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Monthly Review

July 1958 No. 135

TRANSPORT-COMMUNICATIONS

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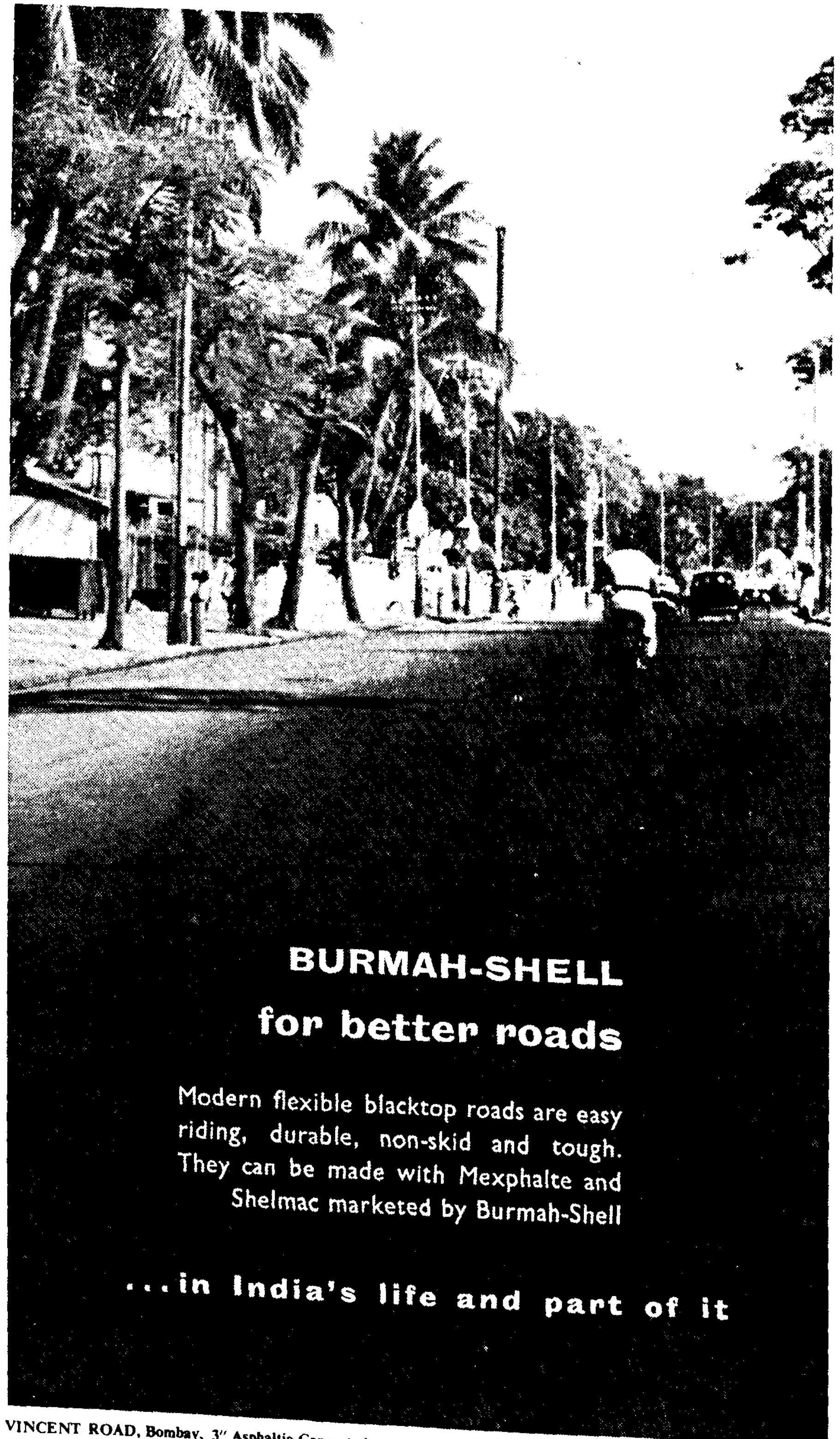
INDIAN ROADS CONGRESS, NEW DELHI.



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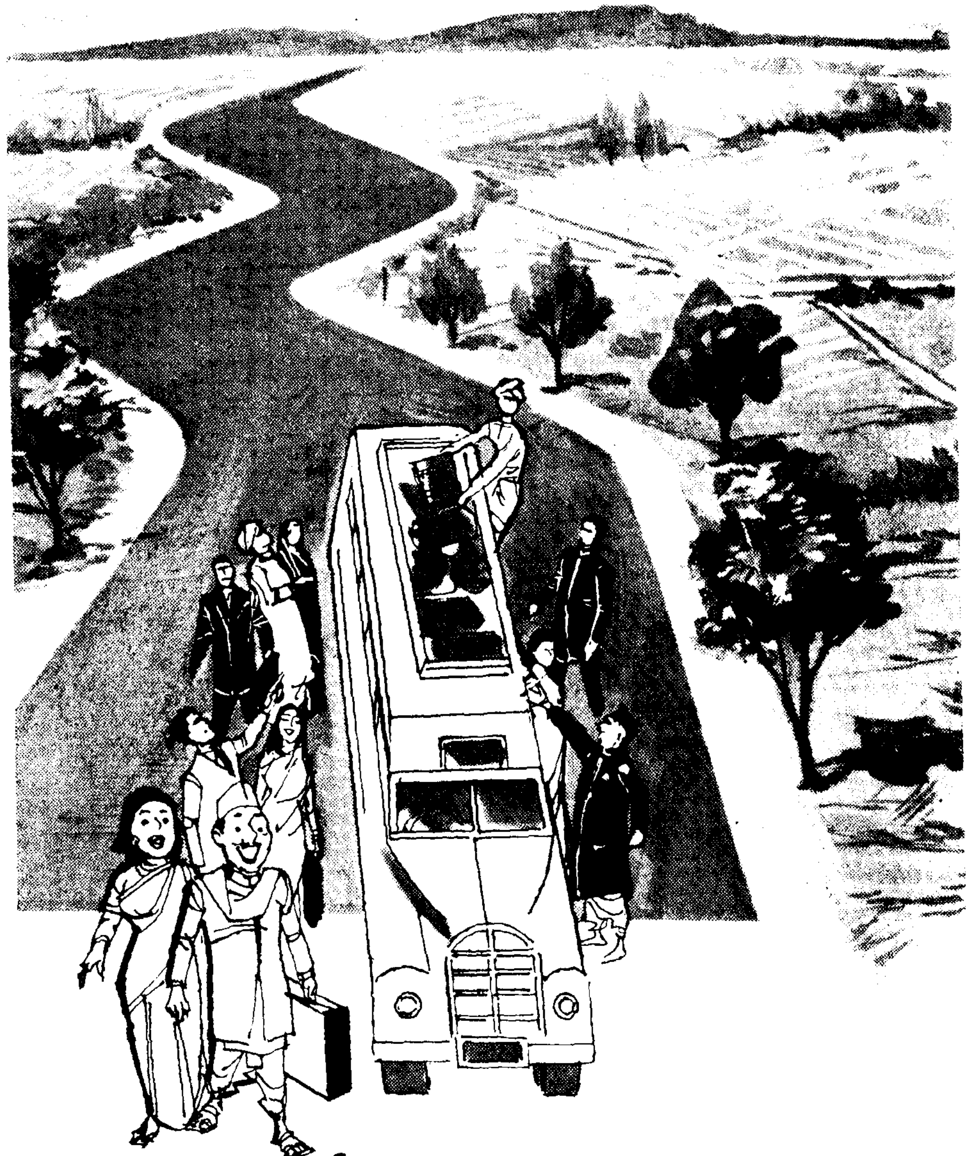

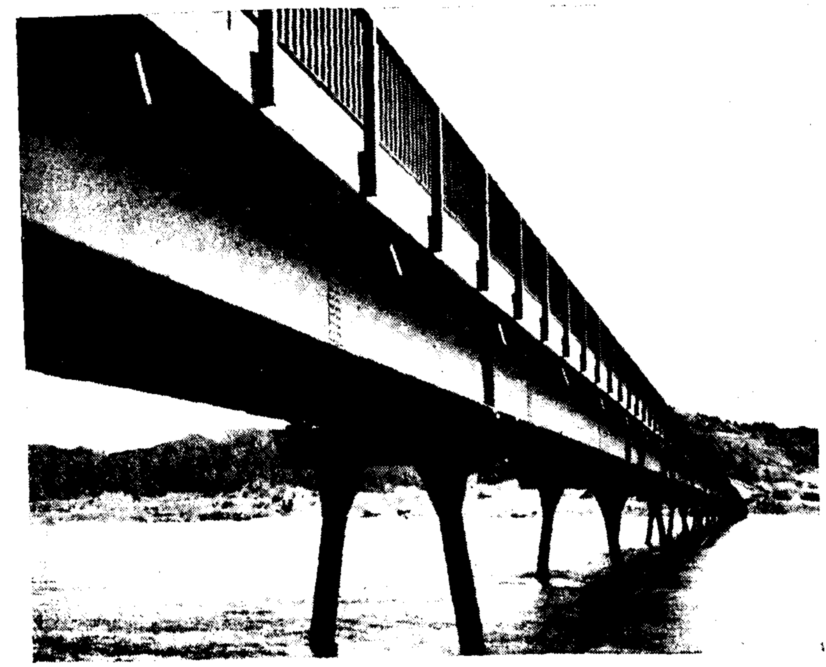

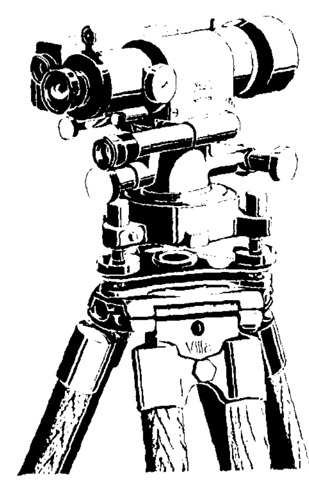

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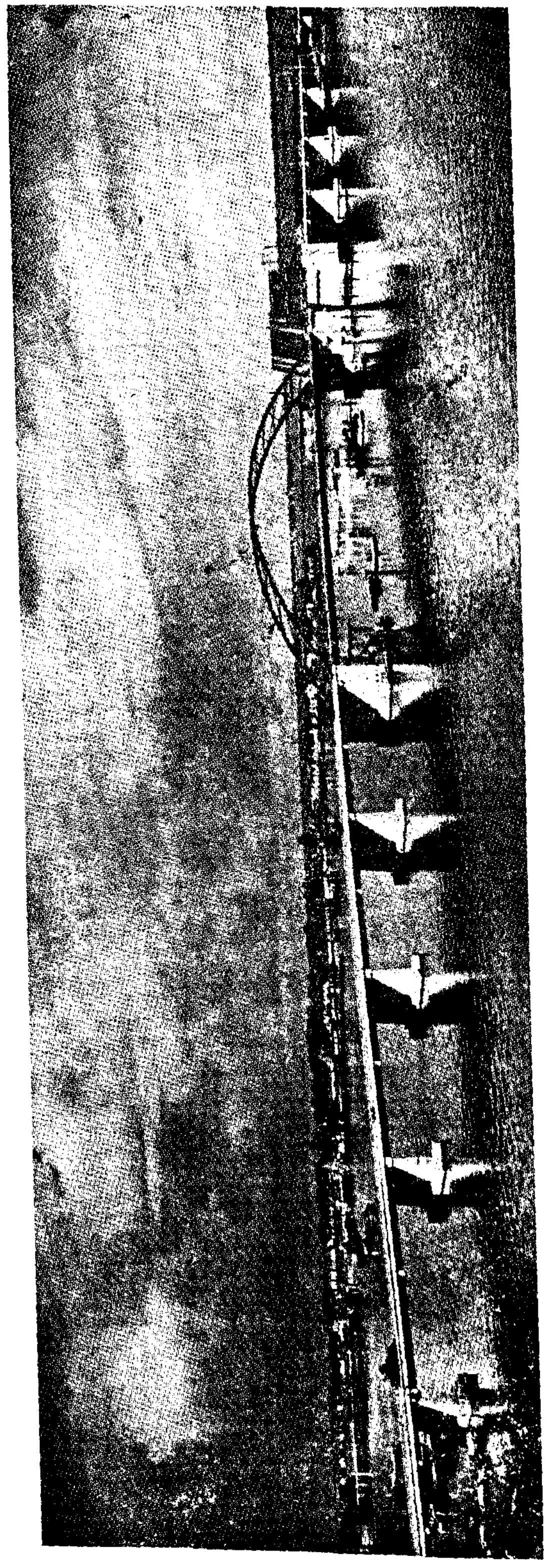


VIEW OF THE BRIDGE OVER THE IJ RIVER AT THE SCHELLING WOUDE.

TRANSPORT-COMMUNICATIONS
MONTHLY REVIEW

A REVIEW OF
ROAD ENGINEERING, DEVELOPMENT & TRANSPORT

JULY 1958 23

ROAD CONSTRUCTION IN BELGIUM

AN ASSESSMENT OF ITS BENEFITS

By

EDMOND GOELEN

Engineer, Bridges and Roads, Belgian Ministry of Public Works *

NEED for extensive road construction exists in Belgium as it does in most countries, because the existing highway system was not designed for the large volumes of traffic which have developed with the motor vehicle. This need, even though it has always been recognised, never before resulted in as comprehensive a building effort as the present one. Belgium's social and economic needs and her geographic situation in the centre of the more important industrial and business places in Europe, make her largely dependent upon easy, fast and low-cost road transport.

Belgium has become so aware of the disadvantages suffered from roads which are inadequate for the traffic desiring to use them that she has recently resolved to remedy the situation. The road problem is made up, on the one hand, of the traffic volume and its future development and of the volume of accidents and their location; on the other hand, of the capacity of the existing roads, their inadequacies and the possibilities of their improvement.

The Brussels—Ostend motorway passes under an ordinary main road and provides non-conflicting connections to it

Increased Traffic

The increase in road traffic in Belgium is so remarkable that various factors have been constant obstacles to this increase. The country was equipped with a dense network of waterway and railway communications before the advent of the automobile. The waterways

* Abstract of a recent address to the All-Party Roads Group, House of Commons.

serve the northern part of the country and total about 1,000 miles (much of which is available to 1300-ton vessels), while the railways (largely in course of modernisation) total more than 3,000 miles, with the world's highest density in relation to area. Rural light railways or tramways further add about 600 miles to the system.

Motor vehicle registrations in Belgium in 1956 were 160 per cent of their 1950 number. With a ratio of about 14 people for every motor vehicle registered at present in Belgium, we know that we are far from having reached a saturation level. In the Brussels metropolitan area, ownership of the automobile is at higher level than in the country as a whole, for there are fewer than 10 people for every motor vehicle registered in our capital city.

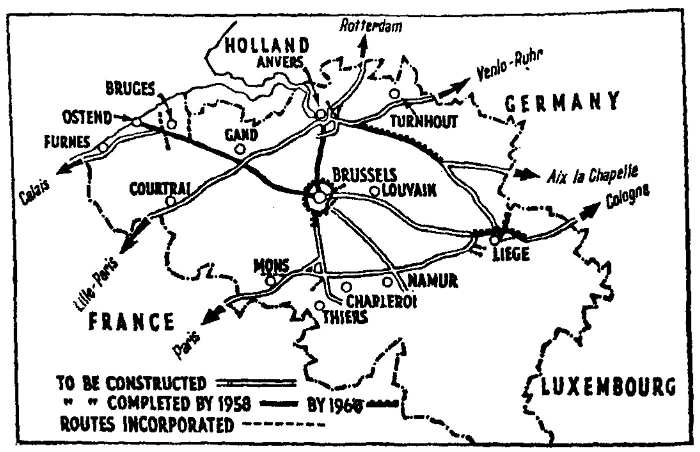
There is an increasing percentage of heavy vehicles in the total registrations. This percentage of lorries over 2½ tons grew from 17 in 1931 to about 30 in 1953. The growing economic value of road transport is further indicated by the total percentage of lorries, which is now about 40 per cent, and by the relative changes in the methods of transport of goods and people. In 1954, of the total 8·8 billion freight ton-miles in Belgium 30.7 per cent was by road, representing more than 75 per cent of the freight work of the railways and 44 per cent of the total movement of goods by rail and water. In 1920 only 3 per cent of the overall freight haulage was by road. Similar changes are observed for the transport of people. Roads now handle 61·8 per cent of the total 9·6 billion passenger-miles generated by public transport while the railways take 30·3 per cent and the rural tramways 7·9 per cent.

Although the use of automobiles has not yet in Belgium developed to the level reached in the U.S.A. for instance, it brings about a greater loss of human lives and a larger volume of physical damage than are found in industry and agriculture, including quarries and mines. The total number of accidents in 1955 amounted to 125,240 and resulted in 828 fatalities, 9,687 serious injuries and 40,670 minor injuries. The total cost of these accidents is estimated at about 21 million pounds, including 7 million pounds for administration costs of the insurance companies. If one of the initial causes of accidents lies in human error, their probability and severity are considerably influenced by the characteristics of the road. Road construction thus can have an immediate effect on the safety and the cost of transport.

Highway Programme

The improvement of the road network in Belgium has been studied in the light of traffic engineering principles; these recommendations resulted:

(i) A motorway system of about 600 miles with fully controlled access;



Existing and proposed motorways in Belgium

(ii) A primary I system (one roadway with three or more lanes of traffic) of about 900 miles;

(iii) A primary II system (one roadway with two lanes of traffic) of about 2,700 miles;

(iv) A secondary system of regional interest of about 8,000 miles; and

(v) Local roads and streets totalling about 24,000 miles.

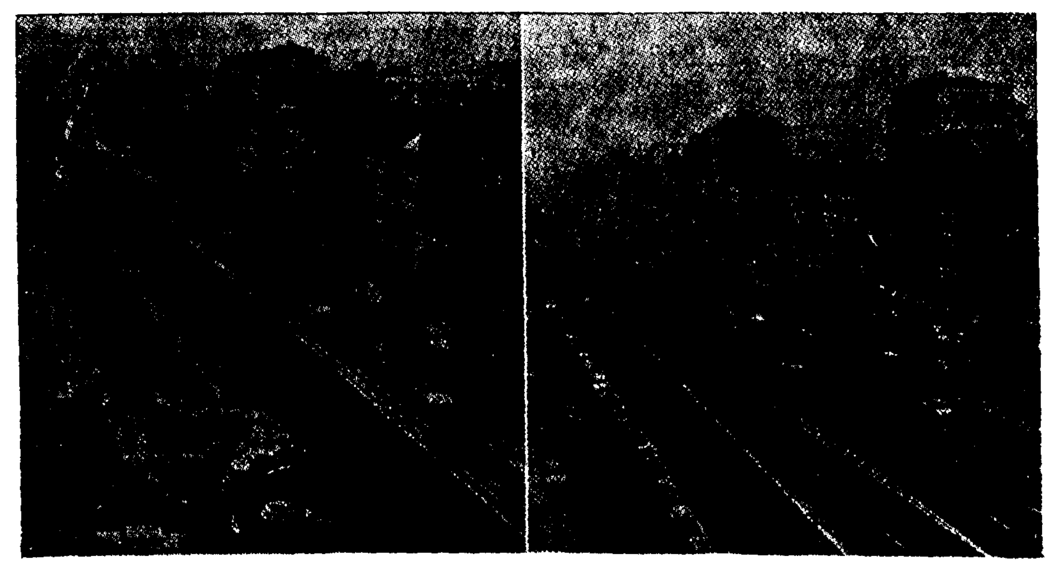
We must endeavour to build the new roads in these systems and complete them as quickly as financial resources permit.

It may seem at first that because there always were and always will be limitations upon financial possibilities, the building in rural areas of expressways with full control of access and for the exclusive use of motor vehicles is an unnecessarily expensive luxury. But the advantages relating to ease, speed, safety and low cost of transport on motorways as compared to ordinary roads in densely populated areas, where numerous unavoidable obstacles to traffic movement have developed, are such that motorways are a must for the access to and for the linking up of the larger urban areas; in Belgium they are about 30 to 50 miles apart.

Cost and Benefits

One mile of motorway costs about 285,000 pounds. In percentages of this unit cost, acquisition of land is about 8 per cent, earthwork about 56 per cent, bridges under and over about 20 per cent and surfacing about 16 per cent. It is accepted that acquisition of land and earthwork are not to be amortised for they are not to be renewed; their annual cost thus corresponds with the simple interest on the invested capital. Life periods of 50 years for structures and 25 years for surfaces are considered appropriate. To the annual cost of the capital invested is added the annual cost of maintenance, including signs and snow removal, which is estimated at 5,700 pounds per mile. The total annual cost, at 4 per cent interest, comes out at 18,500 pounds per mile.

The benefits gained by motorway users may be computed as a saving of over one penny a vehicle-mile on tyre wear and mechanical maintenance; 15 per cent on fuel consumption or one-third of a penny; and a 20 per cent saving in time, equivalent on average to almost a penny vehicle-mile. The gain from accident reduction is substantial in money and most important in avoiding human suffering. Observations made in Belgium during the last few years confirm American data which show that on access-controlled motorways, the number of accidents is lower by 70 to 90 per cent than on conventional public roads. Assuming the reduction is only 70 per cent and considering the total cost of accidents is of about 21 million pounds for 600,000 vehicles travelling an average every year of 8,750 miles each, there results a gain of two-thirds of a penny per vehicle-mile. The total benefit per vehi-



The urban motorway in Brussels: Viaduct in the central area of the city and, right, the Waterloo tunnel

cle-mile derived from all the above savings thus amounts to about 3 pence a mile. The average daily volume at which the financial cost of constructing and servicing a motorway is equalled or exceeded by the benefits gained by traffic in using the motorway relative to using the old ordinary road is consequently roughly 4,000 vehicles.

New Road Fund

The construction of the total mileage planned in the motorway programme, the total cost of which is estimated at 178 million pounds, will take from 20 to 25 years. This amount is for motorways only. A fundamental requisite for their construction is the continuing availability of sufficient funds. The Belgian Government and the Parliament therefore created on August 9, 1955, an autonomous road fund which is to construct part of the total motorway programme and deal with other road works in a 15-year period for a total amount of 215 million pounds.

Belgium is not only building its rural motorway system, but has also started with the construction of urban motorways in Brussels. The nucleus of this urban motorway system in Brussels is made up of a series of grade-separated intersections on the inner ring-road boulevards, in combination with the provision of express and local roadways and of separate rights of way for tramcar operation. This will allow mass transport to provide better service, which is vital for its customers and may eventually check or reverse the trend towards the use of private cars for the journey to work and for shopping.

Brussels Urban Motorways

The works on the inner ring-road, the Avenue Louise and the Boulevard Leopold II, affect over five miles of roads with total widths of from 150 to 250 ft. About 600,000 sq. yd. of surface have been laid, including the surfaces of the local and through-lanes, parking lanes and pavements. The cost of the inner ring-road amounts to about 7 million pounds. The cost of the rest of the urban highway building that is due for completion before the opening of the 1958 exhibition amounts also to about 7 million pounds. The roads concerned are sections of the outer ring-road, of the peripheral motorway link between the motorways to Ostend and to Antwerp of a section of the Brussels-Antwerp motorway proper, of urban radial arteries leading to the exhibition grounds and of related intersections and interchanges.

Savings in time and in cost of operation and the increase in the capacity of the road system are such that the construction costs of facilities will be paid back in a very short time, calculated to be of a maximum period of 5 to 10 years. Volume counts indicate that the saturation of the express roadway at the signal-controlled intersections on the inner ring-road is already being reached. This makes essential the building in the near future of the projected tunnels at the remaining level intersections in the network. It is obvious that maximum benefit from the facilities will only be obtained when the whole scheme of tunnels is completed so that an homogeneous and continuous urban motorway is made of the inner ring-road. At a point between the Rue de la Loi and the Place Madou daily traffic already averages 42,000 vehicles.

Improved Flow

Another important consideration in the usefulness of the tunnels is the higher average speed of traffic that results from the continuity of movement. An average speed of 35 m.p.h. is observed in road sections with continuous flow, while the average speed in road sections without continuous flow drops to low values of 20, and even 10 m.p.h. It is recognised that urban economy and urban living in the Brussels area have come to depend upon urban super-highways as much as upon any single utility, and this should be true for every important city in the world. There is no doubt about the fact that Brussels is gaining considerable attractiveness and prestige in establishing her present leadership in providing herself with an adequate urban road system.

[*From "Modern Transport," **April 19**, 1958.*]

THE YANGTSE RIVER BRIDGE

By

TSAO MENG-HSING

The author, who is the Chief Engineer of the Yangtse River Bridge Engineering Bureau, vividly describes here the various aspects of this grand structure constructed in China, and included is a step-by-step process of construction of the tubular column type foundations, which form a piece of creative achievement in engineering of a very high order.

Introduction

BRIDGE-BUILDING in China once played a brilliant part in the world's history of bridge-engineering. An outstanding example is the Chaochow Stone Bridge in Hopei Province, built 1,350 years ago and still in service today. A feature of this bridge, which has a span of 171 feet, is that at the two spandrels of the big arch are four smaller arches whose function is to lessen the load on the main arch and abutments and to act as spillways. Such scientific designing appeared in Europe only nine hundred years later.

In old China, however, nearly all modern railway bridge-engineering was connected with foreign capital. Fifty-six years ago the Yellow River Bridge was built under contracts with French and Belgian firms. Twenty-two years ago the Chientang River Bridge was designed by Chinese engineers, but its main structure was built by Danish, British and German firms under contract. Now, nearly eight years after liberation, the Chinese people, have designed for themselves and, using their own materials and machinery made by themselves, succeeded in building the Yangtse Bridge. They have turned a new page in the history of bridge building in China. The bridge is important not only for its economic value but as the best evidence of technical advance and economic development in New China.

The construction of the bridge was formally started in September, 1955. By October 15, 1957, both the railway and the highway over the bridge were completed at the same time and opened to traffic. The undertaking of this engineering project has realized a hope of the Chinese people for a number of decades to closely link up China's North and South, thereby further developing the national economy and improving the people's material and cultural well-being.

The engineering work includes the bridge, the railway, the highway, their linking lines, and culverts.

The bridge that spans the Yangtse river is 1,670 metres in length, forming the main part of the entire engineering project. Of the linking lines there is a railway bridge and a highway bridge across the Han River, a tributary of the Yangtse. The former is 300 metres, and the latter, 322 metres long. Besides, there are ten overline bridges for grade separation, with a total length of 480 metres. The railway links total 12·9 kilometres and the highway 4·5 kilometres.

In laying the bridge foundations, the method of tubular columns was used instead of the difficult method of compressed air caissons, thereby solving the problem of deep-water foundationing. This not only sped up the construction of the bridge, but also opened a new way to deep-water foundation engineering, an achievement which is creative and of world-wide significance.

Super-Structure of the bridge

The bridge proper is double-decked for rail and road traffic. The upper deck has a highway 18 metres wide with sidewalks on both sides, each 2·25 metres wide. The railway on the lower deck is double-tracked. Between the centre-lines of the two tracks, the distance is 4·1 metres. The sidewalks on both sides are as wide as those on the upper deck.

The superstructure is made up of three units of continuous steel trusses. Each unit has three spans. Each span has a length of 128 metres. The truss girders are either horizontal or diagonal and consists of short panels, each 8 metres long. The main truss is made up entirely of 'H' shaped members and its gusset plates are placed on the main joints.

An endless stream of vehicles pass through the Yangtse bridge

(Photo by Courtesy of the Indian & Eastern Engineer.)

In order to distribute the large stress over the chord members the reaction against the dead load of the continuous truss is adjusted on the bridge piers. For this purpose the main chords are so manufactured in the factory as to have a special negative deflection moment.

The material for the superstructure is "STZ" bridge steel. In making the steel girders, provision is made in the specifications for possible rivetless jointing. In order to maintain the necessary accuracy of angles and the interchangeability of parts, the chord members are made from 3-dimensional forms.

The girders are projected from both banks by the cantilever method. Balancing girders are first installed on the approach bridge and projected from there to the adjacent permanent pier. When the girders for the first span and those for the last span have thus been mounted, the balancing girders are removed.

For try-out a temporary pier is built under the first span and used as a temporary support. In order to reduce the overlength of the cantilever, joists projected from the various intermediate piers are used as temporary supports for the other spans.

Two 3-spanned units of steel girders are projected from the right bank while the other 3-spanned unit is projected from the left bank, the 2 units meeting at pier No. 6.

The Piers of the Main Bridge

As the river is deep, the difference between water-levels is great. The flow of the river is rapid with the result that the sand deposit on the river-bed is extremely unstable, and the bed-rock beneath the layer of sand and mud is uneven. In view of these conditions, the method of tubular-column is used to build the foundation.

The tubular-column foundation consists in essence of a number of piers each of which is a conglomeration of reinforced concrete columns. Each R. C. column is driven by power through the limestone and sludge into the river-bed. When it reaches the required depth, a steel frame is inserted into the bore. Then, concrete is poured into the under-water part of the column, thus firmly glueing it to the bed-rock. Above the bed-rock concrete is again used to fill up the bottom and to cement all the columns into one under-water foundation for the above-water pier.

The under-water parts of the piers, except No. 1 which is rectangular, are all round in shape. From the point of view of load distribution and actual engineering, the round-shaped pier foundation has decisive advantages.

There are 3 types of pier foundations: (1) Type one is a sealed R. C. and under-water resting on the sand layer and not built into the rock. (2) Type two is end

built directly into the subwater bed-rock. (3) Type three is built on carboniferous shale which decomposes easily and has a low load-bearing capacity. This pier is supported on hollow R. C. piles driven by centrifugal casting into the decomposed shale formation.

A pier of the first two types consists of 24 to 25 columns, each of which has an outer diameter of 1.55 metres. The depth bored into the rock varies from 2 to 7 metres, the diameter of each bore being 1.30 metres. The foundation of the pier consists of the R. C. sealed rock-base united with a R. C. supporting platform.

The height of the pier body is a little more than 33 metres. The highest pier is 64 metres.

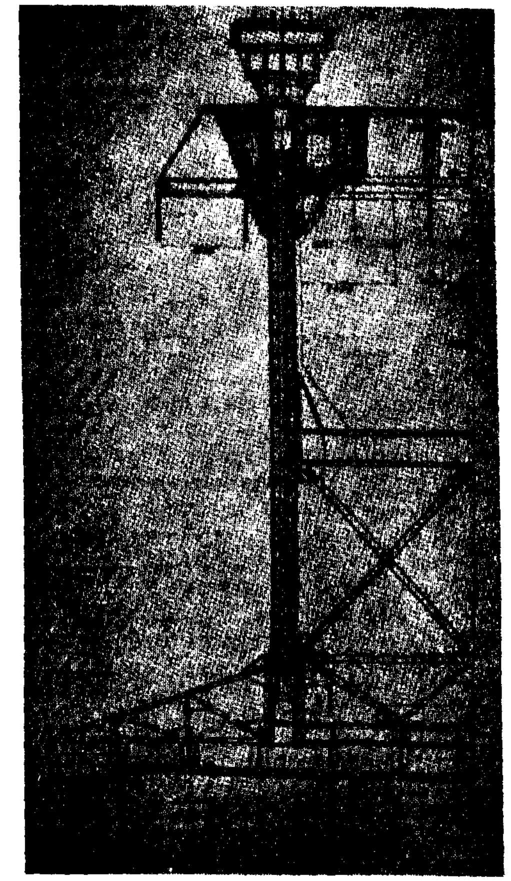
The engineering procedure of types one and two is as follows:

1. Fix up a steel waling to be used under water on the deck of an iron barge.

2. Let ths iron barge carry the steel waling to the pier site, and adjust its position by means of an anchor barge with all the necessary equipment of anchor, iron chains, steel cables and winch together with two guide barges. Then lift the waling up temporarily on a block and tackle by means of the crane on the guide barges. Having lifted the load, pull the iron barge out from under the steel waling.

3. Sink the steel waling down until its bracket falls on the guide barge. Then another steel waling is put on it and the same sinking procedure is repeated several times until every waling sinks to its required position.

4. Through the lattices inside the steel waling insert 8 to 14 fabricated reinforced concrete columns joined with steel turn-buckles at both ends. When they reach the bed-rock, slip the waling down over the columns already sunk and remove the guide barges. Then sink the rest of the columns consecutively.



A typical cross section of the bridge superstructure

(Photo by Courtesy of the Indian & Eastern Engineer.)

The columns are driven down by vibrating pile-drivers. In case of necessity, high-pressure water jets are used inside and outside the columns. Through a layer of sand from 5 to 25 metres in thickness 2 to 6 columns can be driven every 24 hours.

5. Both during and after sinking the columns, a cofferdam of steel sheet piles is built around the waling.

6. After extracting the required amount of sand and mud from the cofferdam by means of a suction dredger, immediately cast the sub-water sealed bottom with concrete.

7. After sand and mud have been extracted from inside columns, begin

drilling on the bed-rock with percussion drills placed on top of the steel walings.

8. After inserting the steel frame into every bore, pour concrete through the columns into the bore. In order that the concrete may be firmly cemented to the bed-rock at the bottom of the bore, use water jets to drive away the dregs inside the bore before concrete is poured in.

9. After pumping out the water from the cofferdam, remove the columns above the platform and start to build the platform with concrete.

10. Place forms inside the cofferdam and start to build the pier body with concrete. Then remove the upper structure on the steel walings one by one, but retain the lower structure in concrete.

11. After the concrete pier body is built, remove all steel sheet piles.

Hollow Sheet Pile Foundations

These foundations are not built with tubular columns. The pier is supported instead by 116 prefabricated hollow reinforced concrete piles each with an outer diameter of 55 cm. In order to stabilize the position of the steel walings, a number of piles are inserted into the lattices near the circumference of the steel waling and several in its central part. These piles are then driven into the bed-rock to a depth of 6 to 7 metres with steam hammers. After properly joining them together, they can then bear the weight of the steel walings and keep them in position.

The rest of the piles are then planted one by one in the right positions with high-pressure water-jets applied on them. At the same time, they are driven into the bed-rock by double acting steam hammers or by vibrating pile drivers, at a water pressure of 30 to 40 atmospheres. After driving them into the bed-rock to a depth of 15 to 20 metres with heavy-type simple-acting steam hammers, concrete is poured into the piles under water.

Sinking steel walings, inserting and driving in the steel sheet piles and cofferdam, making sub-water concrete-sealed bottom and building the body of the pier—the whole engineering process is the same for all other piers.

Approch Bridge

The larger part of the approach bridge lies on slopes on both banks. It is built of reinforced concrete girders with a span length of 17.2 metres. There are 17 spans of the bridge on the north bank, 12 spans on the south bank. The approach is so constructed as to be directly in line with the highway on the upper deck and as to curve down to the lower railway deck, gradually deviating from the high way.

The railway is built with reinforced concrete Tee-beams supported on solid piers. The highway is built of reinforced concrete stringers or cross-beams, with ends resting on reinforced concrete post-piers or retaining walls.

The bridge heads (or abutments), separately supporting the main bridge and the approach, are multiple-storied and partitioned structures built of reinforced concrete. Every storey has a spacious hall and an exhibition room. The one on the left bank is built on a foundation of reinforced concrete piles, each with a diameter of 55 cm. driven into the bed-rock. The one on the right bank is built differently; its front part rests on a tubular-column foundation, but its rear part is on a sheet pile foundation similar to that on the left bank.

The highway bridge proper over the Han River is built of continuous cambered truss of three spans. The railway bridge proper over the same river is built of three spans of standard railway truss members of 55 metres length and four spans of standard railway steel plate girders of 20 metres length. All the piers are built on round shaped foundations of reinforced concrete piles.

Conclusion

The amount of engineering work done under the main items are as follows :—

Concrete and reinforced concrete—126,300 cubic metres.

Stone masonry—25,400 cubic metres

Steel-work in members and girders —24,850 metric tons.

Reinforced concrete piles—62,500 linear metres.

Reinforced concrete columns, each with a diameter of 55 cm. driven under water—224.

The drilling work for the columns—680 linear metres.

Earth excavation—1,900,000 cubic metres.

Rock excavation—300,000 cubic metres.

The Yangtse River Bridge

The Yangtse Bridge is the result of support given by the people of the region and a spirit of co-operation between the various departments. Employees in the department of geology, hydrography, meteorology, etc. have made great contributions. Forty-two factories in the country contracted for the parts required by the bridge. Nearly 25,000 tons of steel truss equivalent to one-sixth of the total steel output of China in 1949, was used. All this was produced by two bridge factories, one in Shanhaikwan and the other in Shenyang.

In the course of the bridge-building the workers and staff set many examples in quality, quantity, speed and economy in capital construction. The cost of the entire construction was under 100 million yuan, of which 65,800,000 yuan was for the bridge itself.

The Yangtse Bridge is now open to traffic. The two trunk lines (the Peking-Hankow and Canton-Hankow Railways) are linked up, shortening the time of passenger traffic between Peking and Canton by two hours thirty-eight minutes. Instead of changing at Wahan incurring the inconvenience of ferrying across the river with their luggage, passengers now go straight through. Goods traffic is also much quicker.

(*From*: "*The Indian & Eastern Engineer*" *May, 1958*.)

DEFINITIONS OF HIGHWAY ENGINEERING TERMS

COMPACTION: The process of inducing a closer packing of particles in a mass of loose material, by blows, or by other external pressure.

(This term is generally used in Laboratory Tests)

COMPACTION: DEGREE OF

$$D_d = \frac{(\text{Void Ratio of Sample})}{(\text{Void Ratio in loosest state}) - (\text{Void Ratio in densest state})}$$

$- (\text{Void Ratio in densest state})$

WORDS OF WISDOM

"Life without hope draws nectar in a sieve, and hope without an object cannot live".

Coleridge

TRAFFIC FLOW AT ROUNDABOUTS

A REVIEW OF THEORY AND PRACTICE

By

B. G. MANTON, B.SC. (ENG.), D.I.C., A.M.I.C.E., M.INST. H.E.

THE principle of gyratory traffic flow is at least half a century old. It was introduced in Paris as far back as 1907 at the Place de l'Etoile and the Place de la Nation. Twelve radiating roads meet at the former and ten at the latter and at each site there is a spacious circular concourse, a combination of conditions peculiarly suitable for roundabout working.

It was not until 1925 that this system of traffic movement was introduced in London, the Aldwych island being one of the first examples. Rotary traffic working was adopted a little later at Parliament Square, Hyde Park Corner, Marble Arch and Trafalgar Square. Roundabouts were incorporated in several of the by-pass roads constructed between the two world wars and some of these have proved inadequate for present-day peak traffic owing to their small dimensions. This circumstance has given rise to the erroneous opinion that rotary traffic movement is only possible with relatively small flows and that the roundabout, as a feature of trunk road design, must be considered obsolete.

It has been suggested that a total of 3,000 vehicles per hour is the limit for a roundabout "of reasonable size."* The assessment of the point at which the size becomes unreasonable depends, however, upon many different factors. One junction, with heavy traffic flows, may be closely built-up with valuable property, another may be surrounded by an ample area of open ground of low value.

In a recent case under consideration roundabout designs were evolved which, according to the Ministry of Transport's capacity graphs[2] and confirmatory evidence from other sources, would comfortably accommodate a total flow of 5,000 vehicles per hour and the additional land absorbed, beyond that occupied by the existing roads, was found to be less than one acre.

It is interesting to compare the estimated capacity of a roundabout, based on the Ministry's method of calculation, with actual traffic counts. One example studied recently had a rectangular centre island measuring 100 ft by 150 ft with rounded corners of only 25 ft radius—at least 10 ft too small for large vehicles to negotiate without swinging well into the centre of the road. The surrounding carriageways were 30 ft wide and, owing to the obliquity of the interesting roads, the weaving angles on two sides were 66 deg. and 61 deg. respectively. As will be seen later, traffic capacity is reduced as weaving angles increase and 30 deg. or thereabouts is regarded as an ideal figure where circumstances permit.

The estimated capacity of this roundabout is 3,000 vehicles per hour and a traffic count taken in May 1956 from 5 to 6 p.m. on a Friday evening showed that 2,859 vehicles got through with momentary pauses in the flow not of sufficiently long duration to cause jamming.

In another case, a roundabout had a circular island only 60 ft in diameter, 30 ft carriageways and weaving angles of over 70 deg. The estimated capacity is of the order of 2,700 vehicles per hour and a peak period count showed that 2,916 managed to get through with momentary jamming on one or more sides.

By contrast, a really spacious design can handle very large traffic volumes. Col. Green[3] has reported, for instance, that 8,000 vehicles per hour have been counted at Hyde Park Corner where the weaving area approximates to a triangle, the outer boundaries of which measure about 660 ft by 660 ft by 800 ft, but this figure is dwarfed by the enormous volume at the Place de l'Etoile, Paris.

Here the circulating roadway has a width of 125 ft, with a central island 300 ft in diameter. Twelve radial roads bring traffic into this ring road, and one of these alone carries as many as 4,000 vehicles per hour at peak periods. The Rue de Tilsit and the Rue de Prebourg form an outer concentric ring road 24 ft wide with a diameter of 520 ft on which clockwise one-way working is in force.

Herzog[4] has reported that when traffic in the roundabout reached the immense peak figure of 20,000 vehicles per hour, traffic jams resulted and pedestrians found great difficulty in crossing the radial roads, but the installation of traffic signals has proved a satisfactory solution to the problem of carrying this very large flow, gyratory working being retained as before.

The use of traffic signals as a supplementary control, breaking up continuous flows into convoys of predetermined length, with gaps in between, can be very effective in improving the capacity of overloaded roundabouts and is discussed more fully later.

The Capacity of Roundabouts

So far in this article the capacity of a roundabout has been regarded as the number of vehicles which have gone through in a given time, but the evaluation of capacity, in this connection, may be considered in several different ways.

To begin with, the term "vehicle" needs more precise definition. As it stands, it may include anything on wheels from a bicycle to a machinery carrier, 60 ft long. The Ministry of Transport has recognised the need for a more logical system of evaluating traffic flow and has introduced the "Passenger Car Unit" (p.c.u.)[5].

In this system vehicles are divided into five classes and given the following weightings.

Type of vehicle	Multiplying factor
Cars and motor cycles ...	1
Light commercial vehicles	1
Medium and heavy commercial vehicles ...	3
Buses and coaches ...	3
Bicycles ...	0·5

By using these multipliers the extra road space occupied by the larger vehicles and their inferior mobility can be allowed for, but, unfortunately, the roundabout data given in the latest (1956) edition of the Ministry's publication "Design and Lay-out of Roads in Built-up Areas" give capacities in vehicles and not in passenger car units.

In the absence of more definite information one can only assume that these capacities apply to traffic of "average" composition, if, indeed, such a conception is feasible, but a clue has been given by Wardrop and Daff,[6] of the Road Research Laboratory, who state that a fairly typical traffic flow consists of 70 per cent cars and light goods vehicles, 20 per cent medium goods vehicles and 10 per cent heavy goods vehicles. Traffic of this composition may be said to have "p. c. u." factor of 1·6.

A further indication of the composition of "average" traffic may be obtained by a comparison of the limiting capacities of rural roads given, respectively, in the Ministry of Transport circulars Nos. 653 727. In the former case the capacities are stated in vehicles per 16-hour day and in the latter in p. c. u.'s for the same period.

The comparable figures are as follows :

Two-lane carriageways— vehicles per 16-hour up to 3,000	p. c. u.'s up to 4,500	Deduced p. c. u. factor 1.5
Three-lane carriageways— vehicles per 16-hour 3000—6000	p. c. u.'s 4500—9000	Deduced p. c. u. factor 1.5
Dual two-lane vehicles per 16-hour 6000—15000	p. c. u.'s 9000—25000	Deduced p. c. u. factor 1.5 to 1.7
Dual three-lane vehicles per 16-hour over 15000	p. c. u.'s over 25000	Deduced p. c. u. factor 1.7

* References will be given in the concluding instalment of this article.

Some actual p.c.u. factors obtained from counts on trunk and class A roads are given later.

The composition of traffic, however, varies from road to road, and almost from hour to hour, and any highway design involving capacities should be based on a detailed traffic survey to obtain a reasonably accurate picture of local conditions.

Then, again, the term " capacity " needs qualification. There is the " free flow capacity " which may be defined as the maximum number of p. c. u.'s which can get through a roundabout without being checked, or the " working capacity " which might be defined as the maximum number which can get through without being halted for long enough periods to cause the formation of queues in the approach roads, or the " ultimate capacity " which would get through irrespective of hazards, comfort, or courtesy and possibly with unreasonable delays to conflicting streams.

This latter figure, in some cases, may be quite high. It sometimes occurs when a heavy, unbroken stream forces its way through and merges, without weaving, with a stream turning left, but, meanwhile, other streams are held up. This undesirable state of affairs can, of course, be rectified by traffic lights and the combination of controlled flow and rotary movement may well be far more efficient than the normal signal controlled junction.

It is perhaps, legitimate, to consider that a roundabout is working efficiently if, in spite of failing to provide continuous free flow, the resulting delays are less, in vehicles-hours per day, than those which would occur at a signal controlled intersection with the same traffic volumes.

In the simplified theoretical case in which four approach roads to a roundabout all carry equal traffic volumes and each of these splits into three equal parts (left, straight through, and right), excluding a 360 degree turn, the volume on any segment of the circulating carriageway will be half the total volume passing through, but usually this symmetrical distribution does not occur and it is necessary, for design purposes, to take a directional traffic count which will give the proportion of traffic on each segment.

If the design is based on the heaviest loading on any one segment, the width of the surrounding carriageway is kept constant, and the weaving angles are equal, the other segments will not be loaded to capacity.

It usually happens, however, that the intersecting roads do not meet precisely at 90 degrees and the central island can sometimes be so located that the weaving angles gives capacities roughly proportional to the loadings on the individual segments.

Many roundabouts function quite satisfactorily except during short peak periods, morning and evening, when tidal flows occur, and the question then arises as to whether reconstruction is justified, possibly with a very extensive grade separation, in order to accommodate heavy flows of short duration. This matter can only be settled satisfactorily by a cost-benefit evaluation, and, in this field the highway engineer is still awaiting fuller information from the economist. Approximate estimates can, however, be made in certain obvious and straight-forward cases.

(To be continued)

(From: " Highways and Bridges and Engineering Works", April 23, 1958).

SURE TEST

If any one believes the radio will replace the newspaper, first let him try to wrap up last winter's suit in a radio.

ANALYSIS OF CONTINUOUS SKEWED SLABS

By

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Introduction

MODERN Highway design, which must meet the speed and safety requirements of the present-day traffic, is making more and more use of the skewed bridge. Increased volume and speed limits of today's traffic make it no longer feasible to cross streams and other obstacles always at right angles.

On the other hand, little has been done in the mathematical analysis of skewed slabs. Such an analysis, in general, asks for the solution of rather complicated differential equations in accordance with the various boundary conditions. At present there is neither an exact nor an acceptable approximate solution for continuous skewed slabs with free sides. Such bridge slabs in practice are being designed by combining the solutions of single-span slabs and the continuous-beam principles.

In January, 1957, a research project on the analysis of continuous skewed slabs was started at the Engineering Experiment Station under the supervision of Professor Robert F. Baker, supervisor of Civil Engineering Research, and Louis E. Vandegrift, Professor of Civil Engineering. This project, through experimental and mathematical methods, sought a satisfactory solution for the continuous skewed slabs to replace currently used design formulas.

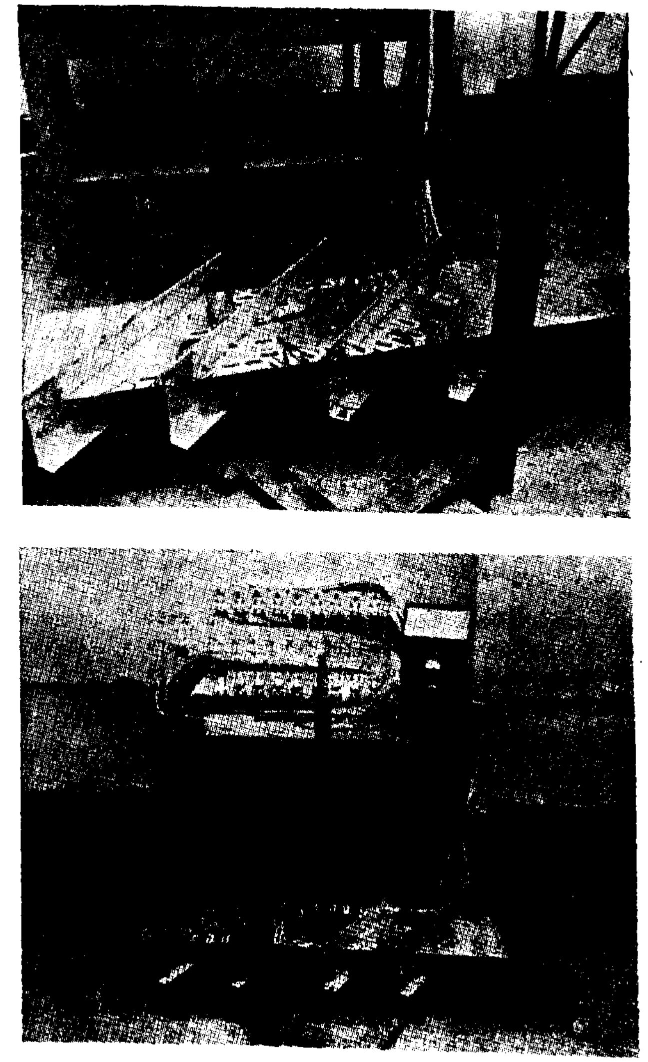


Fig. 1. The model slab

Experiments

As a part of the experimental phase of the project, tests were performed on the model of a three-span continuous bridge made of an aluminum alloy plate. Although a reinforced concrete model would have more resemblance to an actual structure, the results of the tests on such a model would make a poor basis of comparison for the mathematical analysis because of its non-homogeneous qualities. Aluminum was preferred to the other common metals and elastic materials because of its physical properties. It has a Poisson's ratio of 0.33 and sufficient strength against creep and buckling under ordinary test loads. Zinc alloys have a poisson's ratio of 0.15 which is closer to that of reinforced concrete than is aluminum. (The latter is assumed to be anywhere between 0 and 0.15). However, zinc is subject to creep at very small loads. Plastics could make excellent models if they did not have rather high Poisson's ratios.

The slab itself was an aluminum alloy plate of 48-in. length, 12-in. width, and 1/16 in. thickness. The slab and its supports were mounted on a 12-in. channel. There was a certain pattern of drilled and tapped holes on the surface of this channel so that the supports could be screwed down at four different angular positions, namely, normal to the centreline, and at angles of 15°, 30°, and 45° from the centreline, representing varying degrees of skew. The model is shown in Fig. 1.

In a highway bridge the dead load of the slab is sufficient to prevent any uplift over the piers caused by the live load. However, in the case of a small model bridge where the dead weight is negligible, the slab is very likely to have uplift over the supports when it is loaded.

For our particular model this problem was solved by using knife-edged upper supports in addition to the ones underneath the slab. These supports held the plate firm enough to prevent any uplift, but still there was enough "give" against any possible rigid frame action.

The length of the centre span was made 12 in. arbitrarily, and each of the end spans was 9.6 in. long, corresponding to the 8/10 of the centre span length. This ratio is conventionally used for the economic design of continuous beams and slabs; however, its use for the continuous slabs should be questionable.

The aluminum plate was loaded with a steel rod weighted with two hollow brass cylinders, and applied through a steel frame as shown in Fig. 1. The rod, of 3-ft length and $\frac{3}{4}$-in. diameter, weighed 10.2 lb. This weight was transferred to the plate through the blunt end of the rod which had a circular contact area of about 0.012 sq. in. Such a contact area would bear some resemblance to that of a wheel load on an actual bridge slab. The weight of the rod was so calculated that it could produce measurable strains at the remotest corner of the plate without overstressing the metal.

The purpose of the tests was to find the values of the strains at certain points on the plate for different positions of the concentrated load by using SR-4 Type A-1 electrical strain gauges. Strains were recorded by a battery-operated, Baldwin SR-4 Type L strain indicator. The gauges were wired so that each gauge was connected separately to one end of a double-throw double-pole switch, eliminating the use of any common wire. In such a circuit a possible defect in one of the gauges would confine itself to that gauge only and would not affect the others. The number and locations of the strain gauges were determined by considering the characteristics of a continuous skewed slab. In such a slab the study of the strain variations along, and at the ends of the intermediate supports would be very useful. The locations of the gauges were such that, for each degree of skew (0°, 30°, and 45°), sufficient numbers of readings could be obtained at the desired sections. The positions of 36 gauges symmetrically grouped along two intermediate supports and 107 load points are shown in Fig. 2.

In a loaded slab, a biaxial strain field exists where the values of principal and shearing strains at a certain point cannot be found unless strains along any three directions are known at that particular point.

In this experiment, instead of using rosette-type strain gauges, strain values at four different directions for each point, for every position of the load, were found in the manner explained below:

Two identical aluminum plates were used during the tests. On the first plate, gauges numbered from 1 to 18 were placed

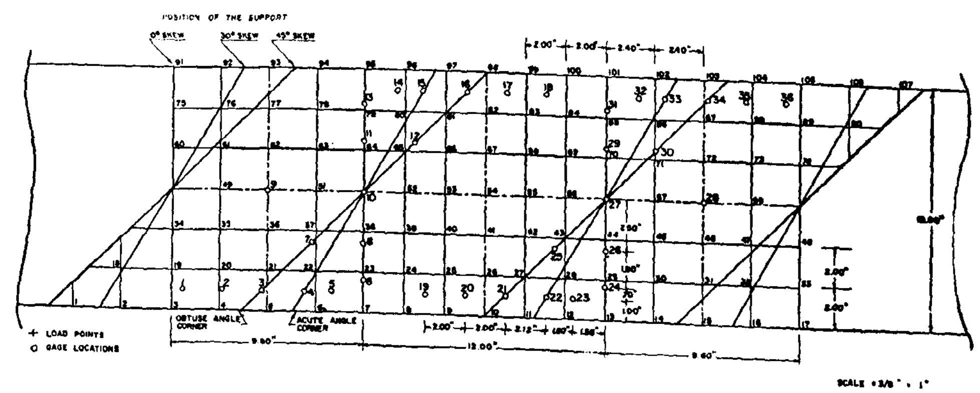


Fig. 2. Gage locations and load application points.

at 0° with the longitudinal axis, and gauges numbered from 19 to 36 were placed at an angle of -45° with the same axis. On the second plate, first and second groups of gauges were pasted at 90° and —30° inclinations, respectively. At the end of the tests performed on these two plates, taking advantage of the longitudinal symmetry, it was possible to obtain strain readings at 0°, 30°, 45°, and 90° angles at each gauge point for each load position. To get these data, about 20,000 strain gauge readings had to be recorded. Later, using the proper formulas and a nomograph, these readings were converted to principal and shearing strain values and tabulated.

Before attempting the theoretical analysis, several strain-influence line and variation diagrams were drawn. A quick study of these diagrams revealed interesting conclusions, such as:

When a concentrated load was placed at the mid-point of the middle span, the strain along the intermediate supports varied considerably for different skew positions of the support. Generally, as the skew increased up to 45°, the value of the maximum strain diminished as much as 20 per cent and the location of the point of maximum strain moved along the support towards the corner of the obtuse angle. Across the acute angle corner of the intermediate support, the maximum strain always occurred directly over the support. However, across the obtuse angle corner the strain curve reached its peak at different points for each degree of skew. Strain-influence diagrams were drawn for certain gauge points with the concentrated load moving in transverse and longitudinal directions. There was a wide range of variation among the values of the ordinates as the angle of skew changed. For instance, strain at one point on a right slab could be 5 times as high as the value when the supports were at 45° skew. Slopes of the curves also differed, and usually at the obtuse angle side they became steeper.

The Mathematical Analysis

The exact mathematical analysis of a slab is possible through the principles of the "Theory of plates". The basic principles of the theory of flexure of medium thick slabs are well known, and much literature is available on the subject. The fundamental expression for the flexure of slabs is a differential equation written as:

$$\frac{\partial^4 w}{\partial x^4} + 2\frac{\partial^4 w}{\partial x^2 \partial y^2} + \frac{\partial^4 w}{\partial y^4} = \frac{p}{D} \qquad (1)$$

Where w is the deflection of the neutral surface of the plate, p is the load per unit area, and x and y are the rectangular co-ordinates. The term D is called the "flexural rigidity" of a plate, taking the place of the quantity EI in the case of beams; D equals $\frac{EI}{1-\mu^2}$ or considering a strip of the slab with unit width it is $\frac{EL^3}{12(1-\mu^2)}$ where μ is the Poisson's ratio, h is the thickness of the slab, and E is the Modulus of Elasticity of the material.

Moments in the x and y directions can be expressed as:

$$\left.\begin{aligned} M_x &= -D\left(\frac{\partial^2 w}{\partial x^2} + \mu \frac{\partial^2 w}{\partial y^2}\right) \\ M_y &= -D\left(\frac{\partial^2 w}{\partial y^2} + \mu \frac{\partial^2 w}{\partial x^2}\right) \\ M_{xy} &= -D\,(1-\mu)\frac{\partial^2 w}{\partial x\,\partial y} \end{aligned}\right\} \quad (2)$$

The term Mxy is called the Twisting Moment. Additional equations can be written for the shears and reactions in the slab. However, in most of the cases, it is first necessary to be able to solve Eq. 1. The solution of this equation depends on the boundary conditions existing at the edges of a slab. Theoretically, for a slab with infinite dimensions, the solution would be rather simple, but in actual practice, plates usually have various kinds of edges; clamped, built in, simply supported, stiffened, continuous, and free. Each of these presents different boundary conditions with varying degrees of complications; for instance, at a simply-supported edge all deflections, moments, and curvatures will diminish to zero. On the other hand, at a free edge, the twisting moment, the vertical shearing force, and only the bending moments along the edge will be zero.

In our particular problem, two ends of the 3-span continuous slab were simply supported, the edges across the supports were free, and over the two intermediate supports there was continuity.

The exact mathematical analyses of various kinds of single-span right slabs are available. However, when the slab is continuous and the supports are skewed the boundary conditions become so complicated that the solution of the basic plate equations may be extremely difficult.

The method of Finite differences has always been a great help in the solution of the problems involving differential equations which are difficult or impossible to solve. Basically, this is an approximate method by which the infinite number of variables and unknowns in a problem are reduced to finite numbers. This method has already been used in the analysis of some plate problems.

Dr. H. Marcus published (1923) his book Die Theorie Elastisches Gewebe, in which he adapted the finite-difference method to the investigation of the bending of various rectangular plates assuming a network of points on the surface of the plate. Professor Vernon P. Jenson, of the University of Illinois, analysed a single-span, simply-supported, skewed slab by means of this difference-equation method. Later, at the same university, T. Y. Chen, C. P. Siess, and N. M. Newmark prepared a bulletin on the moment distribution in simply-supported skewed I-Beam bridges, using the same method of approach.

As far as continuous slabs are concerned, S. Timoshenko, in his book Theory of Plates and Shells, gives an exact solution for a three-span continuous right slab bridge with all sides simply supported. The solution is for a uniform load and, when concentrated loads are in question, the problem becomes very much complicated.

Considering the skewed supports, concentrated loads, and more difficult boundary conditions involved in our problem, and in the light of the work done by Marcus and Jensen, the possibility of finding a solution through finite-difference equations looked much brighter than an exact solution using differential plate equations. The procedure used in such a solution will be illustrated very briefly, as follows:

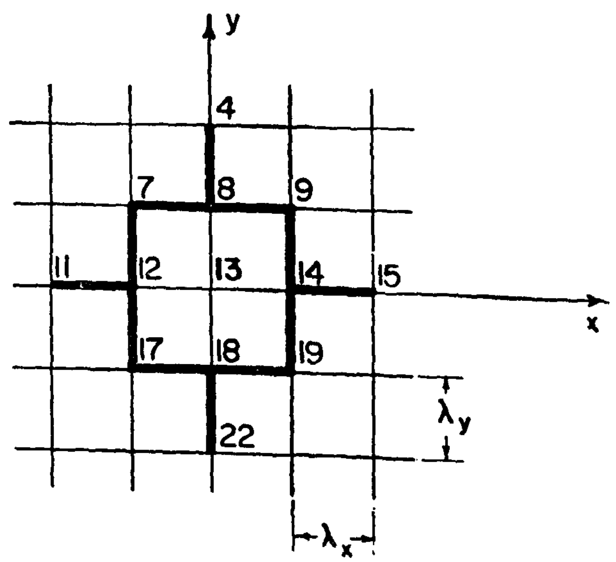


Fig. 3. **Rectangular network.**

Let us assume that the surface of the slab is made of a network of regularly-spaced points, a typical portion of which is shown in Fig. 3. If this portion of the plate is bent by a certain load, the slope in the x direction between Points 13 and 14 can be expressed as:

$$\left(\frac{\partial w}{\partial x}\right)_{13-14} = \frac{w_{14} - w_{13}}{\lambda_x}$$

where λ_x is the distance between the points and W is the deflection at the point. Similarly:

$$\left(\frac{\partial w}{\partial x}\right)_{13-12} = \frac{w_{13} - w_{12}}{\lambda_x}$$

The curvature of the bent plate at Point 13 will be the rate of change of the slopes:

$$\left(\frac{\partial^2 w}{\partial x^2}\right)_{13} = \frac{w_{14} - w_{13}}{\lambda_x} - \frac{w_{13} - w_{12}}{\lambda_x} = \frac{w_{14} - 2w_{13} + w_{12}}{\lambda_x^2}$$

By the same token, the curvature in the y direction:

$$\left(\frac{\partial^2 w}{\partial y^2}\right)_{13} = \frac{w_8 - 2w_{13} + w_{18}}{\lambda_y^2}$$

The "Twist" is the rate of change in the x direction of the slope in the y direction. For Point 13, the average twist is:

$$\left(\frac{\partial^2 w}{\partial x \partial y}\right)_{13} = \frac{w_9 - w_{19} - w_7 + w_{17}}{4\lambda_x \lambda_y}$$

Let us rewrite Eq. 1 in a different form:

$$\nabla^2\nabla^2 w = \frac{p}{D}$$

where

$$\nabla^2 = \left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}\right)$$

Denoting $\nabla^2 w$ by U we have:

$$\left(\nabla^2 w\right)_{13} = U_{13} = \frac{w_{14} - 2w_{13} + w_{12}}{\lambda_x^2} + \frac{w_8 - 2w_{13} + w_{18}}{\lambda_y^2} \quad (3)$$

By the change of variable, Eq. 1 for Point 13, becomes:

$$\left(\nabla^2\nabla^2 w\right)_{13} = \left(\nabla^2 U\right) = \frac{U_{14} - 2U_{13} + U_{12}}{\lambda_x^2} + \frac{U_8 - 2U_{13} + U_{18}}{\lambda_y^2} = \frac{p}{D} \quad (4)$$

The moment expressions in Eq. 2 will take the form:

$$\begin{aligned} \left(M_x\right)_{13} &= -D\left(\frac{w_{14} - 2w_{13} + w_{12}}{\lambda_x^2} + \mu \frac{w_8 - 2w_{13} + w_{18}}{\lambda_y^2}\right) \\ \left(M_y\right)_{13} &= -D\left(\frac{w_8 - 2w_{13} + w_{18}}{\lambda_y^2} + \mu \frac{w_{14} - 2w_{13} + w_{12}}{\lambda_x^2}\right) \quad (5) \\ \left(M_{xy}\right)_{13} &= -D(1-\mu)\,\frac{w_9 - w_{19} - w_7 + w_{17}}{4\lambda_x \lambda_y} \end{aligned}$$

Usually, for certain skew angles, a rectangular system of co-ordinates is found to be unsatisfactory. For general purposes, another pair of axes is added and a new pattern of points is used as shown in Fig. 4. This system of co-ordinates necessitates modifications in the above equations. In the figure, ϕ is the angle of skew. When the skew becomes 45°, δ becomes 0°, and in a right slab, ϕ is 0°. In both cases the general network takes the simplified rectangular form as shown in Fig. 3. The analysis of the entire problem is possible by the solution of a number of simultaneous equations. The number of equations is determined by the number of points in the network which deflect when the slab is loaded. A symmetrical loading would help to reduce this number to half. For each deflected point, an equation similar to Eq. 4 is written, in which each U term should be expressed according to Eq. 3 in its final form, the resulting equation for a certain point contains the deflections at that point and at the surrounding points, and includes an expression depending on the loading condition and the dimensions of the slab. "The surrounding points" are defined as indicated in Figs. 3–4 for rectangular and

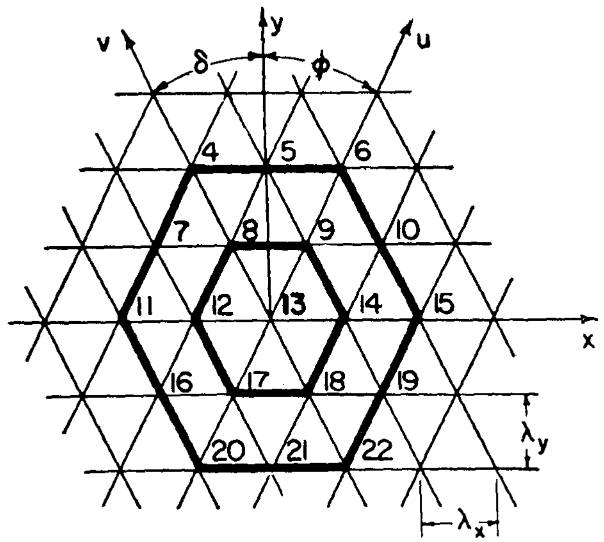


Fig. 4. **General network.**

general network patterns where 13 is the point in question. Further modifications are necessary in the equations whenever a point or one of the surrounding points is on the boundary.

In analysing our problem for 0° and 45° skew cases rectangular, and for 30° skew case, a general network of points was used. Points were spaced at about 2-in. intervals in horizontal and vertical directions. The slab itself was assumed to have the same dimensions as the aluminum plate model. Altogether, there were 91 points on the three-span continuous slab, excluding the ones on the supports. Ninety-one equations were written for these points for each of the three different skew cases, and these equations were modified for simply-supported, free, and continuous edge conditions.

At present, only one loading condition is under consideration: A concentrated load acting at the mid-point of the middle span. Because of the symmetry, the number of equations is reduced to 46 for this case. Currently, a plan to solve these 46 simultaneous equations by IBM 650 Computer is under development at the Numerical Computation Laboratory of The Ohio State University Research Foundation. The solutions of these equations will furnish the value of the deflection at each of the 91 points. Then using these data, Mx, My, and Mxy quantities will be calculated by means of the expressions similar to Eq. 5.

At this stage, the accuracy of the solution is somewhat hard to predict. Generally, the fineness of the network points should increase the accuracy. However, it also increases the number of simultaneous equations, and from a mathematical point of view more simultaneous equations mean more unstable and unreliable solutions. So far in single-span right bridges, a comparison of exact and difference-equation solutions has showed that the latter method is accurate enough for engineering purposes. In the future, the solutions, as obtained from the electronic computer, will be checked with the experimental data; it also will help to compare the different expressions for the effect of a concentrated load in its immediate vicinity. After studying the results of the problem with the present loading condition, the solution will be generalized for all loading conditions and skew variations. Tables and influence diagrams will be prepared for principal moments and stresses. It is hoped that this information will be valuable in the design of continuous skewed slab bridges by replacing the currently used inaccurate design formulas.

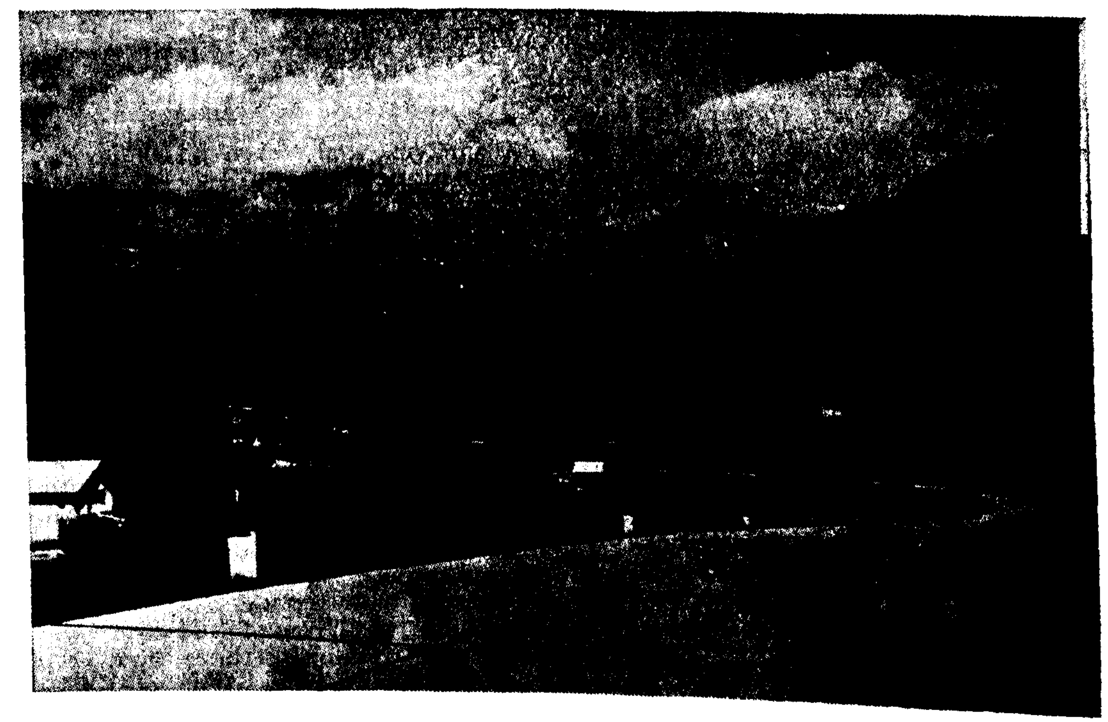
(From: "News in Engineering", February, 1958.)

CONCRETE ROADS IN AUSTRIA

FOR many people in this country 'Austria' spells, first and foremost, delightful holidays—rambling and flower-hunting in the gay valleys of the Tyrol, ski-ing in the heights of the Vorarlberg or the Oetztal, sailing in the Salzkammergut or on the Carinthian lakes, or enjoying the civilized town pleasures of Innsbruck, Salzburg and Vienna. The sensation of "fleeting the time carelessly, as they did in the golden world" is enhanced by a strong impression of a gracious past, a past crystallized in the music of Mozart, the Strausseses and Lehar. But to the Austrians, struggling to survive after the almost mortal blows of two world wars, the present is real and earnest and tourism a fundamental part of their economy which they take practical steps to encourage. Road-building and improvement are one aspect of this policy.

In 1947, with 70 per cent of their total road network in a deplorable condition, the Ministry of Trade and Reconstruction announced a 10-year plan for the modernization of the State Highways. Within five years they had made splendid progress, and the Grossglockner and other Alpine passes were once again open to heavy tourist traffic. Now road-building is going forward very actively, and concrete road-building in particular, to an extent which surprised the German Road Research Association when on a roads study tour in Austria in June, 1956. They were especially impressed by the large-scale use of concrete for Federal and provincial highways.

This activity was confirmed by the party organized by the Pavings Development Group (Concrete and Soil-Cement) and the Cement and Concrete Association,



A typically beautiful stretch of the 37-mile-long Molltal road, which links the route over the Grossglockner pass with the lakes of Carinthia.

The Praterstern from the Hauptallee with the circular concrete road and the connecting roads open to traffic.

which visited Austria en route for the International Concrete Road Congress at Rome in October, 1957, and saw, among other things, round-the-clock concreting on the Vienna-Salzburg motorway.

Why is Austria, a poor country, with a population a million less than that of greater London, doing so much of her road-building in concrete? For economic reasons, and because of good results in the past. Highway authorities in Austria have found, and repeatedly said that the long life and low maintenance costs of concrete roads make them economically advantageous. Austria has many years of concrete road construction which bear this out. The oldest stretch of concrete road in the country from Linz to Melk was laid in 1892. This road forms part of one of Austria's most heavily trafficked highways, was much used by tanks during the last war, but all it has suffered is slight cracking, and it is still carrying traffic with no loss of efficiency.

Roads in Vienna

Vienna has undertaken an impressive urban replanning scheme, in which the reconstruction in concrete of a number of main streets plays an important part. The mileage of concrete roads in the city has, in fact, been doubled since 1951.

A rail and road construction which involves flyovers and a circular road is taking place at the Praterstern junction. The North Railway Station is being re-built and the railway will be carried over the central area and the roadway on over-bridges, two of them of prestressed concrete. The circular road, opened in 1955, is over half a mile in circumference; it takes traffic from six busy roads. The 60 ft wide carriageway has six traffic lanes, coloured alternately red and white as a means of inducing the traffic to keep to its appropriate lane.

Before the reconstruction at the Praterstern the intersection of the Mariahilfer-

strasse and the Gurtelstrasse, constructed of concrete in 1951, was the most important road junction in Vienna; here again, a red-coloured concrete was used, this time to distinguish the pedestrian crossings. The concrete slab for this intersection is 13 in. thick, in two courses of 11 in. and 2 in. The Gurtelstrasse itself was rebuilt as a dual carriageway road between 1951 and 1954. On this road which is proving satisfactory in every way, the traffic has increased from 15,000 to 35,000 vehicles a day. Part of it was concreted in the winter of 1953 with complete success, using up-to-date heating and curing methods. The slab is 9½ in. thick, laid in two courses, a design which is common to most of the Viennese concrete roads. The cement content for these roads is also generally 625 lb per cu. yd. for the top course and 490 lb per cu. yd. for the bottom course.

Other major roads in Vienna rebuilt in concrete since the war include the Wagramerstrasse and the Simmeringer Hauptstrasse, both important exits to the east, the Perspectivstrasse, the Lasallestrasse and the Neubaugurtel. In addition, a large number of new parking areas, such as the "Franz-Josefs-Kai," have also been constructed in concrete, of 8 in. to 9½ in. thickness.

One interesting point on the construction of concrete roads in Vienna is that all services are overhauled and new ones installed, where necessary, before concreting begins. This is typical of the high standard of planning and execution which both the German and English parties found in the Austrian urban roads.

Motorways

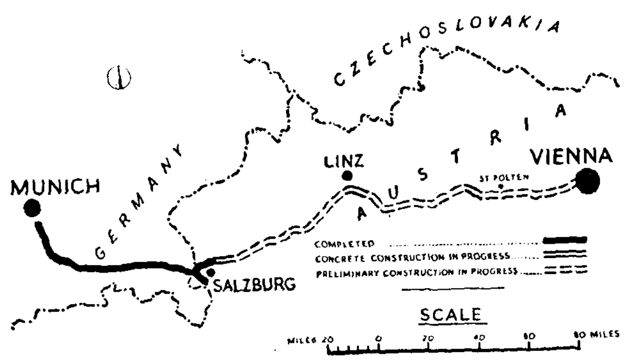
After the war some 17 miles of German concrete autobahen were transferred to Austrian administration, at the Salzburg end of the Munich-Salzburg motorway. Austria's most notable road project is the 192 mile-long motorway, at present under construction—almost wholly in concrete—which will link the capital to the existing motorway at Salzburg and thus to the western European network. A start was made on this road before the war, but it was not until 1954 that work was resumed. Already 13 miles are in use, and it is hoped that a further 73 miles will be open to traffic this year. Good progress has been made on the earthworks throughout the road and a number of bridges are completed or under construction. Concreting is at present being carried out on three different sites—between Salzburg and Mondsee, near Linz, and near St. Polten.

The motorway is designed with an overall width of 93½ ft, which comprises 24½ ft wide dual carriageways, a central strip 13 ft wide, 2½ ft wide sett-paved edgings 8 ft wide hard shoulders and grass verges 2½ ft wide. The 9 inch thick concrete slab is reinforced between the 3 in. top course and the 6 in. bottom course. The two layers of concrete, although spread separately, are compacted as one. The cement content is 575 lb. per cu. yd., and the concrete is air-entrained throughout.

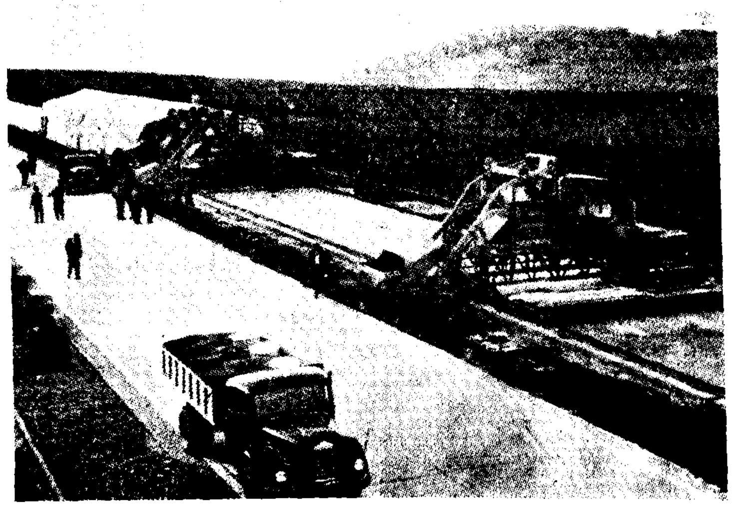
Transverse expansion joints are provided at intervals of about 100 ft, with dummy contraction joints between the expansion joints at intervals of 33 ft. Dowelbars are used in all expansion joints, and tie-bars along the centre of the slab, which is laid full width in one operation.

Construction is by fully mechanized methods and on the site near Salzburg, where concreting has gone on day and night to ensure completion of the contract on time, the output averaged a quarter of a mile in the 24 hours, that is, one and a half miles a week. The German A.B.G. spreading, finishing and joint-cutting machines used are similar to those used in this country on the Alconbury Hill-site on the Great North Road, where a very high standard of riding surface has been achieved. The surface of the Austrian motorway was also noted as very good by the visiting German and English parties. Another factor that undoubtedly contributes to this excellent surface is the use of moving tents to cover the train of plant. In this way a constant temperature is created and these uniform conditions make finishing much easier.

The Austrian Federal Government have futher plans for motorways; they propose to begin work shortly on the construction of a motorway from Vienna to Tarvis on the Italian frontier, via Graz and Klagenfurt, and at some future date to extend



Map of the Salzburg-Vienna motorway, showing construction progress.



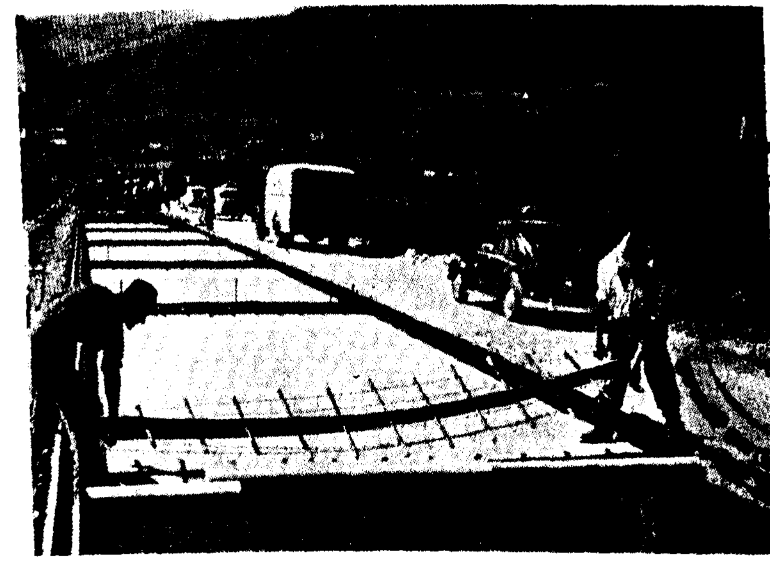
Bridge mixers in operation on the Vienna-Salzburg motorway at Loosdorf near St. Polten.

the Salzburg-Vienna motorway in an easterly direction, towards Budapest.

Federal and Provincial Roads

Concrete is also being used, and is envisaged for future use on a large-scale, on the Federal roads, the trunk roads of Austria. It has given a reliable surface on certain Alpine stretches of these roads where the soil is very frost-susceptible and other surfaces have failed. In one instance concrete has been super-imposed on flexible construction for six miles of mountain road with good results. It is being used for practically the whole of the Styrian stretch of the Vienna-Trieste road, the most heavily trafficked of the Federal roads, after the Salzburg-Vienna road. All the 50 miles from Semmering to St. Michael, near Leoben are being constructed of concrete, with the exception of three miles, where local conditions led to the use of granite setts on an 8 in. thick concrete base. The road has been redesigned to meet current traffic conditions—5,000 to 7,000 vehicles a day; it is being built half-width at a time, as it is impossible to divert traffic on these roads where there is only one possible route through the valleys and over the passes.

Other Federal roads in Styria are to be laid in concrete. The Ennstal road is being widened, in concrete, for a length of about 37 miles, 10 miles of which are already *in service*. Nineteen miles of the Wechsel Federal road, between Gleisdorf



The Vienna-Trieste road under construction at Oberaich: dowel-bar assemblies are being placed in position.

and Hartberg are being laid in concrete. When the road construction plan for Styria is completed, there will be 120 miles of concrete roads, of which 44 miles are already completed and 76 miles are planned or under construction. This is about 15 per cent of the total 808 miles of Federal roads, and applies to one province only.

The large province of Carinthia has similarly a considerable programme for concrete roads. The tourist traffic between Vienna and Italy is very heavy—some days in Vienna, some days in Venice, with perhaps a call at the Carinthian lakes en route, is an obviously attractive programme. The Ossiach Federal road, which connects St. Geit, on the road to Trieste, with Villach on the road to Italy, and which runs the full length of the lovely Ossiacher See, is therefore to be widened to help relieve the traffic on the Vienna-Trieste road, and the St. Veit-Feldkirchen stretch is being reconstructed as a 24½ ft wide concrete road over its full length of fifteen miles. When this is done, the entire stretch of the Trieste Federal road along the north side of the Worther See, the other famous Carinthian lake, is to be rebuilt, as the present line of the road cannot be widened satisfactorily because of the numerous intersections and built-up tourist resorts.

Carinthia can already claim one of the finest concrete roads in Austria, the Molltal road which connects the country's highest pass, the 8,200 ft Grossglockner, with the Carinthian lakes, replacing a road so narrow in parts that the yellow post-bus, a familiar sight on Alpine roads, could scarcely squeeze past a lorry. This 37 miles-long road was constructed between 1953 and 1955—80 per cent of it in concrete—to the latest design standards. Its clean lines wind as harmoniously through this typically beautiful Austrian Valley as the Swift-rushing river Moll itself, both overlooked by romantic castles and pencil-spired churches. It ends at Winklern where the flag-bedecked ceremonial opening of the road—which took place in the summer of 1956, well ahead of schedule—was attended by a gay crowd in local costume, armed with posies of Alpine flowers.

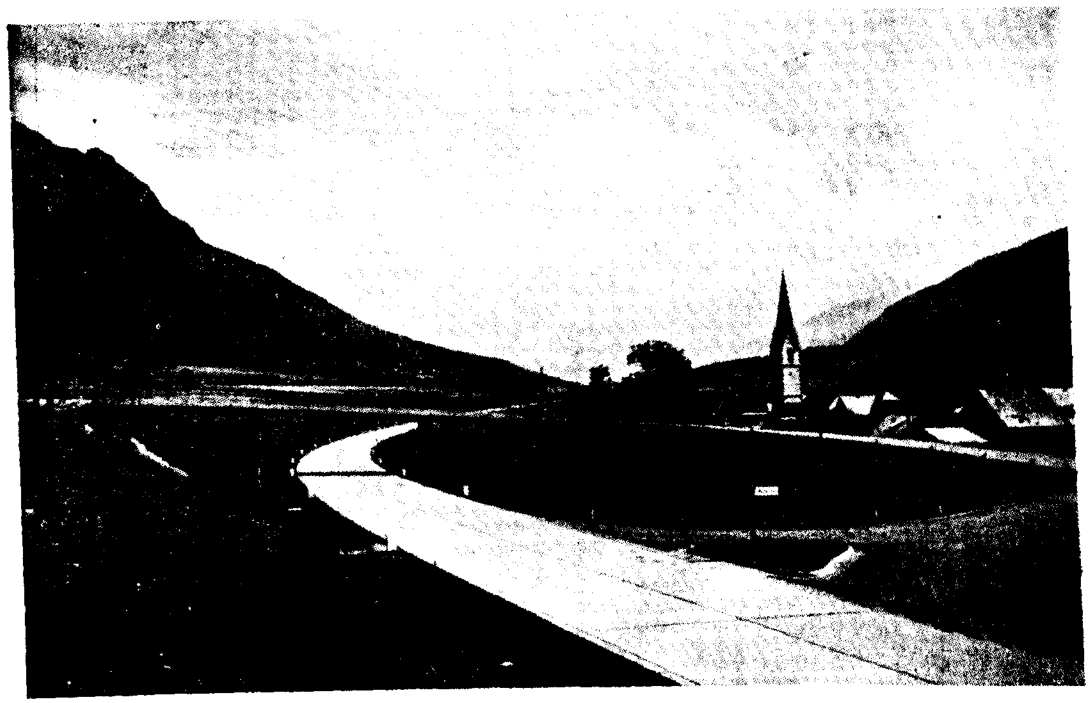
The line of the new road is at some distance from the old road over most of its length, as the existing road had very unfavourable curves, gradients and visibility. The carriageway is 24½ ft wide, and in the lower Molltal has red-coloured verges, 1 ft in width. Expansion joints are spaced about 69 ft apart, with dummy joints at 23 ft intervals; dowel-bars are used in all joints. The unreinforced two-course slab is 8 in. thick, and has a granular sub-base 20 in. thick as a frost-protection blanket.

The high construction standard obtained with reasonably economical methods is a noteworthy feature of the Austrian roads. The importance of the subgrade to the life of the road is fully realized, but, in general, no very expensive precautions are taken. Good compaction of the subgrade and the provision of an adequate frost blanket are considered to be sufficient. A recent innovation of interest, however, in regard to the sand, is that sand is now specified from which the finest particles have been removed, as this 'dust' may be detrimental to the weather and frost resistance of the concrete.

Reinforcement is compulsory for motorways, Federal roads and urban roads carrying very heavy traffic. Generally all transverse joints are constructed as expansion joints—the Molltal road is an exception to this rule—dowel-bars being required for all joints on the most heavily trafficked roads. The technique of sawing joints after construction is not yet in widespread use, other than on the motorway, but the level of the roads at joints has proved to be satisfactory.

Thus for the tourists who are flocking to Austria in ever-increasing numbers, drawn by the magnificent mountain-and-lake scenery, the gay villages and lovely towns, and by the kindly hospitality of the people, the Austrian road authorities are providing an added inducement—good new roads. The Austrian approach is practical, expeditious and economical—and their choice at those points where their tourist and industrial traffic is most concentrated, is concrete. The Austrian authorities are convinced the increased tourist traffic will pay for these roads in a very short time.

(*From*: "*Concrete Quarterly 36*", *January-March 1958*).



A flyover crossing the Molltal road.

HERE AND THERE

1. NEW ROADS FOR OLD

● SUSPECT as pressure groups are in this country, it must be granted that a good deal of reform of great public importance would never be accomplished without the focus they give to public opinion and the stimulus they offer governments. The Roads Campaign Council deserves gratitude for having again staged at Charing Cross underground station an exhibition — "New Roads for Old" which illustrates graphically the need for capital works on British roads, the progress already made and what has been accomplished long ago by other countries. Opened by Lord Brabazon of Tara, it will remain on view until May 17. He pointed out that there is a desperate need to tackle the traffic problem in our large towns and cities while the average speed in Central London is only 10 m.p.h. and in Central Glasgow only 7. "Manchester's rush-hour traffic travels at the unrushing speed of 5.9 m.p.h." The answer to "we can't afford it" was that we could not afford not to provide facilities for the motor vehicle. Dr. W. A. Glanville, Director of the Road Research Laboratory, had said that inadequate roads were costing nearly 500 million pounds a year through delays to trade and industry.

(*From*: "*Modern Transport*", *May 3, 1958*.)

2. TYPES OF ROAD SURFACE

● IN order to assess the hygienic and cleansing merits of the various road surfaces, it will be necessary to consider some of the types in use at the present time:

(a) Hot rolled or mastic asphalt (lightly chipped) surfaces without doubt can be cleaned more easily than others, but if these materials are heavily chipped, then cleansing becomes extremely difficult, the open textures harbouring dirt and dust very tenaciously.

(b) Fine cold asphalt provides a smooth surface, is excellent from the cleansing point of view, and resistance qualities are good; but many highway authorities 'play to the gallery' by using heavy applications of pre-coated chippings to give a non-skid appearance.

(c) Tar and bitumen macadams, when laid by surfacing machines to modern flat cambers, form excellent riding surfaces. The even surfaces, free from depressions and corrugations, make it possible to use mechanical sweeper/collector vehicles to advantage. Many miles of roads in this country are of water-bound macadam construction, but the use of surface dressings has made them comparable to those of the tar macadam group; all have rough surfaces, and the interstices retain dirt and dust and cause considerable wear and tear to hand and mechanical brooms.

(d) Wood paving is rapidly going out of use. Its flat camber and even channels made it most suitable for easy cleansing, although it is inclined to be slippery in wet weather.

(e) Granite setts, much used in industrial areas and heavily-trafficked main roads in the large towns and cities, with their numerous joints and unevenness of surface, harbour dirt and dust, making street cleansing difficult and costly.

(f) Concrete is an excellent surface for easy cleansing, by reason of evenness of channel (without break in surface between channel and remainder of road), and as with rolled or mastic asphalt surfaces, the traffic rapidly moves road detritus to the road haunch and channel, so that cleansing is normally limited to a few feet from the kerb.

(From: "The Surveyor and Municipal and County Engineer," 10th May, 1958.)

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3. IN THE PUBLIC'S NAME

● NEWLY elected county board members and newly appointed engineers must spend a substantial part of their first weeks learning about their jobs and the relationships their jobs involve. A new publication of the Washington State Association of County Commissioners titled "In the Public's Name," provides a guide for new commissioners and new engineers.

(From: Better Roads—April 1958.)

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4. REMEDIAL WORK WITH TAR SURFACE DRESSING

● AN interesting surface dressing job in which hot tar (36–37 deg. C. e.v.t.) and ¼ in. gravel chippings were used was carried out some months ago in the County Borough of Wolverhampton where approximately 65,000 sq. yd. of concrete carriageway were dressed by the spraying contractors normally working for that authority. The roads in question were on a housing estate and carry moderate traffic, which includes a regular bus service. A report on the work states:

Some of the concrete was in poor condition and the surface required considerable brushing to remove loose material, as this would have had a disastrous effect on the subsequent dressings. All depressions at badly fractured slabs were reinstated and the defective joints made good beforehand.

Two separate dressings were applied, the first being at 5 sq. yd. per gal. and the second, a week later, at 5.5 sq. yd. per gal. The ¼ in. chippings were spread at 150–160 sq. yd. per ton and were pressed into the tar by a 7-ton quick-moving roller.

The work was done in September last year and has proved so far a most economical way of dealing with a serious problem.

(From "The Surveyor and Municipal and County Engineer," 3 May, 1958.)

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5. FLEXIBLE CONSTRUCTION AT MANCHESTER AIRPORT RUNWAY EXTENDED 1,100 FT

● THE Manchester Airport runway extension, 1,100 ft long, will provide a total length of 7,000 ft of runway, which will accommodate the largest airliners now operating.

(Continued on page 33)

CURRENT LITERATURE

ABSTRACTS

Inspection of Vehicles for Road Worthiness, with Special Reference to Methods and Equipment; G. Grime, O.B.E., M.Sc., and R. D. Lister B. Sc. (Eng.) (Associate Member) A.M.I.C.E.,* Automobile Division, The Institution of Mechanical Engineers, London, SWI.

AN important section of the Road Traffic Act 1956 makes provision for the compulsory periodic inspection of road vehicles. This paper discusses some of the considerations involved, with special reference to the need for inspection, the items to be inspected, and the frequency of inspection. Descriptions are given of apparatus for measuring braking and lighting performance and, although for steering there is no commercial equipment with which a rapid assessment of the effects of wear and deterioration can be made, an experimental arrangement is described.

Several other items which it is important to inspect can only be assessed in terms of individual judgment which may nevertheless give valuable results. The accuracy and consistency of an assessment made by means of test equipment is affected by variability due to uncontrolled factors and by the accuracy with which the various parts of the operation can be performed. The equipment has been examined from this standpoint and the results are given.

Some of the facts which have to be considered in arriving at standards and test procedures are indicated and discussed.

Highway Capacity Studies; Bulletin No. 167, Highway Research Board of the National Academy of Sciences-National Research Council, 2101' Constitution, Washington, D. C.

This Bulletin contains six papers sponsored by the HRB Committee on Highway Capacity and presented at the 36th Annual Meeting, held in January 1957, as follows:

"Mass Transit in the Utilization of City Streets," by W. P. Walker and R. A. Flynt, compares the relative efficiencies of mass transit vehicles and private automobiles in the utilization of street space.

"New Method of Capacity Determination for Rural Roads in Mountainous Terrain," by H. C. Schwender, O. K. Normann, and J. O. Granum, describes application of the method to West Virginia highway studies.

"Operation of Weaving Areas," by O. K. Normann, gives theoretical means of checking such areas before construction.

"Pressurized Intersections" by R. C. Bluementhal and John W. Horn, reports on comparison studies between current results and those previously reported (1950) for specific locations.

"Effect of Temporary Bridge on Park way Performance," by Matthew J. Huber, describes bottleneck conditions on Connecticut's Merritt Parkway following a devastating flood.

"Trends in the 30th-Hour Factor" by William P. Walker, is an analysis of automatic traffic recorder data for rural highways.

Developing Concepts of Land Acquisition 1957; Bulletin No. 169, Highway Research Board of the National Academy of Sciences—National Research Council, 2101, Constitution, Washington, D.C.

ASSEMBLED in this bulletin are the report of the committee on Land Acqui-

* Road Research Laboratory, Dept. of Scientific and Industrial Research, Harmondsworth, Middlesex.

sition and Control of Highway Access and Adjacent Areas, and 4 papers presented at the Annual Meeting of the Highway Research Board in January 1957.

The report gives a resume of the year's highlights in land acquisition, which reflects the early and strong effects of the Federal-Aid Highway Act of 1956.

The papers by William G. Adkins, "Dallas Expressway Economic Impact Studies," and Robert G. Hennes. Bayard O. Wheeler and William L. Garrison, "Washington Highway Economic Impact Studies," are concerned with the significant effects highways have on the value of real property.

The presentation by Therel and Jerrilyn Black, "Some Sociological Considerations in Highway Development," brings out the importance of the human element in highway development and use.

Leroy C. Moser's paper, "The New Land Acquisition Law of Maryland," gives a verbatim account of the New Land Acquisition Law, which is an attempt to eliminate land speculation by freezing land values.

Those interested in the subjects covered in this report will find it of considerable value.

FIELD STUDIES OF METHODS AND MATERIALS FOR JOINT AND CRACK SEALING: Bulletin No. 166, Highway Research Board of the National Academy of Sciences-National Research Council, 2101, Constitution, Washington, D. C.

THIS bulletin contains two papers presented at the 36th Annual Meeting of the Highway Research Board, January 7-11, 1957.

"A Field Study of Joint and Crack Sealing Methods and Materials," by L. A. Fickes and C. C. Rhodes, describes the construction and subsequent study of performance of an experimental resealing project in Michigan in which six different brands of hot-pour sealer were used. Various methods of cleaning and resealing were investigated and an efficient procedure was developed.

"Field Testing of Materials for Sealing Cracks and Joints in Bituminous Concrete Resurfacings," by Egons Tons and Vincent J. Roggeveen, outlines the physical requirements that appear to be necessary for a successful crack sealer based on their previous research. They describe a series of tests designed to measure whether a sealing material would meet these requirements and report the results of testing 26 compounds by the Joint Highway Research Project at the Massachusetts Institute of Technology.

NEW TYPE OF THE ELEVATED BRIDGES AND DESIGN METHOD: Makato Gomi, C.E., Member, Transactions of The Japan Society of Civil Engineers, No. 53, Tokyo, Japan.

THERE are many problems to research in design of elevated bridges. Several of them are discussed in this report. They are :—

(1) Rigidity of footing to rotation: As a result of Test in most cases, column end might be considered as fixed end for design purpose.

(2) Shrinkage of concrete: The ultimate shrinkage of concrete is tested by 30 cm x 30 cm x 100 cm specimens (both plain and reinforced) in various conditions.

(3) The effect of allowable stress of materials on construction cost is investigated.

(4) Most optimum structure and material of hand rail to shut out the noise caused by the train operation is decided experimentally.

From these investigations, the author concludes that (1) the most predominant factor in the design of long continuous elevated bridge is the stress due to shrinkage and temperature change; (2) therefore, such structure in which shrinkage stress is minimum, is most desirable.

And new type of elevated bridge, using combination of longitudinal and transversal walls instead of beams and columns, is proposed.

(*Continued on page 33*)

SELECTED RECENT LITERATURE IN ENGINEERING JOURNALS

1. **Priority Road Programming;** W. J. FULTON, *Roads and Engineering Construction,* November 1955, pp. 106-120.

2. **Long Range Road Planning, Statistical Requirements and Methods;** DR. R. W. McCOLOUGH, *Roads and Engineering Construction,* November 1955, pp. 120-130.

3. **More Flexibility with Fixed Time Equipment;** LIONEL M. RODGERS, *Traffic Engineering, Vol. 26, No. 3,* December 1955, pp. 110-112.

4. **Traffic Accident Experience Before and After Pavement Widening;** A. J. COPE, *Traffic Engineering, Vol. 26, No. 3,* December 1955, pp. 114-115.

5. **Experiment at Slough, Needs of Pedestrians and Road Traffic Coordinated;** *Modern Transport, Vol. LXXV, No. 1928,* March 10, 1956, p. 8.

   Also, Highway and Bridges and Engineering Works, vol XXIII, No. 1128, February 29, 1956, p. 6.

6. **Report on Traffic Flows on Trunk Road A. I., within the City and County of Newcastle upon Tyne;** T. E. H. WILLIAMS AND A. W. WILSON, *The Journal of the Institution of Municipal Engineers, Vol. 82, No. 9,* March 1956, pp. 373-384.

7. **Accident Reduction at 15 Intersections in Built-up Areas in the Netherland;** IR. C. A. KUYSTEN AND A. L. ROSEAM ABBING, *International Road Safety and Traffic Review, Vol. III, No. 3,* Summer 1955, pp. 40-47.

8. **Traffic Bar;** HERBERT A. ROENEY AND JAMES A. CECHETINI, *California Highways and Public Roads,* January-February 1956, pp. 40-41.

9. **Design of Road Intersections;** *Highways and Bridges and Engineering Works, Vol. XXIII, No. 1134,* April 11, 1956, pp. 1, 3 and 4.

10. **"Pen Pointing" Traffic Signal Troubles;** ROBERT H. WAM, *Traffic Engineering, Vol. 26, No. 8,* May 1956, pp. 335-337 and 340.

11. **Traffic Congestion—an assessment of the Problem and measures for relief;** H. SCHOFIELD, *The Journal of the Institution of Municipal Engineers, Vol. 83, No. 2,* August 1956, pp. 49-63.

12. **Traffic Engineering - A Brief Survey;** D. G. CHARLESWORTH, *The Journal of the Institution of Highway Engineers, Vol. 111, No. 11,* July 1956, pp. 87-91.

13. **The Capacity of Urban Streets and Intersections;** K. V. M. KOEFOED, *Traffic Engineering,* August 1955, pp. 456-458.

14. **Traffic Engineering—Operational Research in Road Design and Construction;** SIR CHARLES GOODEVE, *Modern Transport, Vol. LXXVI, No. 1958,* December 1956, p. 7.

15. **Traffic Engineering in the United States;** *Main Roads, Vol. XXII, No. 2,* December 1956, pp. 50-59, Part I.

16. **Traffic Survey in Cambridge;** BETTY YULE, *Journal of the Town Planning Institute, Vol. XIII, No. 5,* April 1957, pp. 116-119.

17. **Traffic Flow in Urban Areas;** COL. S. GREEN'S PAPER, *The Surveyor, Vol. CXVI, No. 3389,* April 6, 1957, pp. 316-318.

    Also Highways and Bridges and Engineering Works, Vol. XXIV, No. 1185, April 10th, 1957, p. 13.

18. A Turn to the Left; W. E. SCHWANHAUSSER, *Traffic Engineering, Vol. 27, No. 7*, April 1957, pp. 313-317.

19. Some Aspects of Freeway Design and Operation; T. J. GWENS, *Traffic Engineering, Vol. 27, No. 7*, April 1957, pp. 318-319.

20. Urban Carriageway Traffic Survey in Birmingham; *Vol. CXVI, No. 3391*, April 20, 1957, pp. 431-432.

21. Survey Railroad Crossings at Grade for Traffic Delays; *Better Roads, Vol. 27, No. 6*, June 1957, pp. 46 and 48.

22. Parking Studies by Abbreviated Methods; D. W. SCHOPPERT, *Traffic Engineering, Vol. 28, No. 2*, November 1957, pp. 9-14 and 48.

23. Storage Control—A New Concept; W. B. DELANO, *Traffic Engineering, Vol. 28, No. 2*, November 1957, pp. 18, 19 and 50.

24. Urban Roads Given High Capacity Through Medians and Signals; A. L. HIMELHOCK, *Traffic Quarterly, Vol. XI, No. 4*, October 1957, pp. 514-528.

25. Major Street Planning Problems Solved by Factual Studies; EDWARD M. HALL, *Traffic Quarterly, Vol. XI, No. 4*, October 1957, pp. 529-546.

26. Traffic Circles in Washington, D. C.; D. S. BRINKLEYAND, W. L. BRAUN, *Traffic Quarterly, Vol. XI, No. 4*, October 1957, pp. 547-556.

27. Child Pedestrian Safety—A Realistic Approach; HAROLD MARKS, *Traffic Engineering, Vol. 28, No. 1*, October 1957, pp. 13-19 and 25.

28. Limitations of Signal Spacings in a Co-ordinated System on a High Speed, Dual Highway; BURTON M. RUDY, *Traffic Engineering, Vol. 28, No. 1*, October 1957, pp. 20-25.

29. Separating Walkers and Right-turners; M. E. BRUENING, *Traffic Engineering, Vol. 28, No. 1*, October 1957, pp. 39-40.

30. Distribution of Time Gaps Between Successive Vehicles; DR. W. LEUZBACK, *International Road Safety and Traffic Review, Vol. V, No. 3*, Summer 1957, pp. 31-36.

WORDS OF WISDOM

When you have saved a boy from the possibility of making a mistake, you have also prevented him from developing initiative.

John Erskine

"Why can't you use my poem?" asked the would-be contributor. "Is it too long?"

"Yes," snapped the editor. "It's too long, too wide and too thick!"

(Continued from page 28)

Experiments have been also carried out with respect to various points, which may be problematical in this case.

SPECIFICATION FOR HIGH TENSILE STRUCTURAL STEEL: Indian Standards Institution, New Delhi.

THE Indian Standards Institution has published an Indian Standard Specification for High Tensile Structural Steel. This standard is one of a series of Indian Standards being published for implementation of the ISI Steel Economy Programme. High tensile steels are a specific class of steels in which enhanced mechanical properties, and in most cases increased resistance to atmospheric corrosion, are obtained by the incorporation of low proportions of one or more alloying elements besides carbon. These steels are generally intended for application where saving in weight can be effected by reason of their greater strength and atmospheric corrosion resistance.

The Standard prescribes the requirements for high tensile structural steel (including fusion welding quality) in the form of bars, plates and sections, used in bridges and general building construction. The material specified in this Standard has higher ultimate tensile stress and yield stress than ordinary structural steel.

The copies of this Standard (IS: 961-1957), published in English and priced at Rs. 1.50 each, can be obtained from the headquarters of the Indian Standards Institution, 9, Mathura Road, New Delhi, or from its branch offices at Calcutta-1, Bombay-1, and Madras-6.

(Continued from page 30)

It is 150 ft wide within a flight strip 1,000 ft wide and is of flexible construction 39½ in. deep, consisting of layers of consolidated stone on a 'no fines' concrete base 6 in. deep, topped with 6 in. of dry lean concrete and finished with 4½ in. of hot rolled asphalt in two layers to Air Ministry Specification 201/57.

The average longitudinal fall is 1 in 165 and the crossfall is 1 in 70, the surface water falling to gullies which discharge into porous pipe main drains parallel to the runway in the form of french drains, 10 ft to 14 ft deep, which act as cut-off drains to the grassed flight strip.

Pits for the lighting fittings and all the necessary ducts were constructed together with manholes and draw-in pits for the cables.

At the end of the runway extension a stop-way has been prepared 200 ft long and 150 ft wide, so that aircraft over-running the hard surface may pull up without damage. This stopway has been soiled and seeded so that it will not be mistaken by pilots for the hard runway. When a similar stopway 900 ft long at the north-east end of the runway is prepared, it will give a balanced field length for the runway of 8,100 ft.

(From: "The Surveyor and Municipal and County Engineer," 10 May 1958.)

When a motorist who had crashed into a telegraph pole and brought down the wires recovered consciousness, his hands were clutching the wires.

"Thank Heaven!" he exclaimed fervently. "It's a harp."

RECENT ADDITIONS TO THE LIBRARY OF THE INDIAN ROADS CONGRESS

1. **"The Use of Good English in Technical Writing"**; J. H. Bolton, Engineering Report No. 24, 1954-55, Iowa Engineering Experiment Station, Iowa State College, Ames, Iowa, (U.S.A.).

2. **University of Colorado Engineering Experiment Station Circular - The Twenty-fourth Annual Highway Conference of the University of Colorado, Highway Series, May 1951, No. 24**; University of Colorado, Boulder (U.S.A).

3. **Regulations on Weight of Motor Trucks—Problems Illustrated by Wisconsin's Experience in Hauling Fluid Dairy Products Marketing**; L. John Kutish, Research Report No. 28, November 1952, United States Deptt. of Agriculture, Bureau of Agricultural Economics and University of Wisconsin, College of Agriculture, Washington D. C.

4. **"The Benefits of Good Roads"**; Robert J. Potts, Bulletin No. 18, Third Series Vol. 3, July 15, 1917, No. 14, of the Agricultural and Mechanical College of Texas, Texas Engineering Experiment Station, Texas.

5. **Retention of Cover Stone by Asphalt Surface Treatments**; Fred J. Benson and Bob M. Galloway, Bulletin No. 133, September 1953, Texas Engineering Experiment Station, College Station, Texas.

6. **Proceedings of the Twenty-third Annual Short Course in Highway Engineering**; Fred J. Benson, Bulletin No. 112, Fifth Series, Vol. 5, August 1, 1949, No. 8, of the Agricultural and Mechanical College of Texas, Texas Engineering Experiment Station, College Station, Texas.

7. **Annual Report (Technical) 1952, Central Water and Power Station, Poona Research Publication No. 18**; Director D. V. Joglekar, Central Water and Power Research Station, Poona.

8. **"The Skid-Resisting Properties of Roads and Tyres"**; G. Grime and C. G. Giles, Reprinted from Proceedings of Institution of Mechanical Engineers, Automobile Division, 1954-55 (1) 19-30 Disc. 45-48, The Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, S.W. 1 (England).

9. **Experimental Investigations on the Breaking Performance of Motor Vehicles, Reprinted from Proceedings of Institution of Mechanical Engineers, Automobile Division, 1954-55 (1) 31-44 Disc. 49-56**; H. J. H. Starks and R. D. Lister, The Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, S.W. 1 (England).

10. **"The Bulking of Sand and its Effect on Concrete"**; A. T. Goldbeck, Bulletin No. 1, (Issued May 1927), The National Crushed Stone Association, Merchandise Building, 14th and S. Streets, N.W., Washington, D.C.

11. **"Low Cost Improvement of Earth Roads with Crushed Stone"**; A.T. Goldbeck, Bulletin No. II (Issued July 1927), The National Crushed Stone Association, Merchandise Building, 14th and S. Street, N.W., Washington D.C.

12. **"Retreading" Our Highways Bulletin No. 4, (Issued April 1928)**; A. T. Goldbeck, The National Crushed Stone Association, Merchandise Building, Fourteenth & S. Street, Washington D.C.

13. **"Investigations in the Proportioning of Concrete for Highways"**; A. T. Goldbeck, Bulletin No. 7, (Issued September 1931), The National Crushed Stone Association, Merchandise Building, Fourteenth & S. Streets, Washington D.C.

(Continued on page 38)

BUDGETS AND ADMINISTRATION REPORTS

GOVERNMENT OF MYSORE BUDGET FOR THE YEAR 1958–59

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

Revenue

Heads	Revised estimates 1957-58	Budget Estimates 1958-59
	(Rupees in lakhs)	
Rents	3.30	4.50
Ferry receipts	1.51	1.32
Recoveries of expenditure	6.13	102.05
Transfers from Central Road Fund	34.88	7.89
Grants from Govt. of India for construction and developments of State Roads of economic or inter-State importance.	33.16	19.99
Subventions from Government of India for Development		
a. Works connected with Tourism	—	7.05
b. For building works under the Development schemes	—	6.77
Miscellaneous	8.38	6.45
Deduct - refunds	0.11	0.12
Total	87.25	155.90

Expenditure

Buildings		
Original Works	65.98	64.85
Repairs	25.32	21.00
Communications		
Original Works	124.23	196.08
Repairs	175.98	167.•5
Establishment	37.05	38.79
Tools and Plant	23.59	31.26
Grants-in-aid	14.95	33.53
Suspense	5.00	5.00
Add recoveries	325.14	344.27
Total	797.24	901.93

Capital account of Civil Works outside the Revenue account

Head	Revised Estimates 1957-58	Budget Estimates 1958-59
	(Rupees in lakhs)	
Original Works		
Buildings	123.41	201.72
Communications	146.55	151.63
Miscellaneous	0.22	—
Establishment	21.79	22.50
Tools and Plant	1.50	1.61
Grants-in-aid	15.00	11.00
Deduct—Receipts on Capital account	—	24.00
Add—recoveries	16.00	40.00
Total	324.47	404.46
Revenue from Roads:		
Receipts under the Indian Motor Vehicles Act	6.50	5.00
Receipts under the State Motor Vehicles Taxation Act	162.95	181.50
Other receipts	1.26	0.50
Tax on Petrol	57.18	83.19
Tax on Motor spirit other than petrol	20.28	34.07
Tax on Tyres	1.00	1.00
Deduct	0.71	0.71
Total	248.46	304.56

(A brief review of the Budget)

THE revenue and expenditure on revenue account of the Government of Mysore for 1958-59 are estimated at Rs 6549.21 lakhs and Rs 6535.16 lakhs respectively, with an anticipated surplus of Rs 14.05 lakhs.

The expenditure on Civil Works for year 1958-59 is estimated at Rs 901.93 lakhs which is 13.8 per cent of the total revenue of the State. Corresponding figure for the previous year stands at 13.9 per cent.

The expenditure on communications alone (original works and repairs only) works out to Rs 363.23 lakhs for 1958-59 which is 5.5 per cent of the total revenue of the year.

The Capital outlay on Civil Works, outside the revenue account is estimated at Rs 404.46 lakhs for 1958-59.

LIST OF APPROVED WORKS ON NATIONAL HIGHWAYS

S.No.	Job No.	Name of Work	Amount Rs Lakhs
		ASSAM	
1.	1892-AS-40	Widening miles 30 and 31 of National Highway No. 40 near Nongpoh Control Gate in K & J District, Assam.	2.00
2.	1893-AS-31	Reconstruction of bridge No. 173/1 on National Highway No. 31 damaged by floods of 1954 and 1955 between Golakganj and Baxirhat.	0.12
		BENGAL	
3.	1888-BG-6	Construction of a bridge over the river Kangsabati at Panskura on National Highway No. 6.	14.52
4.	1899-BG-34	Construction of a permanent approach road to Khejuria ferry ghat for Dhulian-Khejuria ghat ferry service on National Highway No. 34 in the district of Malda.	0.76
		BIHAR	
5.	1895-BR-28	Construction of National Highway No. 28 from Muzaffarpur to Dalsingsarai in Darbhanga District.	22.39
6.	1896-BR-28	Construction of National Highway No. 28 from Muzaffarpur to Dalsingsarai in Muzaffarpur district.	36.40
		BOMBAY	
7.	1891-BM-8	Providing new culverts on Rajkot-Rihda Road Section of National Highway No. 8-B.	0.27
		JAMMU & KASHMIR	
8.	1889-JK-1A	Construction of high level bridges over Khaderu Khads causeways Nos. 1-2 on Pathankot-Jammu Road, National Highway No. 1-A.	13.24

S. No.	Job No.	Name of work	Amount (Rs in lakhs)
9.	1887-JK-1A	Widening of berms along Pathankot-Jammu Road (National Highway No. 1-A) from mile 63/3 to mile 94.	1.01
		PUNJAB	
10.	1898-PB-10	Improving curves on Delhi-Hissar-Sulemanki Road mile 67.62 to 100 in Hissar District.	1.98
		RAJASTHAN	
11.	1894-RJ-8	Construction of bridge at Ada Nallah in mile 42 of Jaipur-Delhi Road, National Highway No. 8.	0.68
		SIKKIM	
12.	1897-SK-31-A	Providing a course of hard metal of two coats of surface dressing between miles 33/4, to 38/4 of Tista-Rangpo road, National Highway No. 31-A during 1957-58 in Sikkim State.	2.16
		UTTAR PRADESH	
13.	1890-UP-2	Acquisition of land for the construction of Diversion (Barari Bye-Pass) in mile 775-776 of Bombay-Delhi Road, National Highway No.3, in Mathura District.	0.07
14.	1900-UP-28	Construction of approaches to the proposed bridge across the Rapti river on Gorakhpur on National Highway No. 8.	9.59

(Continued from page 34)

14. **" A Method of Proportioning Concrete for Strength, Workability and Durability "**; A. T. Goldbeck and J. E. Gray, Bulletin No. 11, Revised, November 1953, National Crushed Stone Association, 1415, Elliot Place, N.W., Washington D.C.

15. **Ministry of Transport and Civil Aviation—Report on the Administration of the Road Fund for the year 1953-54**; H. M. Stationery Office, London.

16. **" Makeway Ahead "—The Case for a National Authority**; British Road Federation Ltd., 4-a, Bloomsbury Square, London W.C. 1.

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