest. The colour of the material also varies from black and buff on the outer crust to a brick red with yellow streaks as you go deeper, and becomes yellow with red streaks as you reach the soft loose strata. Laterite fit for use in masonry constructions is generally of perforated and cellular structure and of a deep brown red colour.

Quarrying

The quarrying of laterite is a comparatively light operation. It is sometimes found covered with a layer of gravel or gravelly earth for a depth upto 5 or 6 feet. It is also found in cultivated fields as field laterite which, though hard in texture, is honey-combed with octreous clay pockets which disqualifies it as a good building stone. Nodular laterite can only be used as a soling stone or for surfacing Village Roads.

The quarrying consists in removing the overburden of earth or gravel and exposing laterite in a workable pit about 100 to 150 sq. feet in area. The quarrying tool consists of an axe, something like a felling axe with a short wooden handle 2 to 3 feet long at the end of which, and in the same plane, is a cutting edge of steel 3 to 4 inches wide and 12 to 24 feet long. The quarry is cut into steps with the rise equal to the thickness of the stone required, and the quarrying also is done in steps. At the edge of each step an incision is made with the quarrying axe on 3 sides conforming roughly to the size of the stone, and then by a dexterous horizontal stroke just below the depth of the stone, the stone is neatly cut and taken out. An average quarryman can cut 100 to 150 stones of average size a day. Stones of any size can be quarried, but the ordinary building stone is 18 in. × 9 in. × 6 in., $13\frac{1}{2}$ in. × 9 in. × 6 in. or 12 in. × 12 in. × 6 in. Laterite hardens by exposure. The freshly cut stones have to be kept a few months in theopen air when they become covered with a hard hydrated oxide which protects the stone from decay. But since the quarry sap renders the stone easily workable, the dressing of the stones should be done as soon as possible after quarrying.

General Properties

The safe load on laterite can be taken to be 2 to 3 tons per sq. feet and it weighs on an average about 130 to 165 lb per cu. ft. The laterite strata can withstand bearing pressure from 2 to 10 tons per sq. feet. Therefore, if laterite strata is met with under foundations of bridges and culverts, they can safely be founded on them without hesitation. Laterite has a very high cementatious value and is, therefore, a very good base for road surfacing, but due to its poor wearing capacity it is uneconomical to maintain as a wearing surface under heavy traffic. As it can be cut to any shape easily, and since the joints can be made extremely close together, it can most advantageously be used in dry masonry work, like well steinings and revetments where the drainage of the back fill can also be effected automatically without adversely affecting the masonry structure.

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Uses

Laterite has been used on the West Coast of India from time immemorial as a building stone both for ancient fortifications, well-steinings, building masonry and also for the construction of bridges and culverts. Laterite stones of considerable size are seen employed in the thick walls of forts and fortifications of the Dutch, Portuguese and Tippu periods all along the West Coast. The building materials of many of the ancient Temples, Churches and Mosques of this area are also of laterite. Most of the bridges and culverts on the West Coast up to the end of the 19th Century, just before the introduction of reinforced concrete, were constructed of laterite. Culverts upto 3 feet span are seen having one foot thick laterite covering slabs. Above this span, upto even 25 feet span, laterite circular arches are seen in extensive use. These bridges have served their expected life, and are still seen to withstand modern traffic in several places where there is sufficient cushioning on top.

Laterite used in the outer fortification of ancient forts are found to be still standing intact even after 150 to 200 years though exposed to the sun and rain throughout this long period. The walls of the Dutch fort at Tellicherry and Tippu's fort at Palghat and the old walls of the Dutch fort at Chetwayi are some of the standing monuments.

Laterite used as dry masonry for open tunnel lining near Cannanore is still in perfect condition after a hundred years of exposure. Laterite is invariably the masonry for 90 per cent of the buildings on the West Coast even to day.

A large number of culverts of laterite masonry abutments and granite covering slabs can be seen throughout the West Coast which are still good enough to take modern traffic and are in perfect condition.

The above examples are only illustrations to show that laterite masonry, if constructed of selected stones, is quite a good building stone, and as the fundamental economic aspect of development of Highways in this country is to make full use of local materials and skill in construction, it is necessary to recognise the worth of this material, abundantly found on the West Coast, with highly skilled labour also available for its use, and not always to hanker after granite stone masonry and mass concrete and R. C. masonry where they can advantageously be avoided.

Out of the manifold uses to which laterite can be put is its economic use in highway construction works. These can be classified as follows :

1. For masonry in abutments of culverts,
2. For retaining walls and pitching on slopes,
3. As a soling material for all types of roads,
4. As a wearing surface on Village Roads.

1. For masonry walls of culverts

The stones should be above average hardness and of selected quantity. They should be properly weathered and the quality near to Haematite should be selected. There should not be any trace of white nodules, and the stones should be of uniform brick red colour or showing streaks of dark iron compound. The stones should be neatly dressed to size with perfectly square corners and edges. The stones should be laid on their natural bed and the width of each stone should be at least twice the thickness. The length may vary between 12 in. to 18 in. and can be arranged to break joints at least by 3 in. The dressing of the stone is comparatively easier than granite, and one stone mason can dress between 100 to 150 stones a day. The dressed stones shall be laid headers and stretchers in alternate layers. The ordinary bond used is the English bond, and unlike brick masonry the Flemish bond is rarely adopted.

The thickness of joints used should never be more than $\frac{1}{2}$ in.; and lime mortar, surki mortar or cement mortar can be used in construction. For foundations and where they are likely to be submerged under water, surki mortar and cement mortar should be used. Since the stones are absorbent of water, the masonry has to be kept wet for a week after construction. The masonry should not be kept exposed for the extremes of climate for fairly long periods, but it should be kept covered on the top. For arch work the stones should be cut to the correct wedge shape and the thickness of the joint should be reduced to the minimum. The key-stone is best made of granite or plain cement concrete. It is, however, observed that laterite arches are able to withstand only 'B' class loading and they are unable to withstand the modern 'A' class loading, unless a heavy cushioning at least equal to the springing of the arch is available on the top of the arches. This will not be available in most cases, and hence laterite arch culverts have to be relegated to the class of village roads where heavy vehicles are not expected. The foundations of abutments, piers, wing walls, etc. should have a plain concrete base from which the masonry can be constructed, unless the soil in foundation is again laterite rock, in which case the laterite can be benched and masonry laid directly over it, after filling up the pockets, if any, with plain concrete. All exposed faces should be plastered with cement mortar after raking up the joints to a depth at least equal to the thickness of the plastering. Another factor to be attended to in the use of laterite masonry for abutments and piers of culverts is that a bed block of plain cement concrete 1 : 2 : 4 should invariably be used on the top of the piers and abutments. This is generally avoided by many as an economy measure, and is the cause of many failures of laterite masonry culverts especially with granite covering slabs. The reason for this is not far to seek.

Taking for example a culvert 3 feet span of laterite masonry abutments and granite covering slabs, the granite slabs are generally 1 foot or 1 ft-6 in. wide. Suppose due to wear and tear on the road the slabs are exposed, or there is very little thickness of cushioning on top of the slab, with the result that a passing load impinges in effect directly on the slab. Taking the chain-loading of I.R.C. class 'A' loading, suppose the axle load of 25000 lb comes directly over the culvert. A wheel carrying a load of 12500 lbs comes directly over a slab say 1 ft-6in. wide. Assuming the max. impact factor of 50 per cent, the load with impact as the wheel passes over the slab bearing will be 12500 × 3/2 = 18750 lbs. This is taken up by the laterite masonry, and acts on an area 1'-6" × 9" (slab bearing). Pressure on masonry $= \frac{18750}{1.5 \times 0.75} = 16667$ lb per sq. ft. i.e., nearly 7.5 tons persq. ft. This load only very good hard laterite can stand, and so stones of ordinary hardness fail. Thus the slab also cracks or one edge settles down. It is, therefore, necessary that in such cases a bed block equal to the top width of the masonry and one stone thick i.e., 6 in., is laid on top of the abutments and piers. This will distribute the load uniformly over the full width of the abutment or pier, which the laterite can easily bear. An additional precaution in such cases will be to lay a 3 in. thick layer of plain cement concrete on top of the granite covering slabs which will also enable a distribution of load on the slabs and prevent individual slabs from breaking (This method has been adopted on many minor culverts in Kerala and it has proved highly successful.)

The other aspect of the question is regarding the width of abutments to be designed. In the case of stone masonry construction, the width of abutment is generally taken as 0.4 H where H is the depth of the abutments from top of road level. The base width is inversely proportional to the square root of the specific gravity of the material used in construction.

$$B = \frac{H}{\sqrt{P}}$$ where P is the specific gravity of the masonry, H the height and B the base width.

The specific gravity is proportional to the weight per cubic foot of masonry. If W1 and W2 are the weights per cubic foot of stone masonry and laterite masonry respectively, and b1 and b2 the base widths,

$$\text{Then } \frac{b2}{b1} \propto \frac{\sqrt{W1}}{\sqrt{W2}}$$

If b1 = 0.4 H

$$\text{Then } b2 = 0.4\text{ H}\frac{\sqrt{W1}}{\sqrt{W2}} = 0.4\text{H}\frac{\sqrt{140}}{\sqrt{120}}$$

$$= 0.432 \text{ H.}$$

In practice, generally, the top width is given as 2 feet and width calculated as 0.4 H + 1 ft as a thumb rule.

A 6 in. thick plain concrete bed block is provided over this to seat the slab.

2. For Retaining Walls and Pitching on Slopes.

The most useful function of laterite stones is in the construction of low retaining walls and pitching on slopes. For this it is important to note that the laterite stones are always to be laid as headers only, and the length of the stone is to be equal to the thickness of the wall. This is generally 1 ft-6 in. thick which is the maximum length of the stone. The height to which this 1ft-6 in. thick retaining wall can be constructed will be given by the equation,

$$0.432 \text{ H} = 1\text{ft}-6\text{in}$$

$$\therefore \text{ H} = 3.7.$$

Therefore, for embankment heights upto 4 feet approximately, this sort of revetment is quite good.

The stones are neatly dressed on the 5 sides, and laid close jointed, dry and without any mortar. The foundation say about 1 ft-0 in. or 1 ft–6 in. deep is laid with both sides vertical. Above the ground level every course is stepped inwards $\frac{3}{4}$ to 1 in i.e., in effect the retaining wall will have a stepped batter of 1 in 8 to 1 in 6.

The batter further stabilises the equilibrium of the wall and enables it to be constructed upto 9 feet in height with a stable sub-soil in the embankment. The great advantage of this construction is that it enables free drainage for the embankment especially in sandy soil formations, wherein granite revetments will be costly and need back fill of gravel or other binders. Also, where the road is narrow and much space cannot be wasted, this has the advantage over a granite rough stone revetment which requires at least a 1 to 1 slope, and hence width equal to the height of the embankment is thus lost. Here the construction takes only 1/6 the space and the costly back fill can be saved. The length of head walls of culverts can be reduced if the retaining walls of the approaches are of this construction. The foundations of these retaining walls can be laid under water without any difficulty, and costly baling out is avoided.

One precaution to be taken in finishing the top layers of the retaining wall is that at least 2 layers on top should be fixed in cement or lime mortar so that individual stones are not dislodged by rough use. If the top course can be plastered it will be excellent.

Laterite dry masonry can also very advantageously be used as a lining for open tunnels where even though the soil is fairly hard, it may be eroded in rainy weather and may cause slips and hence needs a lining. In such cases the cutting may be made to slopes consistent with the angle of repose of the soil, and then the laterite dry masonry lining may be constructed either in headers or stretchers depending on the height of the tunnel. Open tunnels about 20 feet in height have been lined with laterite stones.

3. For Soling Materials For Roads

Soling is an essential foundation base either in Telford construction or water bound macadam on a soil of low bearing capacity. It is that part of a road structure resting upon and through which the load is transmitted to the sub-grade.

When a particularly hard road bed is required, it is the custom of many Engineers to build what is called the Telford macadam road, i.e., a Telford base and a macadam wearing surface. It is a common experience that during long periods of dry weather in summer, the road surface is apt to disintegrate and become covered with loose stones and this occurs more frequently and to a greater extent with the Telford bases than with the macadam ones. Another objection is that between the Telford base and the heavy wheels of vehicles, the surface stones are subject to attrition and wear off more rapidly. It is also a usual occurrence that where a road is formed on a rocky bed, the surface stones wear off very quickly exposing the rock. A simple experiment will illustrate this fact. If a stone resting on a solid rock be struck a blow with a heavy hammer, it will break; whereas, if resting on soft earth, it will remain unharmed under the same blow but will be driven into the soil. In the one case the reaction of the blow is all taken up by the stone which in consequence is broken. On the other hand, the impact of the blow is mainly taken up by the resistance of the soil and the stone remains unharmed. It is for the same reason that the surfacing on a rocky bed wears out more quickly than when the road bed is more elastic.

Macadam himself worked on different principles in that, he not only did not require the foundation course but also considered it positively injurious. He held that it is the natural soil which really supports the weight of traffic and that, while it is preserved in a dry state, it will carry any weight without sinking and it has only to be preserved dry by a covering impenetrable to rain. He also held that the thickness of road metal should only be regulated by the quantity of material necessary to form such an impervious layer and never by any reference to its own power of carrying weight. He thus preferred a soft foundation to a hard one.

The question of what should constitute this impervious layer has been discussed for a good many years. It is a common experience that a road laid on an elastic base will last longer than one with a solid foundation. Therefore, when the provision of the solid foundation by granite soling stone is costly and not quite impervious, the argument in its favour slowly dies out. Laterite soling offers an advantageous substitute. When properly compacted by a heavy hand roller it provides its own binder, due to its high cementatious value and makes a good impenetrable medium. It also provides an elastic base which can effectively transmit the traffic load on to the natural soil. If a wearing coat of macadam is laid on top, being a softer material laterite can give effective bedding for the macadam and thus provide a perfect impervious resilient base for all macadam roads.

On a well formed and rolled to camber natural sub-grade, laterite soling stone between 3 in. to 6 in. is carefully hand packed to a uniform thickness of 6 in. to 9 in. This is rolled lightly with a 3 ton hand roller and formed to camber. The width of the laterite soling should be one foot more than the macadam wearing surface. The side bunds are then formed with earth and the water bound macadam 3 in. or more thick is laid on it in the usual manner with either hand or power roller as available. Any improvement can also be laid on this.

4. For Wearing Surface

Nodular laterite in the form of metal 1½ in. to 3 in. ring is also used as a surfacing material on village roads. This is most efficient on roads with a sandy or clayey bed, soft and yielding, the former in summer and the latter in winter. A layer of laterite metalling serves to stabilise the above two surfaces and a fairly good riding surface is obtained by hand rolling in all weathers. Since laterite has a high cementations value, it thus provides its own binder. It is cheaper for construction and cheaper still for maintenance. Whereas granite metalling on a sandy bed needs binding material for formation and consolidation and also for maintenance, laterite obviates this difficulty and reduces maintenance cost.

However, the effect of combined pneumatic and iron tyred traffic is disastrous to this surface. The iron tyred vehicles powder the material and the pneumatic tyred vehicles suck up the powder and scatter it as dust. Therefore, laterite is not an ideal wearing surface on main District roads. But it is quite cheap and effective on village roads, where bullock-cart traffic preponderates and pneumatic tyred vehicles are rare. The bullock-carts generally form two tracks on the surface and repairs of the two feet wide tracks only are needed as maintenance.

THE ABIDJAN RAIL - AND - HIGHWAY BRIDGE

ABIDJAN is the capital of the Ivory Coast, the richest of the eight territories which constitute French West Africa. The town lies on the Ebrie Lagoon which communicates since 1951 with the sea through the Vridi Canal. This has given Abidjan a modern port which handles an increasingly large traffic since it is the transhipping terminal for all the products of the Ivory Coast.

The deep water harbour was constructed on "Petit Bassam" Island which is separated from the town of Abidjan by an arm of the lagoon. The native town of Treichville, the industrial area and the airport are also located on this island. As a consequence of this situation, it became vitally necessary to connect the residential town and Petit Bassam Island by a bridge capable of carrying the rapidly growing rail, vehicular and pedestrian traffic. The economic development of the country and of the town made the problem of the bridge more and more urgent. The volume of traffic on the structure now is 25,000 vehicles per day and 2,600 vehicles per hour during the peak periods which is equal to that of the Pont de la Concorde in Paris.

Before the construction of the new bridge, the two sections of Abidjan were connected by a floating steel bridge which had become completely inadequate. This structure dated from 1931 and at that time any other type of bridge did not seem feasible because the bottom of the lagoon did not afford any firm ground for the foundations. By 1954, new techniques in civil engineering made it possible for Enterprises Boussiron, a French public works contracting company, to prepare a project which consisted of a prestressed concrete deck supported by well-columns. The project was executed by S.E.T.A.O., the African subsidiary of Enterprises Boussiron, in collaboration with Societe Francaise d'Enterprises de Draggage et de Travaux Publics, and the new bridge was opened for traffic in May 1957.

General Characteristics

The essential features of the bridge are a double-deck structure with an overwater length of 1,220 feet and two approach viaducts with a length of 292 feet each. The bridge section consists of 8 spans, each of which is 152½ feet long between pier centers. The existing roads on each shore reach the bridge lanes by traffic loops at several levels to eliminate any cutting across the flow of traffic. The entire structure has a total length of 3,940 feet.

The bridge carries vehicular traffic over a roadway with a width of 46 feet, bicycles have a separate roadway and pedestrians a sidewalk, both of which are 13 feet wide, and trains run over two tracks below the upper bridge deck. A gangway for pipe mains and cables, 13½ feet wide, is located between the two tubular girders in which the railroad runs.

The natural conditions of the site and of the bottom of the lagoon necessitated certain completely new design features which give the structure its bold and original character. The main elements of the design include the construction of the foundations by means of vertical and inclined wells of large cross section, executed in bore holes with a diameter of 4 ft 9 in.; complete prefabrication of all elements (caissons, girders, gangways, well casings) on shore and floating into place; prestressing to facilitate assembly and eliminate any fissuring; the preparation of nearly all of the concrete used with pouzzolanic or slag cement to prevent any deterioration of underwater elements by the action of the humic acid in the slime of the bottom. The same type of cement has also been used here for the

Aerial View of the Abidjan Bridge under construction with the Original Floating Bridge on the right

(Enterprises Boussiron)

Front-View of the Abidjan Bridge

(Enterprises Boussiron)

first time in the superstructure to safeguard against the action of the salt air and of the combustion gases of the locomotives running in the tubular girders.

Foundations

Twenty-four exploratory borings confirmed the crucial difficulty which led originally to the adoption of the floating bridge and revealed the centre of the lagoon to consist of a water depth of 32 to 39 feet, followed by a layer of slime 65 to 78 feet deep and resting on 55 to 59 feet of compact silt, below which are various types of sand and small gravel interspersed with thin banks of hard clay. This places the soil suitable for the foundations at the considerable depth of 164 to 180 feet below water level.

In view of these circumstances, it was decided to construct the foundations of the over-water structure by a series of caisson-wells. Several solutions of this combination were investigated and in that finally adopted, the caissons were reduced to simple load bearing footings. Each pier has 8 well-columns with a diameter of 4 ft 9 in. with 4 of these vertical and 4 inclined at 15 per cent and having their line of greatest slope in a vertical plane forming an angle of 45° with the longitudinal centre line of the caisson so that they in themselves provide longitudinal and transverse stability. They descend 50 feet into the layers of sand and their hold has been reinforced by means of plastic sleeves into which cement mortar has been injected. The lateral thrust of the adjacent soil prevents any buckling of these columns, constructed of prefabricated and prestressed tubular elements and placed in boreholes with a diameter of 4 ft 9 in. The latter were sunk by means of Benoto drilling equipment, utilizing salvageable sheet steel tubing. The tubes receive a back-and-forth leverage movement to facilitate lowering and removal.

The well-columns, filled with concrete, are protected against the action of the lagoon water by a bituminous coating over their entire height above the top of the sand layers; by prestressing of the peripheral sheath which prevents any fissuring; and by the utilization of puzzolanic and slag cement for the concrete.

The hollow caissons, 23 ft wide by 19½ ft high, separated by a distance of 152½ ft between centres, are surmounted by piers, formed of a double support which reduces the span of the tubular girders to 134½ ft and provides adequate ventilation and light for the railroad tracks. The underwater section of the prestressed concrete caissons is protected from chemical attack by the nature of the cement and a bituminous coating. Floated into place, connected by a steel gangway, to the preceding pier, and equipped with shafts, they provided an impeccable implantation and inclination of the wells, the upper part of which was subsequently blocked and integrated in the footings.

Abutment Piers

The abutment piers consist of reinforced concrete caissons with a horizontal cross section of 40½ by 82 ft with 6 cells, closed at the base by a plug of slag cement. The caissons were placed by undercutting in a dry excavation and were left empty so as not to overload the underlying soil.

Superstructure

The overwater superstructure is constituted by two large parallel girders of trapezoidal cross section, framed between two overhanging lateral galleries. These galleries, of the same volume and the same profile as the abutments of the roadway of the approach viaducts, contribute to give unity to the structure over a length of 1,804 feet and at the same time lighten the appearance of the girders by the combined effect of their mass, by the light they concentrate on their string-course and by the shadow they throw on the large inclined walls. The space between the large tubular girders serves for the passage of conduits.

The protection of the structure, even of the reinforced concrete, is provided by the attention given to the shape of the sections (absence of sharp corners, completely flat surfaces), by the quality of the concrete (type of cement, specific gradation, intensive vibration, use of plastifiers), by the care in construction (curing of concrete) and by deep embedding in the concrete of reinforcing with improved bonding characteristics. The utilization of three-dimensional prestressing throughout prevents any fissuring, eliminates maintenance and provides the structure with the durability which it was desired to obtain. The prestressing provided by 30-and 100-ton cables of the Boussiron-BBR type, rectilinear in greater part, can be augmented later in case of overload, because a certain number of empty ducts have been constructed for installation of additional cables in the future.

Bridge Approaches

The approaches were designed so as to keep rail, vehicular, bicycle and pedestrian traffic completely separated. On Petit Bassam Island (Treichville), traffic loops have been built for the vehicular traffic. The small available space made it necessary to utilize radii of curvature as low as 82 feet. To maintain the minimum speed of 25 miles per hour required for an adequate flow of traffic, the connecting curves were constructed with varying radii. Banking was limited to a maximum of 8 per cent. The radius of curvature for railroad track is not less than 394 feet and gradients do not exceed 6.6 mm per meter.

The total of the approaches required the construction of four highway bridges which do not exceed a span of 65 feet, with very thin decks to provide adequate clearance. Two upper passages are located in the three-leaf clover-leaf on the Treichville side. On the Abidjan side, we find two much more characteristic auxilliary structures. One of these is the lower lagoon passage with three levels, which is an integral part of the approach viaduct, and provides passage for two roadways of 23 feet and two sidewalks below the railroad tracks of the Lagoon Boulevard. The continuous intermediate slab, 16-3/4 in. thick and 66 feet long, is of prestressed concrete. The other is the upper passage of prestressed concrete with three levels of which the upper carries the approach road to the bridge, the intermediate leads to the North Express Highway and the bicycle path, and the lower runs into Avenue Faidherbe.

With its unusual engineering features and integration into urban planning design, unique in French West Africa and perhaps on the continent, this monumental structure is an important and farsighted contribution to the intense activities and economic development of Abidjan and the Ivory Coast.

(From "French Economic and Technical Bulletin", No. 6, 1958.)

STRANGE

A Politician named Strange lay on his deathbed, and his lawyer was summoned. "As an epitaph on my tombstone", he gasped, "I only want to have the words, Here lies an honest politician".

The lawyer protested. How will people know who's buried under that stone?"

The old man nodded wisely. "Don't worry", he advised. "The folks will take one look at those words, and they all say, That's Strange!"

THEORETICAL AND PRACTICAL ASPECTS OF PRESTRESSED CONCRETE FOR CARRIAGEWAYS

MERITS OF THE SYSTEM FOR HIGH-GRADE PAVEMENTS

BY using prestressing, carriageways can be made continuous, without joints, within certain limitations, and they can also be made stronger to resist high loads, or thinner to resist the same loads as conventional concrete pavements, says Mr. Thoman Cholnoky, of Frederic R. Harris, Inc., Consulting Engineers, New York, in a paper presented at the Highway Research Board's 36th Annual Meeting.

Describing work on an experimental prestressed concrete slab built at the Patument River Naval Air Station, Mr. Cholnoky draws the following conclusions:

The test indicated the over-all superior behaviour of the prestressed concrete slab. Sand and building paper proved an efficient solution to reducing base friction.

The problem of developing prestressing in the concrete has not been completely clarified, mainly because of the presence of several factors affecting base friction. It was found, however, that prestressing can be developed under given circumstances in the most efficient manner when the continuously changing volumetric changes in the concrete have a decreasing tendency (i.e., when the concrete tends to contract).

The effect of repeated prestressing in short cycles proved also beneficial.

High Load-bearing Capacity

As far as load-carrying capacity is concerned, the slab could have resisted extremely high loads. The added compressive energy in the concrete provided by prestressing, coupled with its spring effect would make considerable reduction in pavement thickness possible.

Load tests performed at the shrinkage cracks and at the edges also proved the beneficial contribution of prestressing in concrete pavements.

Prestressing in a pavement can be provided either externally by using hydraulic jacks or internally by prestressing elements which are embedded in the slab.

The use of jacks seems to be economical, especially if they could be used in between a series of slabs, with few abutments. The cost of expensive abutments can thereby be spread over a considerable length of pavement section. The cost of wires or strands would be higher, but such elements would offer greater advantages than those obtained by jacks.

External prestressing represents only an additional compressive and flexural strength in the concrete section, which once exceeded by either loads or stresses created by restrained volumetric changes, would be completely lost and would lead to the failure of the slab. On the other hand, the presence of internal elements represent a tension field in the concrete section, which, coupled with the resistance of the concrete in compression, will be capable of resisting higher loads. When such loads are applied the section will behave as a reinforced concrete section and will be capable of carrying additional loads until ultimate conditions are reached either in the concrete or steel.

Volumetric changes which develop mainly as the result of temperature variations have little effect on the prestressing forces if they are created by internal steel elements because the thermal expansion coefficient of steel and concrete differ only slightly. The preservation of constant prestressing forces, as applied by hydraulic jacks, would become problematic in view of the continuous volumetric changes which will take place in the concrete. Assuming a modulus of elasticity of 4 million and a thermal expansion coefficient of 6 millionths and no friction under the slab, a prestressing of 300 p.s.i. could be offset by a temperature drop of 12.5 deg. F.

It is felt that prestressing provided by hydraulic jacks should be applied only as an auxiliary means in addition to internal steel elements.

The elements should be placed prior to placing of the concrete if post-tensioning is used. Conduits provided in the concrete and pulling the prestressing elements through them after the concrete has hardened seems to be an unnecessary complication. The tests indicated that with sufficiently stiff tubing around them and after careful placing, the conduit resistance in these prestressing elements will be negligible.

Lubricant Alternative

The grouting of conduits several hundred feet long will, of course, increase the cost also. Therefore, it is felt that finding lasting lubricants with corrosion resisting properties would offer the best solution for future applications.

As emphasised in the preceding paragraphs, the main advantage of prestressing pavements is that they become continuous and by virtue of their inherent compressive energy they remain so, even if accidental reasons such as overloads or excessive restrained stresses create temporary discontinuity.

Therefore, the minimum of prestressing applied should be sufficient to maintain and restore continuity in the pavement. It is felt that for such purpose 100-150 p. s. i. prestressing is adequate in addition to the prestressing which may be lost due to base friction. The over-stressing of the slab does not seem to be justified for several reasons.

Considering conventional pavements of 6 to 8 in. in thickness, the actual saving in concrete when prestressing would be used could not affect the additional expense of providing the prestressing element with present prices and construction techniques in view. This is mainly true because of limitations set for reducing pavement thickness. With conduits to be used of approximately one inch in diameter and providing sufficient clearances for possible transverse reinforcement and adequate cover for protection, the practical limitation for pavement thickness would be 5 rather than 4 in. Pavements with less thickness would require high prestressing in the order of 500-600 p.s.i. to offer sufficient resistance to loads. With such higher prestressing the anchorage of the prestressing elements would become problematic because of the high concentration of loads. High prestressing would also increase the number of tendons to be used and would thereby create increased difficulties for placing concrete.

Pavements, if highly prestressed, would carry loads on average sub-bases with considerable deflections without detriment to the concrete slab but definitely causing permanent deformations in the supporting material.

The amount of prestressing necessary to overcome friction of the base is a function of length of the slab and of the unknown friction coefficient. This coefficient should be in the order of 0.5. To secure the proper development of prestressing, it should be applied with temperatures showing a decreasing tendency and in repetition (i.e., the prestressing elements should be released and restressed once but preferably twice after the first stressing).

Longitudinal Stress

It was assumed in the preceding paragraphs that prestressing is to be applied only in one direction. This is recommended for highway pavements. There seems to be no need for additional strength transversely except for some light transverse reinforcement. This reinforcement should be placed above the logitudinal prestressing elements. The prestressing elements should be placed directly under the neutral axis of the slab.

Prestressed concrete pavements are undoubtedly superior in general behaviour to conventional concrete pavements. They seem to provide not only more strength, but also reduce problems which are connected or created by pavement thicknesses, joints, cracking, and

some other phenomena to be dealt with. As a matter of fact, they seem to offer answers to a good many problems for which highway engineers seek solutions.

It would be unwise, however, to overlook important problems of rigid pavements for which even prestressed concrete cannot offer a satisfactory solution.

First of all, it must be emphasised that it would be a fallacy to believe that the adoption of prestressed concrete pavements would lead to the acceptance of poorer sub-base than those presently used. Economical prestressed concrete pavements must be thin and thereby more flexible. Such flexibility itself will result in greater deflections. In this case, attention must be directed to the permissible limits of base deflections in determining the quality of material underlying prestressed concrete pavements.

Pumping, which is one of the paramount problems of rigid pavements is not going to be solved by prestressed concrete pavements either. As a matter of fact, decreased pavement thicknesses and increased deflections resulting therefrom could add to this problem.

Joints cannot be eliminated completely. Their number can be reduced, but by doing so the anticipated magnitude of movement at such joints may be in the order of 2-3 in. Therefore, special expansion joints will have to be devised which by itself will require some ingenuity. In addition, such joints will represent free edges in the pavement right there, where most likely heavy concentrations of applied prestressing forces are present.

The construction of such pavements will also create problems not experienced before. Irregular pavement sections to be formed at intersections, pavement widenings, etc., together with horizontal and vertical curves will present design and construction details which will not always be solved easily.

Damage to such pavements, especially to their prestressing elements, will be more detrimental and will call for more elaborate repair procedures.

Economy above all will probably be the deciding factor. Prestressed concrete pavements should be considered economical only if the savings in reduced concrete thicknesses will not be offset by the cost of prestressing elements and the cost of related new construction methods. In such comparison, the probable increased life-time of prestressed concrete pavements should also be taken into consideration.

This paper can be read in H.R.B. Bulletin 179 which contains three papers. The others are:

"Review of French and British Procedures in the Design of Prestressed Pavements," by Phillip Melville, dealing with current design practices in those countries; and "Model Studies of Prestressed Rigid Pavements for Airfields," by Paul F. Carlton and Ruth M. Behrmann.

(From "Highways and Bridges and Engineering Works", August 20, 1958.)

DEFINITIONS OF HIGHWAY ENGINEERING TERMS

STONE-SETT PAVING: A paving of rectangular blocks of stone setts laid in regular courses.

STONE-BLOCK PAVING: A form of paving in which stone blocks (usually larger than setts) are laid flat with the vertical faces carefully dressed so as to give fine joints.

FLEXIBLE PAVEMENT DESIGN PRACTICE IN GEORGIA

VARIED SPECIFICATIONS CONFORMING TO STATE-WIDE CONDITIONS

AN interesting comparison for current construction methods of flexible paving is provided in a paper by W. F. Abercrombie, State Highway Materials Engineer, State Highway Department of Georgia, presented at the Thirty-sixth Annual Meeting of the U.S. Highway Research Board.

Because there are so many variables and factors which have not been evaluated but which influence the design and construction of a satisfactory flexible pavement, no rational formula is used for design of such facilities in Georgia. Instead, the several factors and variables are studied individually and then combined to give what are considered to be adequate pavements. The factors studied include the results of surveys of the foundation materials, in both cuts and fills; surveys of existing deposits of materials, both in the vicinity of and commercial materials economically available to the project; the location of the project; and the present and future anticipated traffic.

Although several types of flexible pavements are built, they all have the same basic design in that provisions are made to strengthen the weaker sections of the foundations by placing over these sections stronger and more stable materials in varying depths so as to result in a reasonably uniform strength subgrade throughout the length of a project. Over this subgrade is placed a base of uniform thickness commensurate with the basic factors previously given and the thickness of the surface course chosen.

Foundation Categories

For general construction purposes, foundation materials are divided into six classes, which from description and field observation can usually be recognised and treated accordingly. These are:

I. Friable soils: Sands, low clay content, sand-clays, sand gravels, talus materials, cherty materials and marls.

II. Plastic soils with low volume change: High clay content sand-clays, sand-clay gravels, cherts and silty materials.

III. Highly plastic and highly expansive soils: Clays, fine-grained disintegrated granite rock and clay marls.

IV. Peat, muck and organic soils: Highly organic soils, peat, muck, materials found in marsh and and swamp areas.

V. Laminated materials: Shale, slate partially disintegrated schists.

VI. Rock: Ledge rock, boulders.

The six classes nicely cover the whole range of natural materials encountered in roadbed construction. As previously stated, they can normally be differentiated by field observation and examination; but for judging their value for flexible pavement design, more definite methods of examination are necessary for the first three classifications (see Table I).

Soil surveys are made on each project, with representative samples of the various horizons of the materials encountered being submitted to the laboratory for analyses.

The soil survey consists of drillings made along the centreline of the project, with occasional supplemental soundings to the right and left of the centreline.

On the four-lane and wider projects, a three-line survey is made; two of the lines being at some equal distance each side of the centreline with random additional borings being made to secure definite limits of the soil horizons in the cross-section. As the borings are made, the materials in each horizon are given a field identification or description, together with its thickness and extent along the project. All this information is placed on the identification card accompanying the sample. The tests conducted in the laboratory include gradation, Proctor density, and total volume change from dryness to saturation. From the results of these tests and the field description, the classification of the material is made for the purpose of designing the subgrade for flexible pavements.

In general, Class I corresponds to A-1, A-2 and A-3 of the Bureau of Public Roads Soil Classification System; Class II to A-4 and A-5; Class III to A-6 and A-7.

Each of these classes of materials carries its own depth of subgrade treatment. Class I material conforming to the required subgrade specification requires no treatment; otherwise, a 6-in. treatment Class II-A_1 carries 6 in; II-A_2 9 in.; III-A 12 in.; III-B 18 in.; and III-C 24 in. of treatment.

During grading operation the foundation is undercut to the depth required in accordance with these schedules, and backfilled with selected subgrade treatment materials. This furnishes a reasonably uniform subgrade of at least 6 in. in depth throughout the projects.

Subgrade

The subgrade materials usually consist of the best selected soil materials existing in the vicinity of a project. In the Coastal Region they are usually sands or sand-clays; in the Piedmont Region or the central part of the state they are usually sand-clays, top soils, or sand-clay gravels; and in the northern region or mountainous part they consist of charts, talus, or river terrace deposits of sand-clays and sand-clay gravels.

In all cases, wherever possible from an economical point of view, where the undercutting required is 12 to 24 in. selected borrow of at least a Class II material is taken from the cut excavation and placed on the foundation material so that not more than 6 to 9 in. of the more stable subgrade treatment material is required.

In all instances the top 6 in. of the subgrade or subgrade treatment is chosen so as to have a volume change not in excess of 12 per cent., but satisfying the other requirements of density and gradation, so that a highly stable material is obtained in the top 6 in. of the subgrade. For comparison purposes this usually conforms to about an A-1 material in the Bureau of Public Roads classification.

In many instances materials conforming to the subgrade specifications are not economically available in the vicinity of the project, particularly in the southern sandy regions. In such cases, fines (such as fine silts or friable clay silts) are artificially mixed into the top 6 in. of the sandy material. In other cases the Class II materials, which are the clays, are stabilised with coarse granular materials (sands, stone screenings, etc.), using whichever type may be most economically available.

Studies are made in the vicinity of the projects to determine the type of local material suitable for use in base construction.

In the sandy Coastal Region, bases on farm-to-market roads are usually 6 in. sand-bituminous or sand-limerock. The sands are chosen to have a 50-lb stability by the Florida bearing test and the roadway is required to have a minimum of 12 in. of compacted sand conforming to these specifications. This gives the top 6-in. of sub-grade high stability and the 6 in. base is then stabilised with either the bituminous material or crusher-run limerock.

Through the central part of the state the bases are constructed with local sand-clays and top soils, which normally have a weight per cu. ft. of not less than 120 lb and a volume change of not more than 6 per cent. If the project is anticipated to take heavier traffic than the farm-to-market volume, the top 4 in. of the base is stabilised by scarifying in 1 cu. ft. of crushed aggregate ranging in size from about 1 in. to ¼ in.

In the northern or mountainous section of the state the bases are built of either crushed chert or crushed talus containing a minimum of 60 per cent of coarse aggregate retained on the 10-mesh screen and 100 per cent passing the 1½-in. screen.

On all primary projects the bases are usually constructed of soil-bound macadam, which is a stone base having the voids filled with a local binder either occurring naturally or artificially produced so as to have a required gradation and a volume change of not more than 6 per cent.

All bases, regardless of the type of road, are primed with approximately 0.2 gall. per sq. yd. of a bituminous material after they have been consolidated to 100 per cent Proctor density. They are then maintained under rolling for a period of several days to allow curing to take place. After the primes have cured sufficiently, various surfaces are placed thereon.

Surface Materials

The bituminous surface consists of either the so-called double surface treatment or hot plant mixtures. A double surface treatment is constructed of an application of bituminous material on the prime, covered by a spreading of crushed aggregate of nominal 1-in. to ½-in. size. This is "choked" with a small amount of crushed aggregate (size ½-in. to No. 4) prior to a second application of bituminous material and a surface covering of material ranging from ½-in. to No. 8. This type of surfacing is used on all farm-to-market, secondary and medium-traffic roads.

The heavier-traffic roads carry about 1½ in. of hot plant mix binder and a 1-in. asphaltic concrete surface course. To accommodate increased anticipated traffic volume and loads, these surfaces are thickened to as much as 3 in. of asphaltic concrete base course, 2½ in. of binder, and 1½ in. of asphaltic concrete surface.

Most hot plant mix surface course mixture designs are based on minimums of about 2,000-lb stability (Hubbard-Field), but sometimes the stability minimums are increased for more heavily travelled roads.

Table I

LIMITATIONS OF THE VARIOUS CLASSIFICATIONS OF FOUNDATION SOILS

Foundation Material Group Classification	Foundation Soil Classification	Dry Density, lb/cu. ft.*	Total Vol. Change, per cent
I	I	100 to 165	0 to 15
II	II-A_1	100 to 165	15 to 25
	II-A_2	90 to 100	0 to 25
III	III-A	90 to 165	25 to 50
	III-B	80 to 90	0 +
	III-C	80 —	0 +

* At 2.65 specific gravity.

(From "Highways and Bridges and Engineering Works," August 27, 1958.)

PHILOSOPHY OF SCIENCE

Take from the altars of the past the fire; leave the ashes of outworn custom.

RESULTS OF SKID RESISTANCE TESTS IN WILTSHIRE

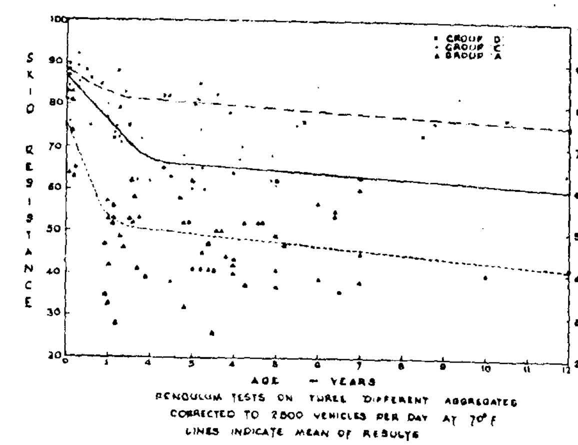
By

J. D. Pocock & R. W. Bell,

County Surveyor's Department.

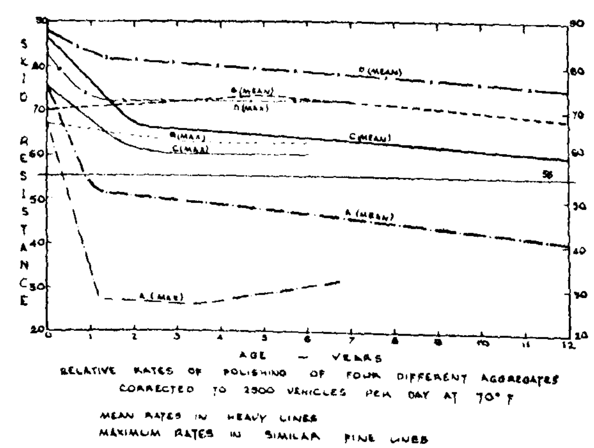
BY-PRODUCTS of the research work done by the Road Research Laboratory are the teaching and propaganda instilled into those who attend the courses held at the Laboratory. There must be many who have come back to their normal jobs determined to pursue some newer aspect of their work.

One such aspect which particularly interested members of the Wiltshire staff was that of skidding, Wiltshire being in the belt of counties across southern England where the percentage of skidding to total accidents was high.



Graph No. 1

Work started with a van fitted to take measurements by the locked wheel method, but the rather cumbersome extras, the variables due to human tolerance and particularly the fact that readings could not be taken where they were most essential, i.e., at bends, all combined to make the system somewhat unsatisfactory.



Graph No. 2

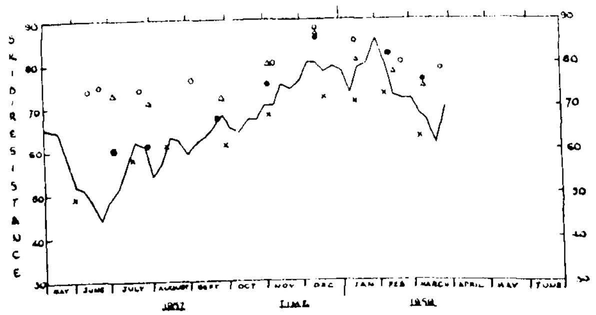
Wiltshire was fortunate in being issued with one of the first batch of R.R.L. pendulums and work on a much wider basis was put in hand immediately. The apparatus itself ha sbeen fully explained elsewhere by the R.R.L. staff. The first job was to test the surfaces at black spots as shown on the accident record map, and the second job was to take series of tests throughout three selected roads, one being a trunk road and the others moderately trafficked A routes.

The standards adopted were :

Below 45	Calling for immediate treatment
45 to 55	to be kept under observation
55 and above	regarded as generally acceptable.

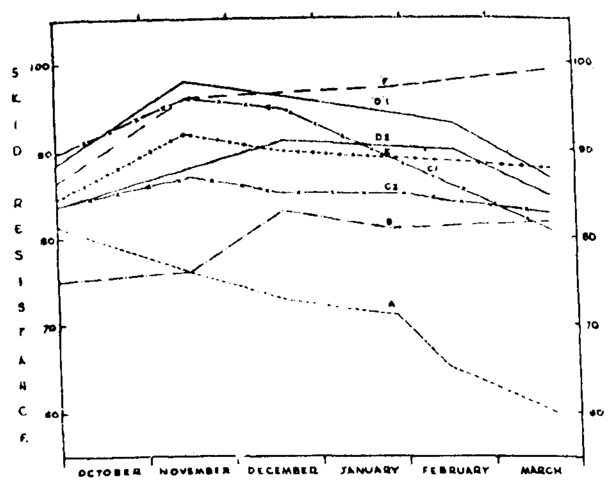
These surveys were well worthwhile practically, but certain apparent facts began to show up and these were further investigated. Sites were selected and tests were repeated at regular intervals, the range covering not only the different aggregates normally used in the county, but also the different surfaces such as bitumen carpets, fine cold asphalts, D.T.S. and surface dressings. Together with this, a test bed of eight aggregates was put down as a surface dressing on a fast level section of a moderately trafficked Class A road. The different aggregates are given identification letters A to F, with C1 and C2, and D1 and D2, denoting stones in the same geological groups.

The first graph was simply a graph where skid resistance was plotted against age, and it gave only limited information, but the following points emerged:



UNCORRECTED SKID RESISTANCES AGAINST AGE COMPARED WITH SOLID LINE COUPLING TEMPERATURE AND HUMIDITY

Graph No. 3



SKID RESISTANCE AGAINST AGE CORRECTED FOR TEMPERATURE TEST SECTION

Graph No. 4

Temperature: Repeated tests at the standard sites showed that for each class of stone the skid resistance went up as the temperature dropped. Skid figures are, therefore, at their lowest in the summer when traffic densities are at their highest and when good resistances are most desirable. It was decided to adopt 70 deg. F. as a standard mean summer temperature and to correct the skid resistance readings for each size or fall in temperature. The correction figures per 10 deg. F. were taken as 2 skid resistance units for stones D and C, 3 for stone B and 4 for stone A.

Traffic density: The heavier the traffic, the greater the rate of polishing, with the exception of certain stones of gritty texture where the aggregate wears away rather than polishes. It was decided that, Wiltshire being a rural county, an average figure of 2,500 vehicles per day for Class A roads was representative.

Weathering: The question of weathering was considered but eventually disregarded, it being assumed that 2,500 vehicles over two years directly equalled 5,000 vehicles over one year.

Age on the graph was then corrected to the 2,500 standard.

The first plot of skid resistance against age was then replotted with temperatures and traffic densities corrected as above. This showed the mean rate of polishing (see Graph No. 1).

A further graph was plotted to show the mean and maximum figures (see Graph No. 2).

Results: The graphs show that the rate of polishing is most rapid in the first two years of the aggregate's life. One can decide which of the aggregates available in the county will be most suitable for each type of road, taking into account traffic densities, gradients and general alignment

The stone suitable for a lightly trafficked straight road would logically be different from that required for a heavily trafficked road or one with appreciable hills or poor alignment. This would be an important economic factor in selecting the correct aggregate. It should also enable one, having obtained the skid figures up to, say, two years, to predict how much longer the surface could safely be permitted to remain untreated, a line being ruled across the graph at the desired skid resistance appropriate to the particular road. The increase in minimum skid resistance for stone A after four years is presumably due to weathering or fracture under traffic. Provision for remedial work can then be made in advance in the annual estimates. The graphs will also indicate whether changes should be made in the choice of aggregate for a road where traffic densities are increasing.

Temperature, Rainfall and Humidity

Rainfall was considered, but its effect could not be taken into account directly, heavy summer rain evaporating so quickly compared with light winter rain which may give wet road conditions for [illegible] time. The answer [illegible] combination of temperature and humidity.

Four diverse types of surface were investigated and graphs plotted for uncorrected skid resistance against age together with a superimposition coupling temperature with humidity. This latter plot was taken empirically after some trials as equalling [illegible] H average relative humidity per week from 1 p.m. daily readings, F = average daily maximum temperature per week in degrees Fahrenheit (see Graph No. 3).

The graph shows the close relationship between these two plots, and particularly clearly how the skid resistance drops as the temperature rises. Its value lies in the fact that one can take a skid test at any season of the year and then read off the figure which can be expected at any other time. Thus a low reading obtained in August calls for no remedial treatment before, say, the following April, but a low reading in April calls for immediate action.

Tyre Temperatures. An interesting point was observed in the laboratory when testing the pendulum on a small concrete slab kept as a standard. With cold water a result of 60 might be obtained, but if this was followed immediately with hot water the figure might drop to about 45.

This raised the question of tyre temperatures and enquiries were made from one of the tyre makers. The information given was that on a dry day the surface tread of a tyre was likely to be 10-20 deg. F. above the road temperature, the temperature inside the wall would be much higher still, and the surface tread on a wet day would have about the same temperature as the road, all these referring to a vehicle in motion.

This suggests that care might be necessary in using the locked wheel method of skid testing; the results may possibly depend on whether the van was driven to the site over dry or wet roads, and whether the tread temperature rises as the heat comes out from the tyre walls when the vehicle is standing.

Test Section. The last graph shows results obtained from the surface dressing test bed referred to earlier (see Graph No. 4).

This is corrected for temperature, but not for traffic density, as the latter remains constant. At the first test the range in results, excluding one aggregate, was only nine units, the variation presumably being due to the difference in the angularity of the chipping samples. After six months, however, the range had increased to 40 and the aggregates in the same geological groups had become very similar. It was clear that one type of stone was showing an appreciable degree of polish, and another type, while giving high skid resistance figures, was wearing.

From "The Surveyor and Municipal and County Engineer", August 30, 1958.

HERE AND THERE

1. R. R. L. PAVEMENT DESIGN EXPERIMENTS AT ALCONBURY HILL

● MEMBERS of the Permanent International Association of Road Congresses visited the section of the Great North Road between Alconbury and Water Newton on Thursday, September 4, in order to inspect the experimental lengths of both flexible and rigid pavements being investigated by the Road Research Laboratory and also the new construction now in progress further north.

It may be recalled that the subsoil at the site consists of boulder clay overlying heavier Oxford clay and that the variables introduced into the experiments were, for flexible construction, different thicknesses of a sand sub-base, different types and thicknesses of base and different types and thicknesses of surfacing while for rigid construction they were different weights of reinforcement, two minimum compressive strengths of the concrete, and different types and thicknesses of base. In addition the thickness of the concrete itself varied between 5 and 11 in.

The traffic loading on this part of the Great North Road includes some four thousand heavy commercial vehicles per day and the Road Research Laboratory has installed automatic weight recorders which incidentally, indicate that the statutory limit for axle loading is frequently exceeded.

Distortions of the flexible pavements are measured by accurate levelling from reference points.

Some Results of the Tests

Officers of the Road Research Laboratory outlined the scope of the experiments and mentioned the results which have so far been obtained. One interesting, and rather surprising, deduction is that soil/cement, under the test conditions, proved an inferior base, but it was pointed out that the mix was formed from a poorly graded fine sand which could not be regarded as an ideal material. Uncoated stone was found to be superior to stabilised soil and tar-coated stone was superior to uncoated material as a base course.

Excessive deformation, occurred with asphaltic two-course work laid direct on the sub-base and with surface coats less than three inches thick on broken stone and soil/cement bases.

Failure occurred on a concrete section which had the following specification: minimum crushing strength: 4,000 lb per sq. in.; weight of reinforcement: 10 lb per sq. yd., thickness of slab: 5 in.; type of base: granular; thickness of base: 3 in. No dowel bars were used on this section.

This was obviously a sub-standard specification for a road of this type, but in order to arrive at minimum requirements for the existing site conditions it was necessary to under-design as well as over-design.

The transverse joints on the concrete sections were cut, after presumably adequate hardening, by a grinding wheel machine and, in some cases, spalling was noticeable at some of the joints so formed.

Further Work in Progress

The northward extension of this Great North Road improvement scheme is making good progress and on the occasion of the P.I.A.R.C. visit R. M. Douglas were putting down two-coat asphalt with a Blaw-Knox spreader and finisher, the undercoat containing a gravel aggregate and the wearing surface, 1½ in. thick, a granite aggregate. The base consisted of lean-mix concrete, 6 in. thick after compaction, overlying a sub-base of limestone brash, 10½ in. thick, compacted dry.

It would appear that the Huntingdonshire section of this famous old road is going to be a magnificent stretch of highway, of which Mr. Longstaff, the County Surveyor, may well be proud.

(*From "Highways and Bridges and Engineering Works", September 17, 1958.*)

2. ITALY: HIGHWAY OF THE SUN

● CONSTRUCTION on the Highway of the Sun between Naples and Milan is ahead of schedule and the motorway will almost certainly be open before its estimated completion date at the end of 1963.

The first two sections, Milan to Florence and Capua to Naples, 174 miles and 25 miles long respectively, should be finished this autumn. They were originally scheduled for completion at the end of 1959. When completed, the highway will be 457 miles long and will cost some 99 million pounds. It will reduce driving distance between Naples and Milan from 527 to 475 miles.

Starting at Milan, the road will run south and connect Bologna, Rome, Capua and Naples. It will by-pass Rome by means of a 50-mile ring road.

The Highway of the Sun will be a dual highway throughout its entire length with a two-lane, 25 ft carriageway in each direction. Except where the road passes through tunnels, it will have a ten-foot median and ten-foot shoulders, giving a total road width of 80 ft.

In mountainous sections of the country the road will be built on two levels, giving both increased safety and opportunity for sight-seeing. Maximum gradient for mountain sections is 3.75 per cent. Outside the mountain areas the maximum is usually two per cent. Minimum radius of curves is 2,300 feet on the section between Milan and Bologna, 800 feet between Bologna and Florence and 1,300 feet on the other sections.

Design speeds range from 100 miles an hour between Milan and Bologna and Capua-Naples, 80 miles an hour on the Florence-Rome and Rome-Capua sections, to 60 miles an hour on the section between Bologna and Florence.

Along the highway's length will be 81 tunnels totalling 39,360 feet. The two longest will be the Citerna Pass tunnel 2,066 feet long and the Rogheto tunnel 1,968 feet long. Seven other tunnels will have a length of more than 1,300 feet. About 60 access points will be provided along the highway.

During recent decades the transport picture in Italy has materially altered. In 1915, 70 per cent of all goods transported on land went by rail; in 1957 more than 70 per cent were transported by road.

(*From: "British Road Federation Bulletin," No. 259, September, 1958.*)

3. LISLE-SUR-TARN BRIDGE (FRANCE)

● THIS structure crosses the Tarn between Lisle-sur-Tarn and Montans. It carries a road 6.00 m. wide and two footways each 1.80 m. wide. It is an arch with a span of 94.00 m. the central portion carrying the road being extended by two beams tailed into the arch and resting only on the abutments at points 101.52 m apart.

This structure replaces a suspension bridge, the piers of which act as the sup-

Pont de Lisle-sur-Tarn (France)

ports for the deck beams, while the access viaducts have been retained after widening by means of a slab extending over the entire width and projecting as corbels on either side.

The foundations of the towers were converted to serve as abutments for the arch which is supported by means of joints of iron-bonded concrete.

The arch is constituted, in the central part, by two box-girders connected at the top by the slab under the roadway. The springs of the arch consist of two U, open at the top, without cross-bracing.

The structure was built on a cocked centre made of wood nailed to two hinges.

(*From "Bulletin No. 17, 15th August, 1958, IABSE.*")

4. TRAFFIC PLANNING—FOR WHAT ?

● NEWLY returned from their visit to West Berlin and Vienna, 22 members of the all-party roads study group in the House of Commons were this week loud in their praise of our Continental friends for making up their minds what needed doing with their city traffic problems and then going ahead with the construction of under-passes at overloaded intersections and throughways to accelerate the first or last stages of travel out of or into the inner zone. The visit was organised by the Roads Campaign Council. Mr. Ernest Davis, leader of the Socialist party of visitors, summed up the lesson for us in a few words: we needed a fresh assessment of our traffic needs and an overall plan for meeting them. The best way to achieve these aims was to appoint an expert working party and not to scorn the use of overseas traffic engineers, a breed which so far we have taken no pains to develop. But much road traffic planning, especially in cities, is planning for the unknown. Traffic has an unfortunate habit of outstripping the most generous estimates of its growth and there is no need to ask who is the principal offender. Is it not saner to cultivate a public opinion which acknowledges the merits of public transport as a mass provider? The London Transport survey of street traffic during the bus strike rams home facts already well-established about efficient use of streets whether they be broad or narrow-two-thirds more passenger vehicles on the streets, but 40 per cent fewer people riding in them. It really makes little difference

whether this was wholly the consequence of the strike or partly the outcome of a steady increase in car usage in the Metropolis; the lesson is the same. So is the effect on average speeds. It was only when the first tide of extra cars turned that speeds began to rise above the normal with buses on the street. Provision of off-street parking is no more than a palliative if it releases an even greater flood on to the streets during the crucial peak hours.

(*From "Modern Transport", July 19, 1958*).

5. THE RESULTS AND SOURCES OF INVENTION

● IN a report of the Organisation for European Economic Co-operation the authors state that they saw laboratories that had been created only because the directors of a company "had been caught in a research boom and had established laboratories without any clear idea of what the laboratories could do."

The discovery of new ideas does not depend only upon the number of people employed in a laboratory. The powers of discovery and invention are given to few and, although these men may need trained assistants, it is too often thought that if an expensive laboratory be filled with science graduates something useful is bound to be discovered. The authors of this book ask whether the concentration of so many research workers in large laboratories is an unmixed blessing in view of the fact that so many inventions have been prodnced by people who are not organised in this way: "Attempts to make research systematic do not guarantee results. The industrial laboratory does not appear to be a particularly favourable environment for invention." Sir Alexander Fleming, the discoverer of pencillin, has expressed the view that the employment of a team to undertake research was the worst possible way of starting, because "although a team will do some work it is not likely to initiate anything...Organisation, attendance at committees, paper work, regular hours spent in a laboratory, are liable to quench orginality." Certainly the large industrial research organizations have not been responsible for invention and discovery to anything like the extent that could be expected in relation to the numbers of people they employ and their cost.

Many of the most useful ideas have come from men unattached to an organisation and from the freer atmosphere of the universities. It may well be that much of the work done in industrial laboratories could be better done at the universities to the advantage of the nation and of the students, many of whom to-day are so busy filling their heads with what Dr. Glover called "loads of learned lumber" that they have no time to think; unfortunately too many graduates, in the words of Montaigne, "Know the theory of all things, but you must seek who shall put it into practice."

(*From "Concrete and Constructional Engineering," July, 1958.*)

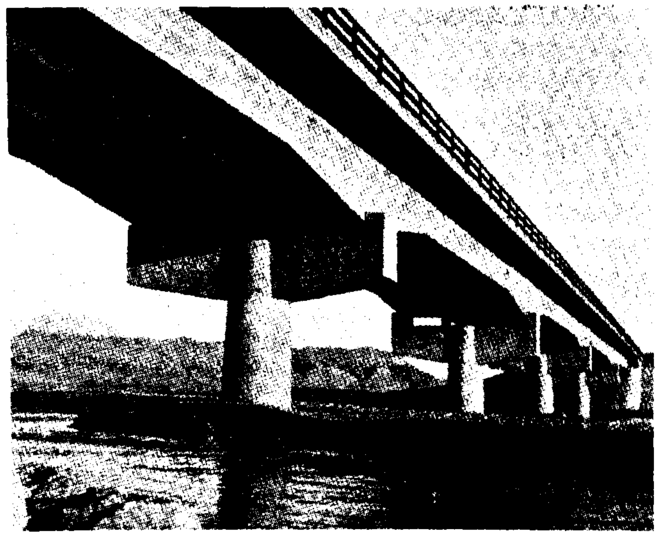
6. GAZIPASA BRIDGE (TURKEY)

● THIS bridge is one of the engineering structures on the tourist coastal road between Mersin and Antalya. It is situated about 1 km. from the sea.

Statically, the bridge consists of a Gerber girder carried over five spans (21.00+3×25.00+21.00).

The total width of the bridge is 9.40 m. and comprises an 8.00-m wide carriageway and footways on each side 0.70 m. wide.

Owing to the obliquity of the bridge (about 40°) the piers were designed with a circular section as small as possible.



Pont de Gazipasa (Turquite)

Calculation gave a reinforced-concrete section of 2 m. in diameter.

The bridge was calculated to carry heavy lorry traffic (H 20—S 16).

Length of bridge ...	117.00 m
Approach spans ...	21.00 m
Centre spans ...	25.00 m
Width of carriageway ...	8.00 m
Width of each footway ...	0.70 m
Diameter of piers ...	2.00 m
Weight of cement used ...	640 T
Weight of steel used ...	139 T

Construction was completed in December, 1956.

(*From: No. 17, August 15, 1958, IABSE*")

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7. SMALL HIGHWAY IMPROVEMENTS THAT REDUCE ACCIDENTS TO NIL

More Evidence also of Motorway Safety

● NOWADAYS it is the popular custom among police and magistrates to blame vehicle drivers in highway accidents. Any driver who was travelling at more than 40 mph will certainly be labelled automatically a road-hog. More often than not the errors of judgment are caused by the road itself which is (a) slippery under certain weather conditions, (b) has bad sight lines, (c) is too narrow for comfortabie passing, (d) badly sign-posted, (e) has bends altogether too sharp, (f) has no footway, and so on.

Consistent and spectacular reductions in accident rates have been achieved by small improvements as the late Col. Bennet showed in Oxfordshire and Buckinghamshire, and as many other country surveyors have proved.

Two interesting recent examples of small highway improvements which have reduced accidents to nil are reported by

the Division of Highways, California Dept. of Public Works, U.S.A.

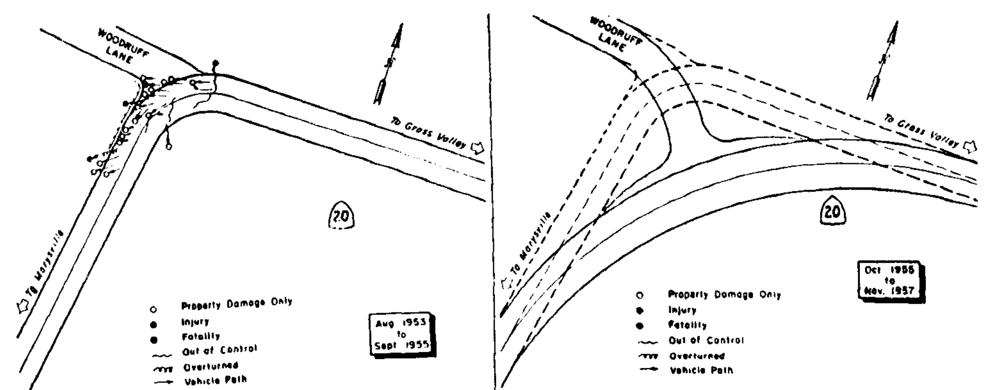
One of these trouble spots, for example, was a sharp curve on State Sign Route 20 at Woodruff Lane in Yuba County. A 25-month record of accidents at this location revealed a total of 20 accidents—16 property damage and four injury. Most of these mishaps resulted from vehicles failing to negotiate the curve. A correction might consist of more warning signs or an easier curve. In this case, it was possible to construct an easier curve.

As a result, not one accident was reported at this location in the 25 months following the improvement.

Value of the Motorway

Although divided highways have greatly reduced the danger of cross-median accidents, they are a direct attack on only one of the accident-producing traffic conflicts, says the State Highways Division. To show an even better safety benefit, a highway must reduce all types of these conflicts.

This is successfully accomplished by modern, properly designed freeways. That freeways are effective can be seen by the fact that the freeway accident rate is about one-half the rate for conventional highways, and the fatality rate is about one-third the conventional highway figure.



U.S. State Sign Route 20 before and after improvement

Another of these problem locations was on Sign Route 29 at the intersection with Rio Del Mar in Napa County. Here reports listed a total of six accidents in a year—five property damage and one injury. According to collision diagrams, vehicles that stopped to make left turns (right turns in U.K.) were involved. To remedy the situation, the dividing strip opening was widened a left-turn lane constructed, taken out of the centre medium, and signs installed.

In the year following the improvement not one accident was reported.

These examples show the benefit derived from the study of specific accident locations. Such corrections contribute very substantially to traffic safety.

The superiority of freeways over conventional highways is illustrated by the effect of construction of a 10.5 mile freeway between Sacramento and Roseville.

In a 22-month period immediately preceding the opening of the freeway, there were 418 accidents. Only 70 accidents were reported during an equal period after the freeway was opened, even though the traffic volume increased from 17,600 to 21,600 vehicles a day.

In addition, the combined volume of traffic on the old road and the freeway was 60 per cent greater than the volume prior to the opening of the freeway. Even with this increase, the combined accident total on the old road and the freeway in the "after" period was about half the number that occurred on the old road before the freeway was completed.

This is another striking example of added traffic safety through engineering.

California now has a full 500 miles of freeways in operation with another 209 miles under construction. In addition, most of the State's 916 miles of expressways, which have some intersections at grade, are designed for future conversion to freeway status. Also constructed in recent years have been a number of miles of "two-lane freeways", planned access highway with two lanes initially and with design and right-of-way provisions included for an ultimate multi-lane freeway.

(From "Highways and Bridges and Engineering Works", August 13, 1958.)

8. RAILWAY OVERBRIDGE AT ANDELFINGEN, SWITZERLAND

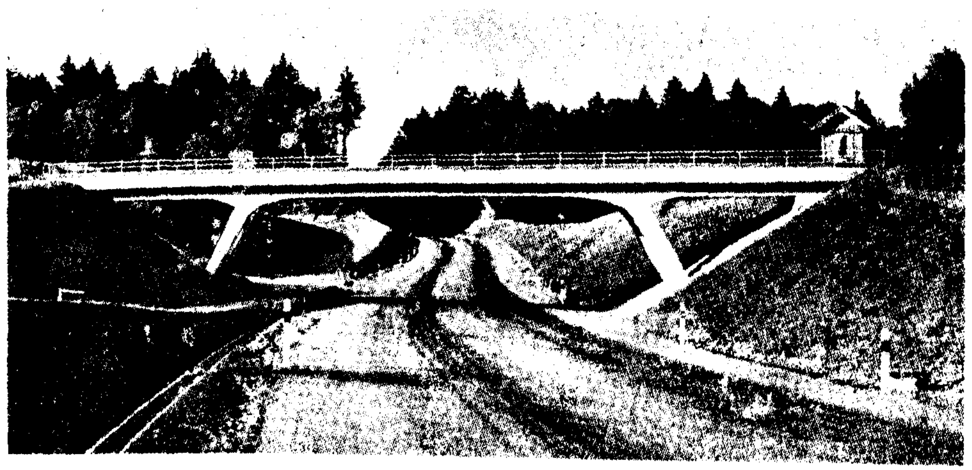


Fig. 1.—Passage superieur des C.F.F., a Stigli pres d'Andelfingen.

● THIS bridge consists of a prestressed concrete frame bridge with triangular piers corresponding to the standard types of the Federal Inspectorate. The inclined external prestressed concrete supports merge completely into the sloping embankment. The visibility on the road is excellent and the inclination of the supports internally increases the psychological width of the road. The load tests on the bridge have proved that these types of prestressed bridges behave with respect to static and dynamic loads exactly in the same way as a classical reinforced concrete bridge.

(From "Bulletin Technique De La Suisse Romande", 26th April, 1958.)

SHORT CUT

Two domestic employees were talking shop on their day off.

"My lady", complained one, "always wants me to warm the plates for our dinner guests".

"Mine, too", said the other, "but it's too much work, so I just warm hers and she doesn't know the difference".

CURRENT LITERATURE

ABSTRACTS

TESTS OF ENERGY-ABSORBING TRAFFIC BARRIERS; Bulletin No. 185, Highway Research Board of the National Academy of Sciences, National Research Council, 2101, Constitution, Washington, D. C.

THIS bulletin contains two papers sponsored by the Committee on Guardrails and Guide Posts, as presented at the 36th Annual Meeting of the Highway Research Board.

The first, by Russell R. Skelton, describes crash barriers tests on multiflora rose hedges as carried out by the author for the Bureau of Public Roads. The test results indicate that many serious automobile accidents could be prevented in the future if hedges of this variety were planted now in the median strips of divided highways.

The second, by Norman L. Padersen, John H. Mathewson, and Derwyn M. Severy, describes the development and testing of an energy-absorbing barrier for highways. The barrier consists of a series of corrugated concrete slabs extending about 2 ft above the road surface and arranged in a row in the centre of the median strip. The tests indicate the feasibility of providing a collapsible barrier to govern the deceleration of out-of-control vehicles to prevent injury to the vehicle occupants and prevent head-on collison.

RAINSTORMS AND FLOOD RUN-OFF IN SOUTH AUSTRALIA; J. S. Gerny, M. E., The Journal of the Institution of Engineers, Australia, Vol. 30, No. 7-8, July-Aug., 1958.

AN investigation of rainstorm and flood intensities in South Australia is described, and the conclusions are presented in a form derived during the investigation. A relation between the derived rainstorm and flood formula is deduced and an empirical method is obtained for the estimation of probable floods from rainstorm data and some knowledge of the catchment area. The empiricisms are based upon general physical features of the catchment area and are shown to be applicable where the records show that a reservoir has caused a significant change in flood characteristics. The derived data are tabulated and sufficient information is presented diagrammatically to permit a rapid estimate to be made of probable rainstorms and floods for the greater part of the State.

URBAN ROADS AND STREETS; R. J. Smeed, Road Research Laboratory, Department of Scientific and Industrial Research, United Kingdom, International Road Safety and Traffic Review, Vol. VI, No. 3, Summer, 1958.

THIRTY-four papers were presented to the Study Weeks on the subject of Urban Roads. In addition, four general reports and the discussion on them that took place at the Hague, Burgenstock and Stresa have all been published. The Author has attempted to give a summary of this large mass of information in a report of limited size. Nearly all of the information has been classified into the following subjects:

(a) Capacity or roads
(b) Capacity of intersections
(c) Traffic signals
(d) Pedestrian traffic
(e) Effect of regulations.

The information presented should be of considerable assistance to the traffic engineer in the course of his work. Research on many of the important problems is still urgently required.

DISCHARGE FROM HEAVY RAINFALL: Ernest Edward Dawson, B.A., A. M. I. C. E., Proceedings of the Institution of Civil Engineers, Volume 10, August, 1958.

A simplified catchment is used to obtain the hydrograph resulting from rainfall of an intensity varying in time and area; in this simplified catchment the value of C/s in Chezy's formula is assumed as constant and later shown to be so for the Damodar River in India: the hydrograph for intensity uniform in time and area is obtained by mathematics and a graphical method is used for other variations of intensity.

The actual hydrographs for five storms on the Damodar catchment are reproduced from the known rainfall by the graphical method, and in the process "C/s = constant" is confirmed and its value obtained.

By these means a prediction is made of the maximum discharge likely to occur in this catchment.

(Continued from page 37)

17. **Blast Furnace Slag and Iron Works Slags in Road Construction New Series No. 9 (1952);** Dr. Hans Lues Dr. Wilhelm Lorenz, Kirschbaum Verlag, Bielefeld (Germany).

18. **Bibliography on Soil Mechanics New Series No. Bound 10-1953;** Dr. Lug Habil H. Peterman, Kirschbaum Verlag, Bielefeld (Germany).

19. **Determination of the Capacity of Road Traffic Junction not Controlled by Light Signals New Series No. 11;** Dr. Lug Walter Grabe, Kirschbaum Verlag, Bielefeld (Germany).

20. **The Design of Signal Controlled Traffic Junction Points New Series No. 12;** Dr. Lug. Habil Max-Erich Feuchtinge Kirschbaum Verlag, Bielefeld (Germany).

WORDS OF WISDOM

Scientific men talk nonsense when they observe differences between science and practice, and so-called practical men act foolishly when they ignore science, and assert that an ounce of practice is worth a ton of theory. Practice based on true science means immediate success and economy; practice based on rule of thumb means error, delay and excess of estimates. The engineer cannot neglect the laws of nature, any more than the scientific man can ignore the success of practice.

—SIR WILLIAM HENARY PREECE.

SELECTED RECENT LITERATURE IN ENGINEERING JOURNALS

X. BRIDGES AND OTHER STRUCTURES

1. **Notes on Materials for Prestressed Concrete;** FAUL W. ABLES, *Concrete and Constructional Engineering, Vol. 41, No. 9,* September 1957, pp. 297-310.

2. **Ultimate-Strength Design of Reinforced Concrete Slabs;** G. W. GERRIFFIN, *Civil Engineering, Vol 27, No. 8,* August 1957, pp. 62-63.

3. **Prestressing Strengthens Wrought Iron Bridge;** P. S. A. BERRIDGE, *Civil Engineering, Vol. 27, No. 8,* August 1957, pp. 38-39.

4. **The Complete and Exact Calculation of Circular Cylindrical Shells of Constant Thickness;** JEAN HARRAS, *Travaux, Vol. 41, No. 276,* October 1957, pp. 523-527 (in French).

5. **Prestressed Bridge - A 120 Ft Span Erected Daily;** *Engineering News Record, Vol. 159, No. 14,* October 3, 1957, pp. 40-46.

6. **A New Centering System for Bridges;** *Civil Engineering and Public Works Review, Vol. 52, No. 617,* November 1957, pp. 1255-1257.

7. **Design of Cross Connected Grillage Beams;** JEAN COURBON AND ROGER LACROIX, *Annales des Ponts et Chaussees, Vol. 127, No. 4,* July-August 1957, pp. 391-443, Part 4 (in French).

8. **The Use of Welding in the Construction of the New Road Bridge over Save at Belgrade;** M. M. RADOGKOVIC AND M. WIDMAN, *Annales de L'Institute Technique du Batimente des Travaux Publics, Vol. 200, No. 117,* September 1957, pp. 863-876 (in French).

9. **Reinforced Holes in Plates-Total Weight Reduced by Varying Thickness of Reinforcement;** RAYMOND HICKS, *Engineering Vol. 184, No. 4773,* August 30, 1957, pp. 280-281.

10. **Masonry Arch Bridges: A Study;** CYRIL STAPLEY CHETTOL AND WILLIAM HENDERSON; *Proceedings of the Institution of Civil Engineers, Vol. 7,* Session 1956-57, August 1957, Structural Paper No. 53, pp 723-774.

11. **Recent Highway Bridgeworks in Glamorgan, with Particular Reference to Prestressed Concrete Design and Construction;** EDWARD WILLIAM DAVIES, *Proceedings of the Institution of Civil Engineers, Vol. 7,* Session 1956-1957, August 1957, Paper No. 6234, pp. 897-900.

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BUDGETS AND ADMINISTRATION REPORTS

JAMMU AND KASHMIR (CIVIL WORKS) BUDGET FOR THE YEAR 1958—59

The following extracts relating to civil works budget have been taken from the Jammu and Kashmir Budget for the year 1958-59:—

Revenue (civil works)

Heads	(In lakhs of Rupees)		
	Acutuals 1956-57	Revised Estimate 1957-58	Budget Estimate 1958-59
Rents	4.21	2.66	4.04
Ferry receipts	0.54	—	—
Road Toll	32.78	46.00	75.00
Recoveries of expenditure	0.01	—	—
Transfer from Central Road Fund	—	4.00	—
Miscellaneous	4.88	0.47	0.48
Govt. of India grants for Plan schemes	—	—	3.50
Deduct—refunds	−0.05	−0.04	−0.04
Total	42.37	53.09	82.98
Expenditure (civil works)			
Buildings			
Original works	@	17.15	24.01
Repairs	3.00	*	*
Communications			
Original works (Bridges)	@	0.60	1.26
Repairs	10.20	*	*
Miscellaneous			
Original works	@	16.94	21.00
Repairs	0.04	*	*
Establishment	7.66	8.54	9.22
Tools and Plants charges	3.49	—	—
Suspense	5.58	—	—
Works financed from Central Road Fund	—	4.00	—
Development expenditure	19.75	—	—
Total	65.85	80.23	88.49

* Expenditure on repairs for Buildings, Communication and Miscellaneous is Rs 33.00 lakhs for each of the years 1957-58 and 195859. Break-up not available.

@ Expenditure on buildings, communications and miscellaneous in the year 1956-57 is Rs 16.13 lakhs. Break-up not available.

Capital account of civil works outside the revenue account

Heads	(In lakhs of Rupees)		
	Actuals 1956-57	Revised Estimate 1957-58	Budget Estimate 1958-59
Communications	120.51	84.06	64.90
Buildings	—	35.08	40.32
Tourism	—	9.18	7.83
Tools and Plant	—	3.50	1.60
Establishment	—	6.00	5.00
Deduct Govt. of India share on centrally sponsored schemes	—	—	−5.52
Total	120.51	137.82	114.13
Revenue from Roads			
Receipts under Motor Vehicles Act	1.29	1.50	1.50
Receipts under Motor Vehicles Taxation Act, 1957	—	2.38	5.50
Motor Spirits Taxation of sales	8.32	9.00	12.50
Sales Tax on Motor vehicles	—	0.25	3.00
Total	9.61	13.13	22.50

A BRIEF REVIEW OF JAMMU AND KASHMIR BUDGET

THE total revenue receipts of Jammu and Kashmir Government for the year 1957-58 (revised estimate) is Rs 825.56 lakhs and the total revenue expenditure is Rs 753.40 lakhs, which show a surplus of Rs 72.16 lakhs. The estimated revenue and expenditure for the current year are Rs 1046.90 lakhs and Rs 760.41 lakhs respectively, indicating a surplus of Rs 286.49 lakhs.

Revenue expenditure on civil works for the budget for the year under review i.e. 1958-59 is Rs 88.49 lakhs which forms 8.5 per cent of the total revenue of the State. The corresponding ratio for the revised estimate for the previous year was 9.7 per cent.

The total expenditure on civil works outside the revenue account for the year under review i.e., 1958-59 is Rs 114.13 lakhs, while the expenditure on communications from the same account is Rs 64.90 lakhs only.

LIST OF APPROVED WORKS ON NATIONAL HIGHWAYS

Sr. No.	Job No.	Name of Work.	Amount (Rs in lakhs)
1	2	3	4
		ASSAM	
1.	1927 AS 37	Remetalling and surfacing certain miles of Assam Trunk Road East—National Highway No. 37 in Nowgong Division.	3.95
		JAMMU & KASHMIR	
2.	1926 JK 1-A	Providing temporary lighting in the Western tube of Jawahar Tunnel in Jammu & Kashmir State and running of maintenance of Power House during 1958-59.	0.41
		MYSORE	
3.	1925 MY 4	Improvements to sharp bends near Kolar—Amanikere-Madras-Cannanore road National Highway No. 4.	1.05
		ORISSA	
4.	1923 RS 6	Construction of a bridge over Tangna Nallah at mile 135 of National Highway No. 6.	1.49
		PUNJAB	
5.	1924 PB 1	Providing Electrical Installation in the Public Works Department Rest House at Shahabad in Karnal District.	0.06

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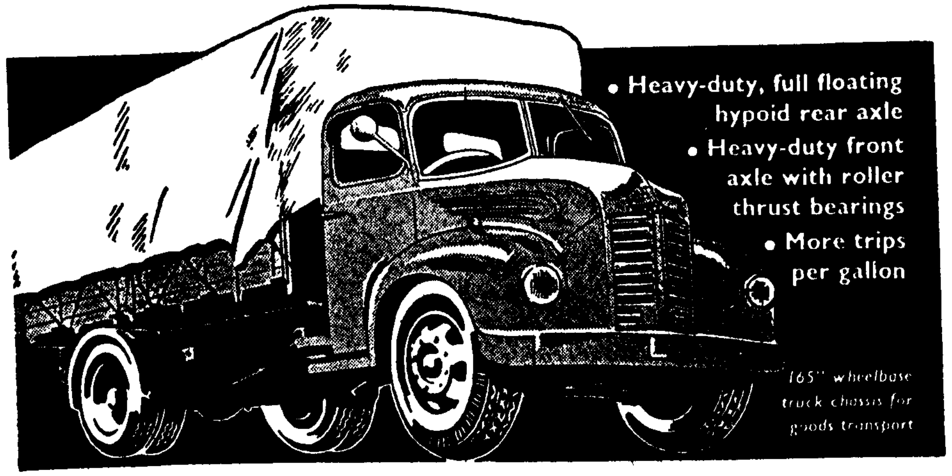

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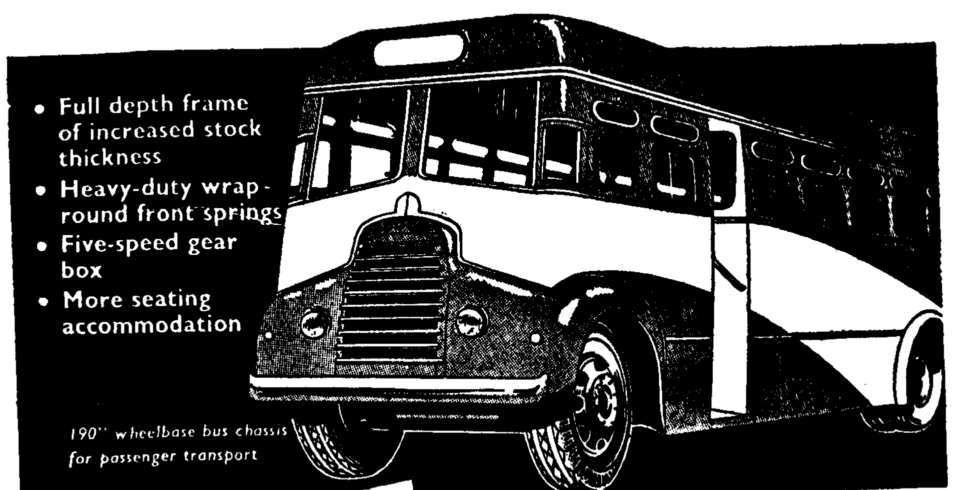

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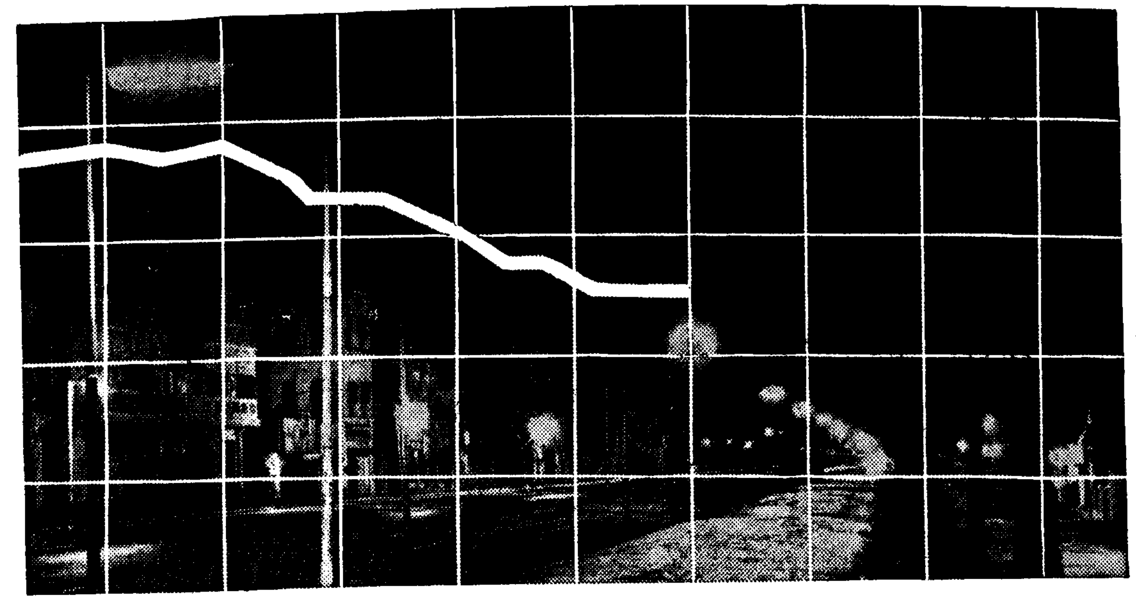

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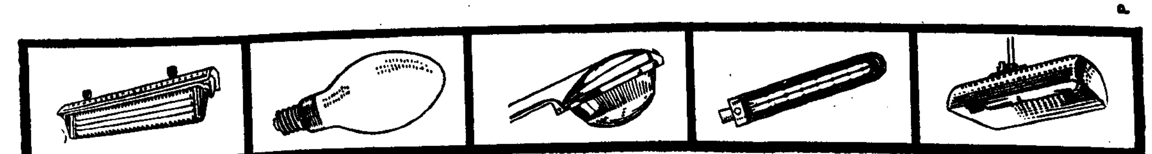

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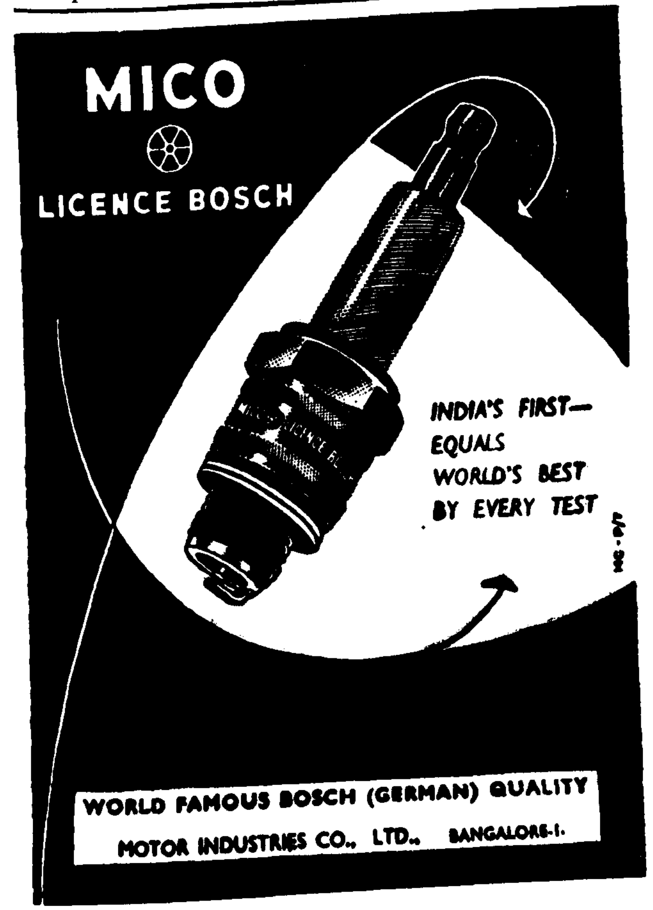

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