TRANSPORT-COMMUNICATIONS

MONTHLY REVIEW (TCMR)

OCTOBER 1961—No. 174

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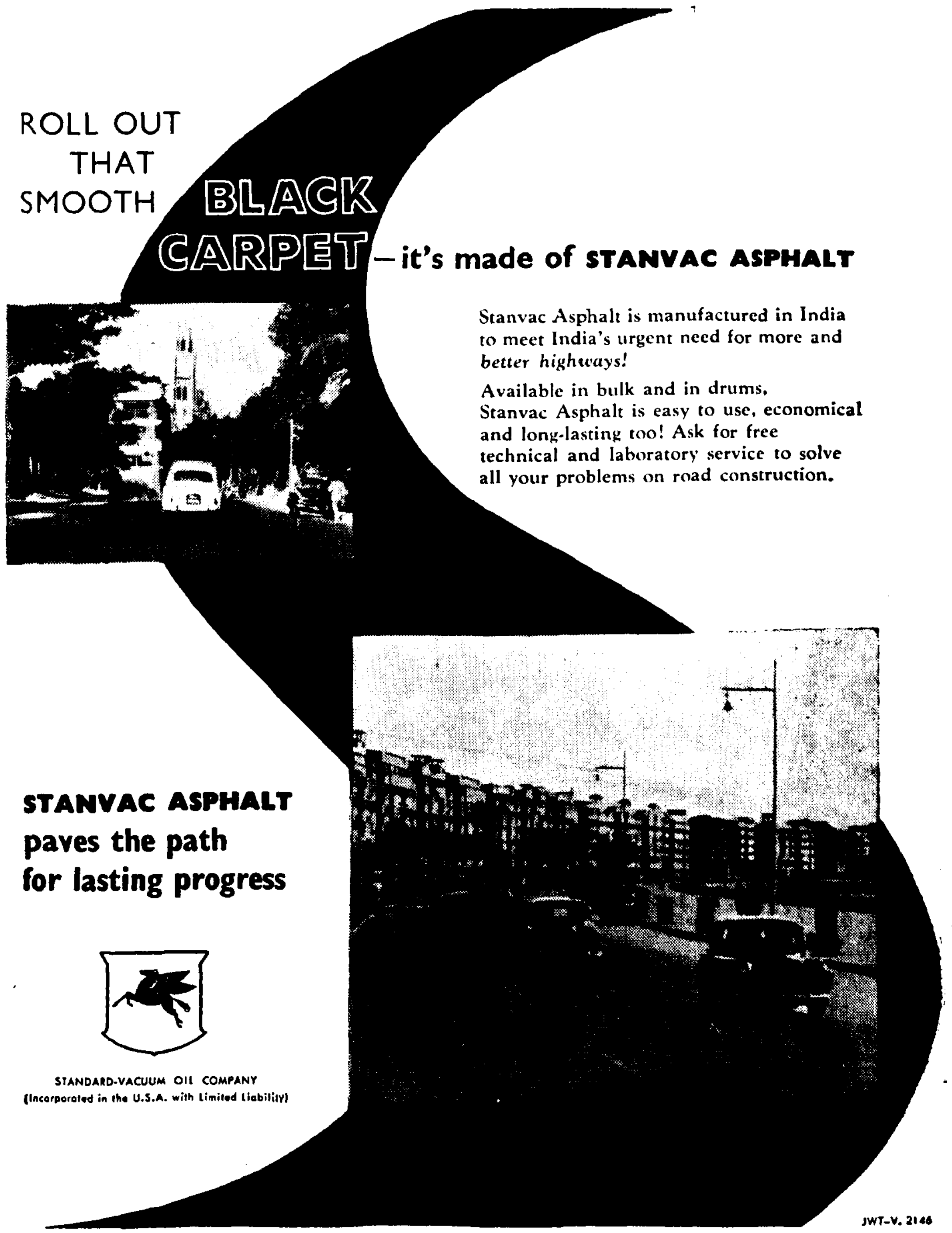
INDIAN ROADS CONGRESS, NEW DELHI.



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LIST OF CONTENTS

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ROAD RESEARCH BULLETIN NO. 7

PERFORMANCE OF STABILISED BASE COURSES VALUE OF WBM COURSE UNDER BLACK TOP SURFACING

Road Research Bulletin (No. 7) issued by the Indian Roads Congress gives details of a series of tests carried out between 1949 and 1958 at the Test Track at Majherhat, Alipore, Calcutta, on the performance of different types of stabilised base courses under adverse moisture conditions.

These tests were conducted with a view to

(i) finding out the thickness of stabilised soil base required to replace the double layer of flat brick soling normally used in deltaic regions, particularly in West Bengal, where bricks are expensive and stones are scarce;

(ii) determining the feasibility of using stabilised pavement as a base or top course with suitable bituminous surface dressing for further economy.

One of the most important findings of the present series of tests was that a 7-in. thick stabilised soil base, has comparable qualities with those of a 6-in. thick double flat brick soling, and can replace the latter even under adverse moisture conditons.

From the performance of different types of stabilised base course it has been found that there should be at least a 3-in. thick waterbound macadam coat between the black top surfacing and the stabilised base course.

Experiments to find suitable surfacing for stabilised bases included the laying of a 1 in. precoated asphalt chip carpet laid over the following surfaces:

(i) Sand-moorum stabilised base course with stone metal grafted surface.
(ii) Sand-soil-cement stabilised base course with stone metal grafted surface.
(iii) Sand-soil-cement stabilised base course with waterbound macadam surface.
(iv) Sand-soil aggregate stabilised soil base course.
(v) Sand-soil-aggregate stabilised base with stone metal grafted surface.

A seal coat with Shell Primer No. 1 at the rate of 40 lb per 100 sq. ft. was given over the sub-grade in two test sections to cut off the rise of moisture from the sub-grade.

All the test sections were observed to have failed except test section No. 3 (W.B.M. course over stabilised soil base course). Failure in the form of sliding of the carpet along with the materials in the top portion over the stabilised soil wearing course over which it was laid took place under the wheels in all the test sections. At the test sections, where the wearing courses were grafted with stone metal, the carpets slide along with the grafted metal and the materials around it. The effect was more pronounced in test section No 4 and 5 i.e., in the sand-soil-aggregate stabilised pavement.

The failure was due to the softening of the top portion of the stabilised soil base course due to the presence of moisture and the consequent reduction in the shearing and bearing values of the upper portion of the base courses. Moisture rise occurred neither in the test sections with bituminous seal coat over the sub-grade nor in those test sections without the seal coat.

The level of free water in the water indicators did not appear to give correct indication of the capillary movement of water. It was, therefore, considered that the presence of moisture in the upper portion of the wearing course might be due to the ingress of rain water from the surface through the carpet and through cracks which might have developed subsequently.

As indicated above it is necessary to have a compacted layer of waterbound macadam in between the bituminous surfacing and the stabilised soil course under the conditions of the test in which water could not be completely prevented from getting into contact with the stabilised soil course.

(From " Highways and Bridges and Engineering Works ", July 5, 1961.)

TRANSPORT-COMMUNICATIONS MONTHLY REVIEW

A REVIEW OF
ROAD ENGINEERING, DEVELOPMENT & TRANSPORT

OCTOBER 1961 27

SOME OBSERVATIONS ON THE EFFECT OF 'SPEED LIMIT', 'STOP/DEAD SLOW' SIGNS AND CURVE MARKINGS ON DRIVER'S BEHAVIOUR

By

SHARFUDDIN *

Introduction

THE effectiveness of the road signs depends upon their respective values, clear understanding, proper location, observance on the part of the drivers and other related factors. Sufficient statistics of traffic accidents in Delhi during 1958 show that out of the total of 2,838 accidents, 24 per cent occurred at the road intersection due mainly to drivers' inability to yield right-of-way at the crossings and about 27 per cent occurred at suburban roads due to rash driving ignoring the posted speed-limit signs. Thus about 51 per cent of the accidents could be attributed to either ineffectiveness of the signs or to non-observance of other traffic rules.

This study deals with effectiveness of the 'Speed Limit', 'STOP' and 'DEAD SLOW' traffic signs and the driver's behaviours in relation to road-marking at the road curves.

Field Observations and Analysis (Before and After)

(i) Speed Limit Sign and Drivers

On the suburban sections of Kitchner road, Rohtak road and Mathura road, the average speed of the traffic under categories light motor vehicles, buses and trucks were determined by spot speed method in July 1959 before speed restriction signs were erected. Speed-limit signs were erected in January 1960 and similar speed surveys were carried out in June-July 1960. In each case the surveys were conducted in off peak hours, i. e., between 11 a.m. to 4 p.m. so that the speed of the vehicles could not be affected by congestion. Observation made (before and after), the standard deviations and average speed of the vehicles computed are shown in Table 1.

On Rohtak road the average speed of the light motor vehicles was 29.64 miles, decreased by 1.52 miles an hour after the installation of speed-limit signs. The difference was statistically examined and found significant.

On Kitchner road where the speed limit for light motor vehicles was 35 miles per hour the average speed increased by 1.74 miles after the installation of the speed signs. This increase could be due to the higher speed limit fixed on this road.

On two sections of Mathura road one near Supreme Court and the other near I.S.I Building there was some decrease in the average speed but the same was not statistically significant. On section of Mathura road near Friends Colony, road surface having been appreciably improved after imposition of speed limit restriction, the observations (before and after) cannot be

* Central Road Research Institute, New Delhi.

Photo 1

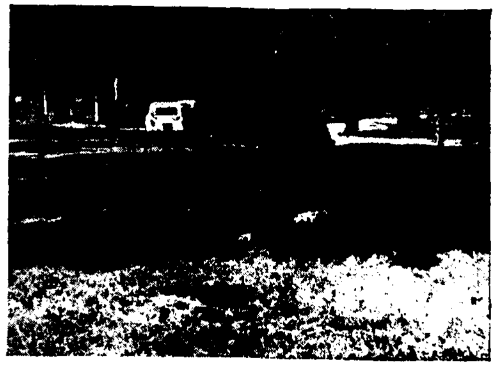


Photo 2

At Safdarjung Road curve the drivers are taking wrong turning to right side

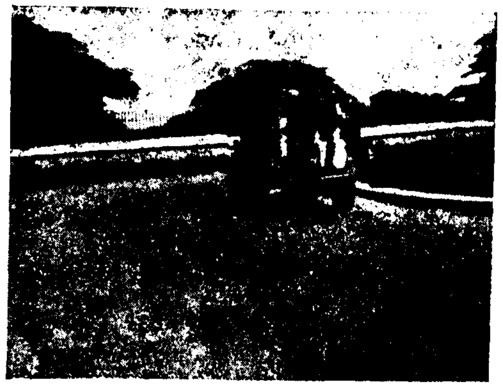


Photo 3

The driver is taking wrong turn to right side at Sundar Nagar Road

Photo 4

At Sundar Nagar Road curve

Photo 5

At Safdarjung Road curve

Vehicles are taking correct turning to the right sides after marking the central line (broken type)

TABLE 1

Reaction of the drivers to Speed-Limit Sign

Name of the Roads	Direction	Light Motor Vehicles					Buses					Trucks (Others)				
		Average speed before	Stand. deviation	Average speed after	Stand. deviation	Change in average speed	Average speed before	Stand. deviation	Average speed after	Stand. deviation	Change in average speed	Average speed before	Stand. deviation	Average speed after	Stand. deviation	Change in average speed
Rohtak Rd. (near Ring Rd. Crossing)	Towards Delhi	29.64	3.23	28.12	3.42	− 1.52	24.9	6.57	25.9	6.79	+ 1.0	26.5	6.99	27.6	6.36	+ 1.1
Kitchner Rd. (near Gurgaon Rd. Crossing)	Do.	30.36	3.37	32.1	4.11	+ 1.74	26.0	7.68	25.11	4.79	− 0.89	26.0	7.23	26.5	5.21	+ 0.5
Mathura Rd. near ISI Building	Towards Mathura	25.97	3.4	24.8	2.5	− 1.17	24.3	4.79	23.1	3.69	− 1.2	23.0	6.7	22.7	6.0	− 0.3
Mathura Rd. (near Supreme Court)	Do.	31.0	5.0	30.55	4.0	− 0.35	27.3	6.8	26.8	6.3	− 0.5	26.5	5.0	25.9	6.9	− 0.8
Do.	Towards Delhi	29.7	4.6	28.6	3.6	− 1.1	25.0	4.6	24.7	5.2	− 0.3	25.5	6.0	25.5	5.6	0.0
Mathura Rd. (near Friends Colony)	Do.	30.0	3.9	33.56	4.07	+ 3.56	27.5	7.3	28.25	6.9	+ 0.75	29.6	3.9	30.9	4.8	+ 1.3

Speed Limit

For Light Motor Vehicles 30 m.p.h. on all the roads except Kitchner Road where speed limit was 35 m.p.h.

Buses 25 m.p.h.

Others (Trucks) 20 m.p.h.

compared statistically for evaluating the effectiveness of the signs installed.

The traffic intensity between Delhi Gate to Hardinge Bridge on Mathura road is several times more than traffic on it near Friends Colony but the numerical speed limit is the same for this road.

From Table 1, it can be seen that a single overall speed limit over the road sections with wide disparity in driving conditions is unsatisfactory and unreliable.

The speed limit for buses on all the roads in Delhi was 25 miles per hour. On Rohtak road, there is some increase in the average speed of buses and trucks but not

Photo 6

Photo 7

More vehicles at Safdarjung Road curve are taking correct turning to right side after marking the central solid line

significant. On Kitchner road, Mathura road (near ISI Building and Supreme Court), the average speeds of the buses have slightly decreased, but the decrease is not statistically significant.

After imposition of speed limit (20 miles) for the trucks on these roads, the average speed of the trucks is not much affected excepting on Rohtak road where the increase in average speed is found insignificant. There was either slight increase or decrease. But they were statistically insignificant.

On further analysis, it was found that 28 per cent of light motor vehicles, 86 per cent of the trucks, 48 per cent of buses were travelling at speed more than the speed limits prescribed. After erection of the signs 21 per cent light motor vehicles, 84 per cent of the trucks and 44 per cent of the buses were travelling at speed greater than their permissible speed limit. It can also be seen that there was no significant change in the uniformity of speeds as represented by the standard deviations. It is thus clear that after imposition of speed limit there is comparatively some improvement in the behaviour of drivers and appreciable reduction or increase in the speed of light motor vehicles.

Field studies, however, show the general compliance of Delhi drivers with speed-limit signs is very poor.

(ii) Stop and Dead Slow Signs and Driver

On three intersections of minor and major roads with 'STOP' signs, five intersections with 'DEAD SLOW' signs and four intersections with no sign at all, the counts were made of the number of the drivers who stopped, slowed down or did not stop at all under the following conditions:—

(i) When the intersection is clear in the absence of other vehicles.

(ii) In the presence of other vehicles which approached the intersection from other sides.

Similar counts were made after covering the existing signs with paper. The observations are shown in Table 2.

In Table 2 it can be seen, that at the intersections where 'DEAD SLOW' signs are installed 23.7 per cent vehicles voluntarily slowed down, 24.6 per cent slowed down owing to the presence of other traffic at the intersection, and 43 per cent did not react to the sign for slowing down. At the intersections with 'STOP' signs only 2 per cent stopped voluntarily and 3 per cent

stopped due to the approach of other vehicles at the intersection, 25 per cent voluntarily slowed down, 20 per cent slowed down due to presence of other vehicles at the intersection, 36.5 per cent did not stop/slow at all.

After covering the existing 'DEAD SLOW' signs with paper only 18.2 per cent drivers voluntarily slowed down, 19.7 per cent slowed down due to presence of other vehicles, 54 per cent did not slow down. At the covered 'STOP' intersection 1 per cent stopped, 21.4 per cent slowed down, 53 per cent did not stop/slow. At the intersection where no signs have been installed 16.7 per cent of the drivers slowed down and 16 per cent slowed down due to the presence of other vehicles at the intersection. About 62 per cent did not stop or slow

TABLE 2

Reaction of drivers to 'STOP & DEAD SLOW' Signs

Site No.	Sign installed	No vehicle at the intersection: No. of vehicle stopped/dead slowed before entering the intersection: Stopped		Slowed down		No. of vehicles which did not stop or slow down		Vehicles at the intersection: No. of vehicle stopped/slowed down before entering the crossing: Stopped		Slowed down		No. of vehicles which did not stop or slow down		Total No. of vehicles observed
1.	DEAD SLOW	—		48	29%	63	38%	13	8%	40	24%	1	.67%	168
2 (a).	—	—		27	19%	62	44%	15	11%	36	26%	—		140
2 (b).	—	—		30	24%	44	34%	19	15%	32	26%	—		125
3.	—	—		14	16%	62	70%	—		12	14%	—		88
4.	—	1	.6%	35	22%	72	45%	13	8%	36	22%	4	3%	160
5.	—	—		63	27%	92	39%	11	5%	69	29%	1		236
Average		1		217	23.7%	395	43%	71	8%	225	24.6%	6	1%	914
6.	STOP	1	1%	31	28.4%	34	30%	17	15.6%	25	23%	1	1%	109
7.	—	6	4%	39	26%	40	27%	29	20%	29	20%	5	3%	148
8.	—	1	1%	22	20%	61	54%	8	7%	19	17%	2	2%	113
Average		8	2%	92	25%	135	35%	54	14.6%	73	20%	8	2%	370
9.	No Sign	—		5	9.3%	44	81.5%	—		5	9.3%	—		54
10.	—	—		7	9.4%	46	62%	3	4%	17	23%	1	1.3%	74
11.	—	—		17	24%	40	56%	—		7	10%	7	10%	71
12.	—	—		20	21%	51	54%	—		19	20%	5	5.3%	95
Average		—		49	16.7%	181	61.6%	3	1%	48	16%	13	4.4%	294

TABLE 2—(*Contd.*)

Site No.	Sign installed	No vehicle at the intersection: No. of vehicle stopped/dead slowed before entering the intersection — Stopped	No vehicle at the intersection: No. of vehicle stopped/dead slowed before entering the intersection — Slowed down	No vehicle at the intersection: No. of vehicle which did not stop or slow down	Vehicles at the intersection: No. of vehicle stopped/slowed down before entering the crossing — Stopped	Vehicles at the intersection: No. of vehicle stopped/slowed down before entering the crossing — Slowed down	Vehicles at the intersection: No. of vehicles which did not stop or slow down	Total No. of vehicles observed
1.	After covering the Dead Slow sign	—	54 26%	85 41%	17 8%	49 24%	1	206
2 (a).		—	28 17%	69 50%	18 13%	26 19%	—	136
2 (b).	—	—	27 23%	48 42%	17 15%	23 20%	—	115
3.	—	—	10 11%	71 76%	—	13 14%	—	94
4.	—	—	18 12%	85 59%	7 5%	32 22%	2 1.5%	144
5.	—	—	16 14%	81 69%	1 1%	17 15%	2 2%	177
Average		—	148 18.2%	439 54%	60 7.4%	160 19.7%	5 1%	812
6.	After covering the Stop sign	—	28 22%	63 50%	14 11%	20 16%	—	125
7.		2 3%	20 29%	25 36%	6 9%	16 23%	1 1.3%	70
8.		1 1%	21 16%	83 65%	4 3%	16 13%	3 2%	128
Average		3 1%	69 21.4%	171 53%	24 7.4%	52 16%	4 1.3%	328

down. Although the differences in presence of sign and in the absence (covered) of signs and with no sign at all are not very much but these differences where statistically analysed were found significant.

From the field observations, it appears that the intersection-control devices are not very much respected by most of the motorists but certainly a percentage of them do observe. Many drivers stopped/slowed down only at the approach of vehicles from other arms of intersection to avoid any mishap.

The existence of signs increases the percentage of the observing drivers by about 5 to 7 per cent. Although apparently this difference seems to be quite small but checked statistically it is significant and demand the provision of the signs at all uncontrolled intersections.

(iii) Curve Marking and Drivers

At sharp curves, it has been observed that the drivers take easy and defective turnings. This is the main reason of more accidents at such points—Photos 1 to 3.

The central line on the road is for the motorists to keep in their own left lane. In general practice one broken type central line is marked on portion of roads where the traffic could cross the line and firm continuous line on the portions of road where traffic cannot cross from one traffic lane to another. To see the effect of this continuous line at road curves on the drivers' behaviour, two right-angled road turnings (Safdarjang road and Sundar Nagar road curves) were selected. In the absence of central line, drivers both taking correct or wrong turns were counted on three week days separately in

TABLE 3

Drivers' behaviours at the Curves

Site	Direction	No. of vehicle at the Curve: Without Central Line — Correct turning	Without Central Line — Wrong turning	Without Central Line — Total	With Central Line (Chain Type) — Correct turning	With Central Line (Chain Type) — Wrong turning	With Central Line (Chain Type) — Total	With Central Line (Solid) — Correct turning	With Central Line (Solid) — Wrong turning	With Central Line (Solid) — Total
Safdarjung Rd. near Safdarjung	Left turning (Race Course to Safdarjung)	253 94.8%	14 5.2%	267	446 97%	14 3%	460	499 98%	10 2%	509
Do.	Right turning (Safdarjung to Race Course)	45 15%	256 85%	301	253 50%	252 50%	505	287 61.2%	182 38.8%	469
Sunder Nagar Rd.	Left turning	196 87.5%	28 12.5%	224	188 90%	21 10%	209	233 96.28%	9 3.72%	242
Do.	Right turning	69 31.9%	147 68.1%	216	115 68.5%	53 31.5%	168	186 81.6%	42 18.4%	228

the absence of other vehicles (coming from opposite or same direction at the curve). After taking the counts, at both the sites, broken central line was provided and again similar counts were taken on three week days. After a month, continuous solid lines at both the sites were provided and similar counts were taken for the same period.

In Table 3, it can be seen that at both the sites in the absence of central line about 88-95 per cent of the left turning traffic took voluntarily correct turns and a very small per cent took wrong and defective turns. About 75 of right turning traffic took sharp and defective turnings. At Safdarjang road curve in the absence of central line, only 15 per cent of the right turning traffic took proper turns voluntarily, 85 per cent wrong turnings. At Sundar Nagar road curve 31.9 per cent took correct turns and 68.1 per cent wrong turns.

After marking the central line broken type at both the sites, 50 per cent of the right turning traffic took voluntarily correct turns, 50 per cent wrong turns at Safdarjung road curve and 68.5 per cent correct turns, 31.5 per cent wrong turns at Sundar Nagar curve.

After providing the central line continuous at both the sites, the percentage of traffic taking correct turns to the right side has considerably increased. At Safdarjung road curve, the percentage of correct right turning further increased from 50 per cent to 61.2 per cent. At Sundar Nagar road curve, it increased from 68.5 per cent to 81.6 per cent. The right turning traffic taking wrong turns also correspondingly decreased. This shows that the central continuous marking has marked effect on the drivers' behaviour to keep them in their own lane—Photos 4 to 9.

Recommendations

The following recommendations are based on the limited study carried out in the field and explained in article.

1. Since the Delhi drivers at present pay little attention to the speed signs, strict enforcement seems to be a necessity specially in the area where such signs are posted. The study indicates that special

Photo 8

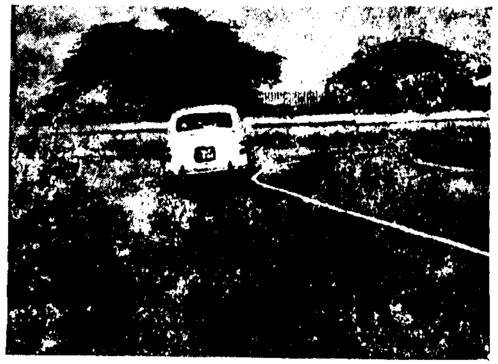


Photo 9

Vehicles at Sundar Nagar Road Curve are taking correct right turns after marking central continuous line

emphasis for speed enforcement may be given to truck drivers and bus drivers as 84 per cent and 40 per cent respectively were found to drive faster than the speed allowed.

2. While fixing the speed limit, prevailing speed of traffic should be kept in view. If 85 percentile of the prevailing speed of traffic is used for fixing the speed limit, then traffic conditions warrant different speed limits on the different sections of the road.

3. From the three intersections observed it was found that not more than 2 per cent drivers stop on the 'STOP' sign.

4. The effect of solid central line on road curvature is encouraging for improving drivers' behaviour as indicated on the two trial spots with 90-degree curve on each. At Sundar Nagar curve, the percentage of drivers taking correct turn to right side improved from 25 per cent to 70 per cent, when broken line was put in. With solid central line the percentage further increased —83 per cent. This points out the usefulness of central solid line marking on road bends.

DESIGN AND CONSTRUCTION OF THE HAMMERSMITH FLYOVER

THE flyover project at Hammersmith, West London, is making good progress and promises to be one of the finest structures of its type in Europe. It is likely that this flyover, which is costing 51,300,000 pounds will be open to traffic this year.

The flyover is, of course, the link in the Cromwell Road extension and will relieve the Broadway Circus which has been used by 70,000 vehicles per 12-hour day. It is a precast, prestressed and reinforced concrete structure of 'T' design, arranged in 16 spans, 11 of 140 ft, 2 of 120 ft, 2 of 94 ft 6 in., and 1 of 74, this 2,043 ft length of suspended structure being flanked by approach ramps which increase the overall length to 2,831 ft. It is 61 ft wide made up of two 24 ft carriageways separated by a median strip and with outlying service footways.

Concrete Columns and Foundations: The concrete column foundations are simple reinforced concrete spread footing swhich bear on the compact stratum of Thames ballast.

The columns are of hollow rectangular section, tapering from 10 ft × 8 ft 6 in. at the top to 8 ft 6 in. × 7 ft at the bottom, the walls being 2 ft thick and on the average 16 ft high, all four being cast in one continuous pour.

Each column is supported on a pair of roller bearings stradling the centre line of the flyover at 8 ft 6 in. centres. These bearings are 7.87 in. in diameter and 31.5 in. long and are designed to take a load of 1,000 tons each.

Arrangements are made so that each column can be jacked from above the bearings, should it be desired to do so as the result of settlement at any time during the flyover history. The columns have indeed been jacked to release temporary staging to carry the beams and gantry rails.

Superstructure

The superstructure is to a very large extent formed of precast units

The main structural element is a continuous hollow spine beam 26 ft wide and varying in depth from 6 ft 6 in. at midspan to 9 ft at the supports. It is formed of beam segments 8 ft 6 in. in length which alternate with 12 in. thick transverse cantilever units. The joints between these precast units are of fine concrete 3 in. thick so that together the units make up a 10 ft module. The units are prestressed together by longitudinal cables of $1\frac{1}{8}$ in. diameter which pass through the hollow spine beam in 4 clusters, one cluster on each side of each inner web.

The reinforced concrete cantilever units, serve a dual purpose; they act as diaphragms for the spine beam, and their outer arms support the precast reinforced concrete slabs 8 in. thick, which forms the outlying sections of the carriageways. The roadway slabs are made continuous by overlapping their projecting reinforcing steel and placing *in situ* concrete joints.

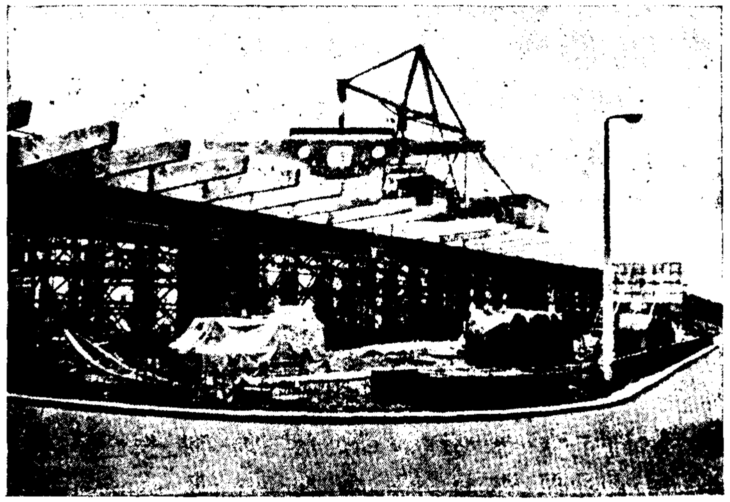
Substantial and continuous *in situ* concrete edge beams complete the load-carrying superstructure and form the outer footways.

The columns are connected to the spine by vertical prestressing bars.

The deck contains only one expansion joint occurring in the middle of the 74 ft span at the ends of the two lengths of spine beams cantilevered out from the columns. The joint is supported by *in situ* concrete cast on to the precast anchor blocks which form the end of the free cantilevers.

Beam Segments and Cantilever Units

The smallest beam segment weighs approximately 36 tons and the largest, which is placed over the columns and



The Rail-travelling gantry erecting a cantilever unit

A view of western end of the flyover showing the attractive curve of the continuous hollow spine beam

contains some special features, nearly 60 tons. Within the segments are three large compartments: the central one contains the services comprising a water main supplying the fire hydrants, drainage and electricity cables for supplying road-lighting and road-heating.

The top slab of the beam segments forms the inner part of the carriageways and supports the 5 ft wide median strip within which are placed the lamp standards and manholes for access.

The cantilever units are 12 in. thick and 59 ft long and have a maximum weight of 15 tons. They vary in depth from mid-span to the supports, matching the neighbouring beam segments. The arms which protrude on either side are tapered in depth and these repeat along the entire superstructure.

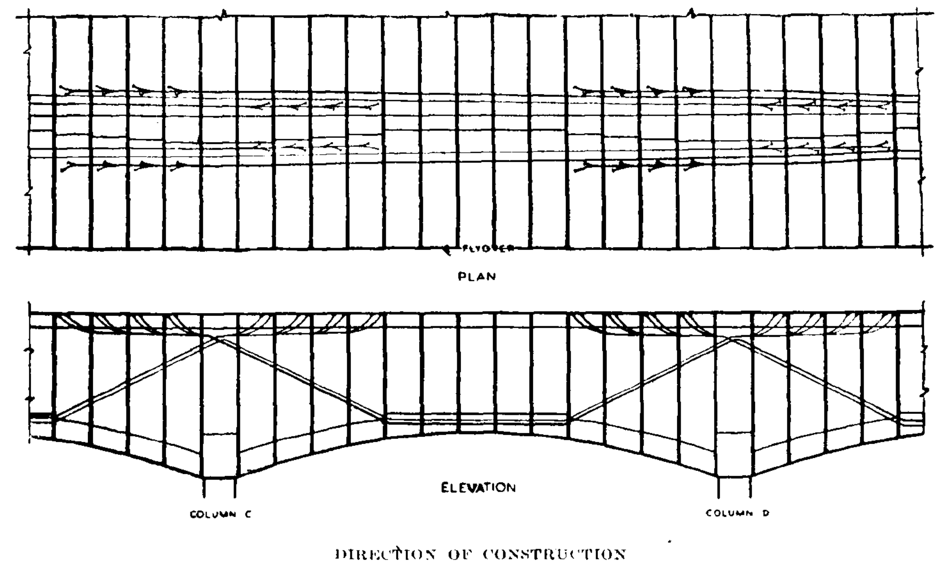
Each cantilever arm is of heavily reinforced section. In all there are 202 beam segments and 202 cantilever units.

The precast roadway slabs are of simple reinforced concrete construction being 14 ft 4 in. by 9 ft 6 in. by 8 in. thick. There are 408 altogether, each weighing about 6 tons.

Prestressing Methods

The beam segments which are placed over the columns are prestressed to them by means of 24 Lee-McCall high tensile bars of $1\frac{1}{4}$ in. diameter. These bars pass right down the walls of the columns inside ducts with their lower anchorages cast into the column foot. The bars are stressed from the top, and besides stitching the beam segment to the column, they also provide sufficient stress for the columns to resist neutral axis of the spine beam, each cluster passes through 10 in. diameter ducts, within the bottom flange.

In order to avoid massive anchor blocks and excessive concentration of anchorages and also to facilitate the construction sequence, the cables are arranged longitudinally in overlapping groups, on a similar principle to staggered lap lengths in reinforcing steel. Each group passes through two successive spans being anchored at both



Arrangement of Prestressing Cables

both longitudinal and lateral bending. These particular beam segments are further stressed by 6 similar bars passing transversely in ducts through the top flange. The purpose of these is to provide adequate strength for the transference of the shear carried by the outer webs of the spine beam, transversely to the columns.

The longitudinal prestressing of the spine beam is provided by $1\frac{1}{8}$ in. diameter stranded cables supplied by British Ropes Ltd., using the Gifford-Udall system and is shown in general arrangement in the figure. Across any section of the spine beam the cables are arranged basically in 4 clusters of 16, one cluster passing on either side of and immediately adjacent to each internal web. At midspan where the cables are at the maximum eccentricity from the

ends in the top flanges of beam segments on the far side of the extreme columns of the particular pair of spans affected.

Precasting and Erection

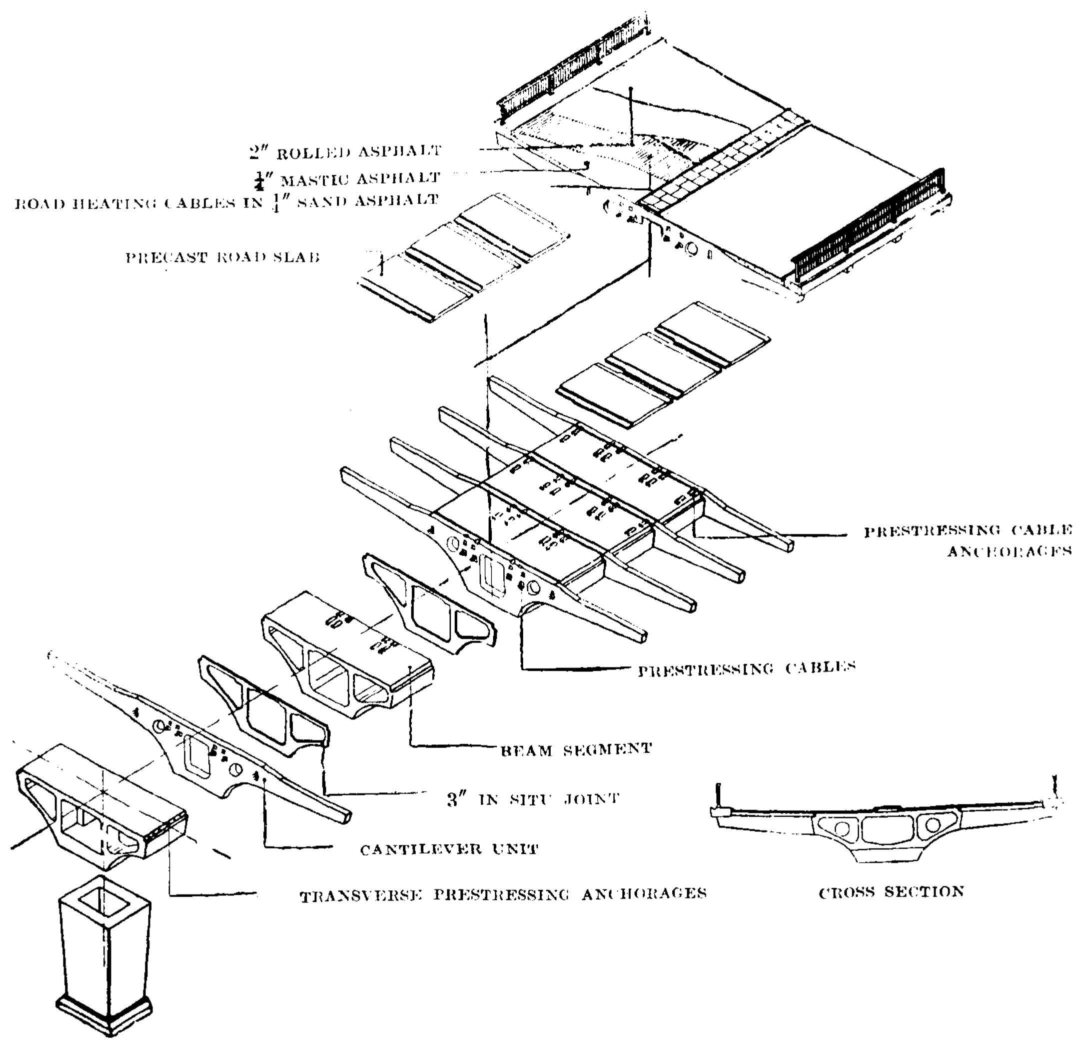
Both the beam segments and cantilever units are cast on their sides, i.e., on a face which will become vertical when erected and in contact with a joint. They are cast within steel shutters: there are four sets for the beam segments, one set for the 5 shallowest segments, 2 sharing the other 9 deeper segments, forming any one 140 ft span and the fourth set fitted to do any segment. Similarly there are 2 sets of shutters for the cantilever units. This enables a steady casting programme to be maintained with the units being manufactured in the order—or close to it—in which they are erected.

The erection of the main precast units is by another special steel gantry which is driven by its own electric motor along rails placed at 24 ft centres close to the edges of the beam segments. The gantry collects the newly arrived beam segment at the bottom of the ramp and carries it up the ramp and over the units already erected. The segment is lowered into place and this is followed by the placing of the next cantilever unit. The gantry rails are then extended by another 10 ft over these last two units and the cycle can be repeated again.

The staging is so arranged to support the units directly beneath the rails near the outer edges of the underside of the beam segments. Each bearing pad is 3 ft 9 in. long and straddles a cantilever unit, supporting it and the corner of the beam segment on either side. Provision is made for jacking under these pads for the final adjustments for level when setting the units and also for striking these pads after the units have been stressed.

Supplementary prestressing is provided by 8 capping cables which pass through ducts within the outer webs for a short length on either side of a column.

The cables are jacked at both ends simultaneously and, in case it is necessary owing to excessive relaxation, provision has been made for re-stressing the cables



Exploded view of the construction, Hammersmith Flyover

(Continued on page 21)

PRESTRESSED CONCRETE BRIDGE ACROSS ULLAI RIVER IN MILE 19TH OF JAMUI-JHAJHA-CHAKAI ROAD IN MONGHYR DISTRICT OF BIHAR STATE

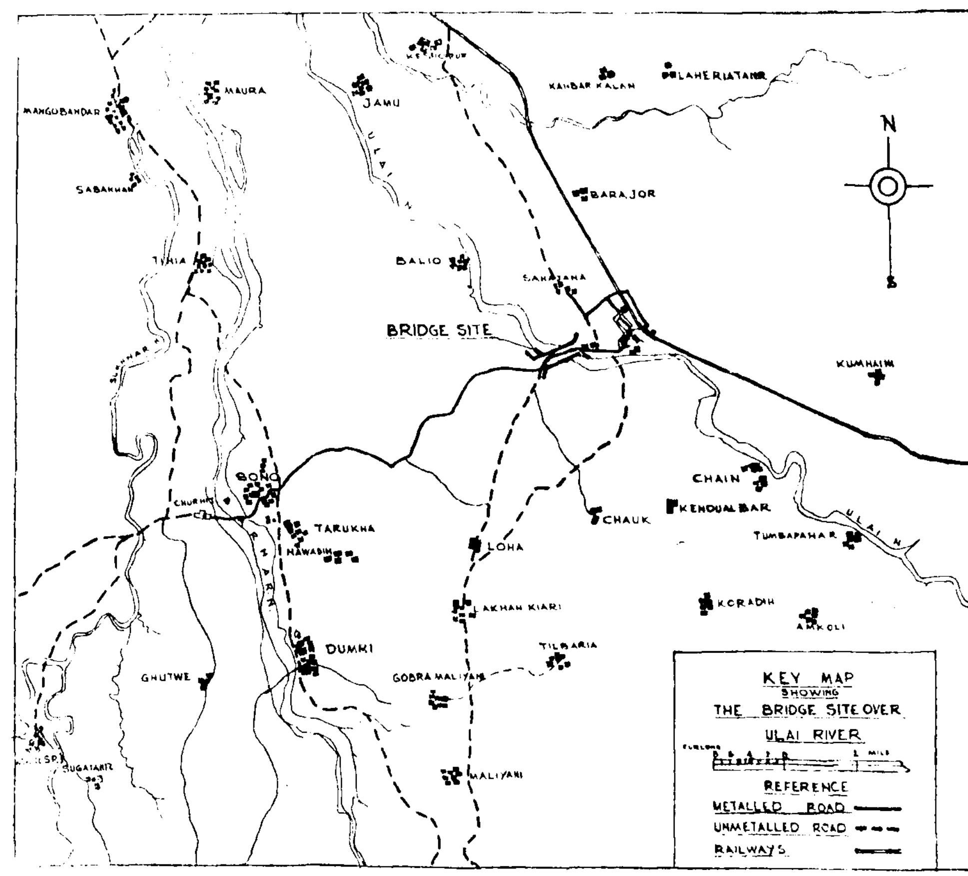
By

R. D. SHARAN SINGH*

RIVER Ullai is in the hilly area of Bihar and falls in river Kiui near Jamui. The Ullai bridge is situated in Mile 19th of Jamui-Jhajha-Chakai road in Monghyr District. (see key Plan)

Selection of the Site

The existing road-crossing being at the confluence of two rivers and the reach of the river being not straight was unsuitable. The bridge could not be sited on the up-stream side towards Jhajha town and the Railway Station as it involved construction of expensive approaches and overbridge. The only alternative was to select a site having firm banks and more or less straight reach further downstream. The width of the river there was less. Easy approaches



* Assistant Engineer, P.W.D., B. & R., Bihar, Ranchi.

were not possible on Jhajha side due to non-availability of sufficient land at reasonable cost as such, Jhajha town was bye-passed. On the Jhajha side the approach was 200 ft straight and then curve of 800 ft radius at a grade of 1 in 75. On the other side, the approach was ideal with 500 ft length straight practically level and a curve 1,000 ft radius beyond that. For the embankment of the approach on the Jhajha side earth was not available near at hand and the public were not inclined to allow taking of the earth from their paddy fields. Accordingly it was thought to use the sand available nearby. A wall of earth 3 to 4 ft thick on both sides to confine the sand in between was made and the sand filled inside. At the top 2 ft thick earth was laid. The slopes were pitched with stone (see Plate 1).

Test Borings

Test Borings made along the selected site and alignment at 50 ft intervals had shown that rock was available at 38 ft depth. Hence it was decided to embed the foundation into the rock.

Hydraulic Data

(i) Catchment area...78.5 square miles

(ii) Average annual rainfall...60 inches

(iii) Width of the river...563 ft bank to bank

(iv) Maximum H.F.L ..404.00

(v) Discharge...53,000 cusecs

(vi) Velocity...8.2 ft/sec. under bridge and average valocity 5.65 ft/sec.

(vii) Maximum depth of scour in the natural channel under H.F.L ... 19.6 ft (Lacy's)

Design Data

Road way...22 ft clear

Spans...9 spans of 67 ft each

Length...603 ft

Permissible Stresses

(i) 1 : 2 : 4 High Grade Cement Concrete ...950 lb per sq. in.

(ii) Mild steel re-inforcement...18,000 lb per sq. in.

(iii) Modular ratio...15

(iv) Wind pressure...20 lb per sq. in.

(v) Sessmic force...G/12

(vi) Maximum allowable pressure at the base of well...4 tons per sq. ft.

(Data for girders has been given separately).

Description of the Bridge

General: The Bridge consists of 9 spans; each 67 ft centre to centre. Well foundations consisted of two separate wells with a 2-ft thick R.C.C. well cap. Sub-structure consisted of mass concrete piers. Superstructure consisted of three Prestressed concrete beams for each span, one end resting on concrete pad and the other on roller bearings (Fig. 2).

Well Kerb

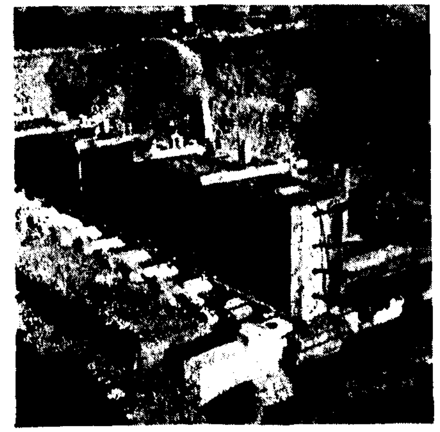
The cutting edge of the wells was made of 4 in. × 4 in. × 3/8 in. angle iron welded to 8 in. by ½ in. thick mild steel flat. 32 No. 7/8 in. diameter bond rods with lower end fixed to the cutting edge by double nuts were taken right upto the top of the steining. ½ in. dia. rods 9 in. centre to centre were used as stirrups. The cutting edge was placed on the sand at correct position, reinforcement fixed, shuttering of well-seasoned teakwood fixed, and the kerb was concreted with 1 : 2 : 4 cement concrete. The vibrator was used for compaction.

Steining

The inside diameter of each well was 8 ft 6 in., thickness of the steining was 1 ft 6 in. The distance between the centre of the two wells was 18 ft. There were 32 No. 5/8 in. dia. vertical bond rods in the steining coming direct from the cutting edge. There were ½ in. dia. hoop rings at 12 in centres. 1 : 3 : 6 cement concrete with black granite stone aggregate from Pananwa Quarry and local river sand was used for the steining.

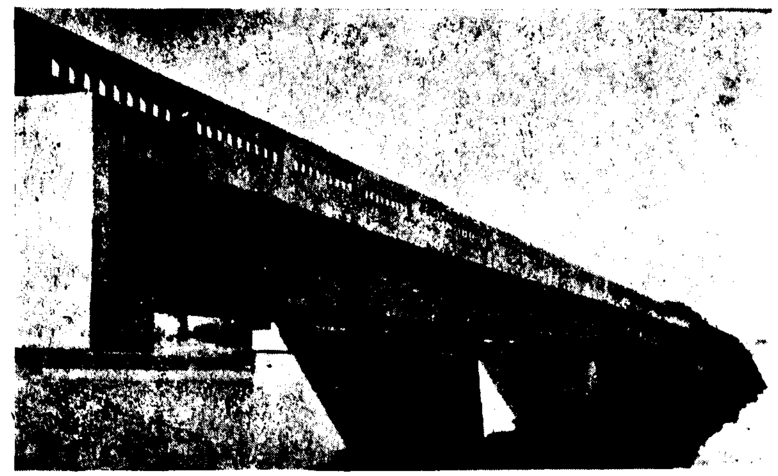
Sinking

The wells were to be taken down to a depth of 38 feet below river-bed. Initial sinking upto 3 ft depth was done by taking out the sand manually. Then one steam-operated grab 5 cubic ft capacity was used for removing the soil from within the wells. Almost all the wells were sunk

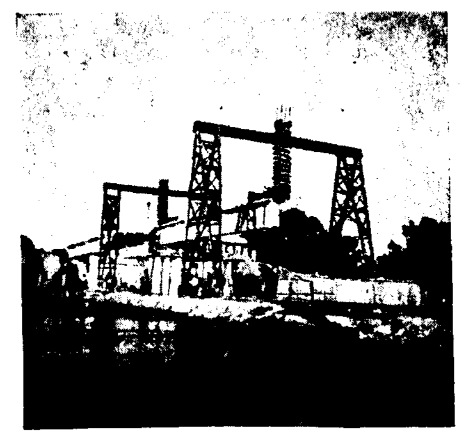


Showing the bending of cables

Showing the end blocks in form ready for casting



Girder is being rolled and carried near the gantry for tying. The gantry is seen standing in river bed



Both ends of the girder are tied to the both ends of the gantry and launching is in progress

5

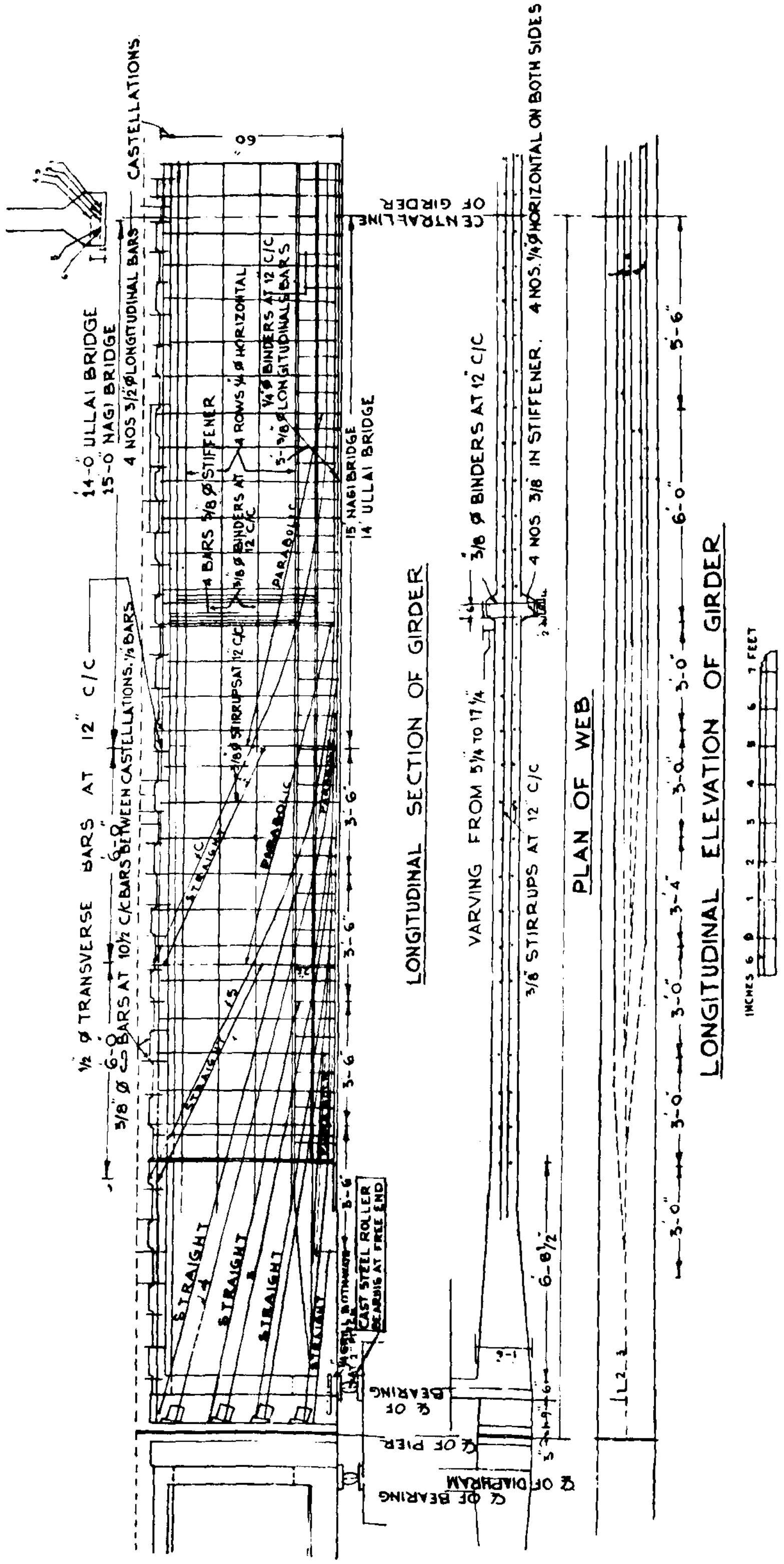


Fig. 1.

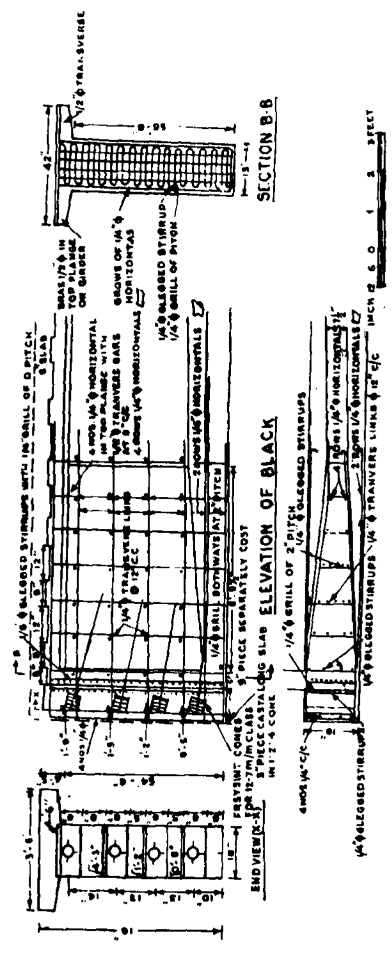


FIG. 3

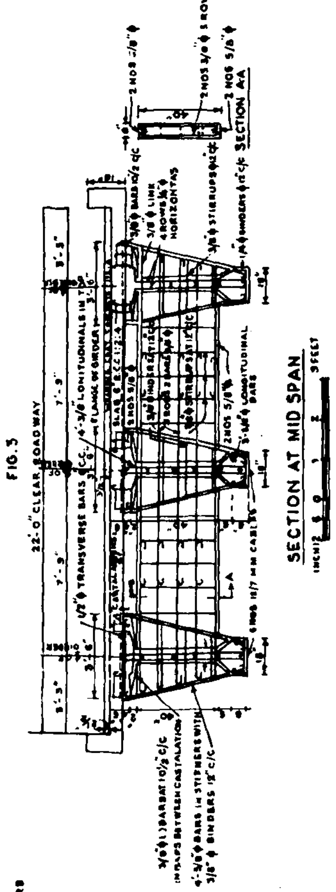


FIG. 4

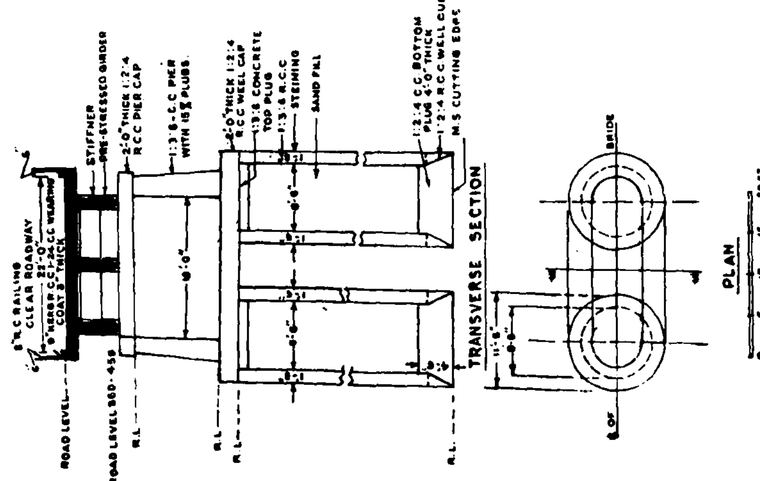


FIG. 2.

without any special difficulty. In some cases where stiff clay was met approximately 300 tons kentledge was used. The non-uniform sinking was corrected by adjusting position of kentledge.

Bottom Plug

After the well was sunk to the required depth, it was checked for tilt and shift. Except in case of wells Nos. 9 and 10, the tilt and shift did not exceed 1/80 and 4 in. respectively.

Four ft. thick 1 : 2 : 4 Cement concrete bottom plug was placed by a skip box, which opened on touching the bottom and deposited its contents there.

Sand Plug

Over the bottom plug, right upto 2 ft from the top sand was filled.

Top Plug

The top 2 ft of the well was filled with 1 : 2 : 4 cement concrete.

Well Cap

28 ft 6 in. × 11 ft. 6 in. × 2 ft thick doubly reinforced 1 : 2 : 4, high grade R.C.C. well cap with bottom reinforcement consisting of $\frac{3}{8}$ in. dia. rods 7 in. centre to centre and $\frac{3}{4}$ in. dia. rods 6 in. centre to centre and top reinforcement consisted of $\frac{3}{4}$ in. dia. rods 7 in. centre to centre and $\frac{3}{4}$ in. dia. M.S. rods 12 in. centre to centre with 2 legged and 4 legged stirrups of $\frac{3}{4}$ in. dia. rods was laid.

Piers

Concrete of the piers consisted of 1 : 3 : 6 cement concrete with 15 per cent plums. Dowel bars 2 ft projecting from the well cap were embedded in the pier for bond between the pier and the well cap.

Pier Cap

Over the top of the pier, 2 ft thick 1 : 2 : 4 high grade reinforced concrete cap was provided. The spiral reinforcement consisting of 8 Nos. vertical rods of $\frac{1}{2}$ in. dia. with $\frac{3}{8}$ in. spiral with 3 in. pitch were also provided under the seat of each girder.

Bearings

$5\frac{1}{2}$ in. diameter cast steel roller-bearing was provided under the free end of each beam. At the fixed end one number 1 in. dia. rod fixed in the bed plate and projecting above went through a slightly bigger hole in the prestressed beam.

Precasting & Prestressing of Girders —Prestressed Concrete Beams

Each beam was 4 ft $6\frac{1}{2}$ in. deep, 3 ft 6 in. wide top flange, 1 ft. 6in. wide bottom flange and $7\frac{1}{2}$ in. thick web. The top flange is 4 in. thick at the edges and increases to 6 in. where it met the web. Diaphragms 7 ft 6 in. centre to centre were provided. 6 in. thick reinforced concrete bridge deck slab was laid *at situ*.

Freyssinet Cone Anchorage:

There were two varieties of cones which fit one inside the other.

(i) Male Cone with tappered end and having 12 grooves over it for holding the 12 wires of the cable. Approximate bore and guage of tub...$\frac{1}{2}$ in. Weight in lb...0.77.

(ii) Female Cone was made of reinforced concrete of high strength having tappered hole. Its hole was lined with a close spiral of high tensile steel wire of about 11 S.W.G. The main reinforcement consisted of triple helix of No. 4 S.W.G. The female cones were cast along with the end block and the male cones were inserted at the time of stressing. The function of the female and male cone was to hold the stressed wires of the cables in position and not to allow them to slip. The success of the prestressing depends on the successful working of the anchorage cones. Details of anchorage are given below:

Length in inches	...	4.72
Exterior diameter in inches	...	4.72
Interior dia. of top in inches	...	2.44
Do- -do- Bottom -do-	...	1.50
Weight in lb	...	9.68

High tensile Steel Wires: In Ullai Bridge 6 cables each consisting of 12 wires of 7 mm. diameter were used for each girder. Four cables passed through the end of the girder and remaining two cables in the top.

Laying of Decking Slab

Six inch thick R.C.C. slab was laid *in situ* along with 15 in. wide 9 in. high R.C.C. wheel guards. The reinforcement consisted of mild steel rods. The Vibrators were used for compaction. The 5th and 6th cables which were left unstressed were stressed after the slab was concreted and cured to neutralise any tensile which may develope.

Three inch plain cement concrete 1 : 2 : 4 wearing coat was provided over the R.C.C. slab. Expansion joints were provided at centre of each span. 3 ft high R.C.C. railings was provided.

Materials Consumed for the Whole Bridge

1.	$1\frac{1}{2}$ inch stone metal		42,980 cu.ft.
2.	$\frac{3}{4}$ inch stone chips		29,615 cu.ft.
3.	$\frac{1}{4}$ inch stone chips		9,910 cu.ft.
4.	Cement	...	14,804 bags of one cwt each.
5.	Mild steel	...	126 tons
6.	High tensile steel		13.5 tons

Cost of Bridge

			Rs
1.	The total cost of bridge	...	7,73,000
2.	Cost of steining including well kerb, sinking and plugging	...	4,02,500
3.	Cost of R.C.C. well cap	...	40,000
4.	Cost of mass concrete Piers	...	20,000
5.	Cost of pier caps	...	9,700
6.	Cost of steel roller and rocker bearing including fitting and fixing complete	...	30,348
7.	Cost of foundation	...	4,42,500
8.	Cost of substructure		5,02,548
9.	Cost of superstructure	...	2,70,462
10.	Cost per running foot	...	1,232
11.	Cost per sq. ft. of the elevation area comprised by the formation level and the bottom of the foundation.	...	38/12.

(Continued from page 14)

six weeks after their initial stressing. The cables are eventually grouted where they are within ducts and elsewhere bonded to the webs by a fine concrete casing.

This method of prestressing allows each span to be stitched in turn to the previously stressed spans which means that construction can go smoothly forward from one end, and that the structure is fully continuous for both live and dead loads. The act of stressing, however, induces in the indeterminate structure vertical reactions at the columns and parasitic bending moments. These net parasitic moments considered in isolation are sagging throughout the structure which although welcome at the support are an embarrassment at midspan where they act in opposition to the desired prestressing moments.

To help overcome this undesirable effect, extra prestress is being obtained by building each span to a slightly warped profile, and then jacking it "straight", thereby locking in a small permanent hogging moment. As each column will have to be jacked in order to correct for the unknown settlements that will occur immediately under the dead load, no extra operation is thus necessary, and a virtue is being made out of this necessity.

(From "Highways and Bridges and Engineering Works," February 15, 1961.)

FACTORS AFFECTING ROAD CAPACITY

J. G. WARDROP, B.A., F.S.S. & J. T. DUFF, M.SC., A.M.I.E.E.

METHODS OF ASSESSING THE CAPACITY OF ROAD

Theoretical Capacity: In the past the capacity of roads was usually studied by obtaining an estimate of the maximum flow (volume) which could be achieved in a single traffic lane, assuming a uniform speed for all the vehicles in the lane and using either observed minimum headways (distances between the fronts of successive vehicles) or calculated "safe" headways. These methods produced very variable results depending in the case of "safe" headways, on extremely arbitrary assumptions about what is safe. In general, they produced capacity values of over 2,000 veh./h. per lane, sometimes as much as 3,000 veh./h. per lane, which common experience showed to be too high in practice on most roads. Under actual driving conditions, particularly with mixed traffic, severe congestion often occurs at flows much lower than these.

Practical Capacity: The term "practical capacity" was introduced in the U.S.A. in the Highway Capacity Manual, where it was defined as "the maximum number of vehicles that can pass a given point on a roadway or in a designated lane without the traffic density being so great as to cause unreasonable delay, hazard or restriction to the driver's freedom to manoeuvre under the prevailing roadway and traffic conditions". This definition gives a reasonable method of approach, but in practice, it is necessary to choose one or more arbitrary criteria of what constitutes restriction of traffic movement, or "congestion". Measures of congestion which have been studied are:

(i) mean speed of traffic:

(ii) mean difference in speed between successive vehicles ;

(iii) standard deviation of speeds ;

(iv) actual speeds in relation to desired speeds ;

(v) actual numbers of overtakings in relation to desired numbers ;

(vi) proportion of vehicles impeded, based on the distribution of time—intervals betweeen successive vehicles.

Method (vi) depends on the distinction between "random" intervals between vehicles which do not influence one another, and intervals between vehicles where the first is impeding the second. In the American studies all these measures were considered and emphasis was given to those concerned with speed. In a report on the capacity of straight level two-lane rural roads in various European countries, it was concluded that the proportion of impeded vehicles is the most useful measure of congestion and dismiss mean speeds as being too variable to be reliable.

At first sight the proportion of impeded vehicles is an excellent index of congestion, and it has the advantage over all the others that it does not require speed measurements to be made. It is, of course, open to the objection that it is not obvious what is the maximum degree of congestion which can be tolerated but a similar difficulty occurs with all the measures which have been mentioned. A more serious objection is that no account is taken of the amount by which the vehicles are impeded, and it is very desirable that this should be included.

Speed/Flow Relations: The British Road Research Laboratory has concentrated almost exclusively on the relation between the average speed of vehicles and the flow as a guide to road capacity, particularly in towns. The chief reason for this preference was that loss of time is of direct concern to drivers and vehicle operators, and this can be calculated from the average speed. Also the average speed can be found without the need for very precise measurements, and

the effects of delays at intersections or bottle-necks can be included without difficulty.

It has been argued that average speeds tend to vary in an inexplicable way, and therefore they do not provide a firm basis for capacity calculations. It will be shown below that a large part of the variation in average speeds (particularly in towns) can be explained as the effect of a number of factors and the relations found between speed and these factors can be interpreted in terms of capacity.

The results of measurements of speed and flow on roads of various widths both in Central London and in rural areas show that on narrow roads upto about 30 ft in width the average speed falls linearly with increasing flow. On wider roads the average speed remains substantially constant at about 24 mile/h. in Central London and 38 mile/h. in rural areas for moderate flows, while after a certain volume is reached the linear reduction of speed with increasing flow occurs. The slope of the line decreases as the carriageway width increases. A large difference in speed at the same flow between urban and rural areas was attributable to the effects of pedestrians, parked vehicles, minor intersections and the greater caution required in built-up areas generally.

In order to arrive at a figure for capacity it is necessary to decide what is the minimum acceptable average speed. Suppose that 15 mile/h. is accepted as a minimum speed between controlled intersections in towns. Reference to Table below shows that in towns the maximum permissible flow for a 22 ft road is about 300 veh./h., for a 32-ft road 700 veh./h. and so on.

Economic Capacity: Much of the arbitrariness involved in choosing the minimum acceptable speed can in principal be removed by relating the savings in time which could be achieved by widening the road to the cost of widening. If the rate of return expressed in money terms compares favourably with that available for capital investments in general, widening is economically justified, and the road may be considered to be carrying a volume in excess of its "economic capacity". This approach was suggested by Schuhl and independently by Charlesworth, and appears to be the most logical one.

The method has one apparent disadvantage in that the "economic capacity" of a road varies with the cost of the land through which it passes. In practice, this means that much more congestion will be accepted in cities where land is expensive than in rural areas where it is relatively cheap; but this is normal policy, and the economic approach merely underlines the reasons for it.

The Effect of Various Factors

Carriageway width: For the purpose of estimating capacity, since sufficient data to make a precise economic calculation are not available it will be assumed that 15 mile/h. is an acceptable minimum average speed in towns (between intersections) and that 35 mile/h. is acceptable for rural conditions. On this basis the following approximate capacity values are obtained :—

No. of lanes (lane widths 10–12 ft)	Capacity (veh./h.)	
	Towns (15 mile/h.)	Rural (35 mile/h.)
2	300 (150)*	—
3	700 (230)	700 (230)*
4	1,400 (350)	Dual: 3,000 (750)
6	2,300 (380)	Dual: 4,500 (750)

* Figures in brackets are volume per lane.

It must be emphasised that these values refer only to the conditions under which they were obtained; much more work is required under a wider variety of condition.

It will be noted that upto 4 lanes the capacity per lane increases markedly with width, being particularly high on the dual carriageways.

Goods Vehicles: As long as the proportions of cars, goods vehicles, etc., remain constant the average speed of all vehicles (excluding pedal cycles) is a satisfactory measure of congestion. But an increase in the proportion of slow and heavy goods vehicles will produce a reduction in average speed whether they cause any interference or not. When considering the effect of composition, therefore, it is necessary to measure speed changes in different classes of vehicles separately. The average speeds of vehicles in four classes—cars, light goods (under $1\frac{1}{2}$ tons unladen), medium goods ($1\frac{1}{2}$ to 3 tons unladen), and heavy goods (over 3 tons unladen) have been measured at a considerable number of sites on level rural roads both straight and curved and in an urban area. Plotting the average speeds of goods vehicles against those of cars, we find that the correlation between the speeds of various classes is very good, and it follows that for many purpose it is only necessary to measure the speeds of cars (which are most sensitive to changing conditions), the speed of other vehicles being deduced.

The average speeds of cars have therefore been considered in relation to the flows of vehicles, classified both by direction and type, on a 24-ft two-lane straight and level rural road and on a busy town street 30 to 35 ft wide. Multiple regression analysis has been used, the regression of car speed on the other factors being calculated. Where regression coefficients were not very different from one another, they have been combined. The results are as follows:

Direction	Class	Reduction in average speed of car per 100 veh./h. (mile/h.)	
		Town (30–35 ft)	Rural (24 ft)
Same	Cars/light goods	0.69 ± 0.16	0.85 ± 0.60
	Medium goods	1.85 ,, 0.27	1.54 ,, 0.55
	Heavy goods	2.08 ,, 0.46	2.84 ,, 0.94
Opposite	All vehicles	0.59 ,, 0.13	0.82 ,, 0.34

The Table above in each case is the standard deviation of the regression coefficient. All the coefficients are significant at the 5% level except that for cars and light goods vehicles on the rural road.

Having regard to the degree of precision with which these coefficients are established, we may summarise them as follows: Each 100 cars or light goods vehicles in either direction reduces the speed of cars by $\frac{1}{2}$ mile/h. on roads of these widths. The effects of medium goods vehicles in the same direction are about twice those of cars, those of heavy goods vehicles in the same direction are about three times those of cars, and all vehicles in the opposite direction have about the same effect as cars. For a fairly typical composition of traffic, 70% cars and light goods, 20% medium and 10% heavy goods, the "average" vehicle in either direction has about $1\frac{1}{3}$ times the effect of a car. These ratios may be used to estimate the effect of changes in composition of traffic on the capacity of roads. Similar calculations have not been made for wider roads, but in the absence of any contrary evidence it seems reasonable to apply them on all level roads.

Research has shown that for a given change in the speed of cars, the corresponding changes in the speeds of other types of vehicles are in general smaller. As a rough rule, the following relations may be assumed:

Class	Ratio of speed reduction to that for cars (level ground)	
	Town	Rural
Light goods ...	1.00	0.65
Medium goods ...	0.95	0.50
Heavy goods ...	0.90	0.20
"Average" goods ...	0.95	0.45
"Average" vehicle* ...	0.98	0.70

Other Factors in Towns

Buses: The effect of buses has proved difficult to measure as their flow tends to be very constant on a particular road. However, it was found that, in the street used for studying the effects of traffic composition in towns, each bus per mile (moving or at a bus stop) reduced the speed of cars by about 0.12 mile/h. The average speed of buses including stops was about 9 mile/h. so that the average effect of the bus volume was a loss of speed of 1.3 mile/h. for each 100 buses per hour, or about twice the effect of an equal number of cars.

Pedal Cycles: In the same street the effect of pedal cycles on car speeds was negligible, but this was partly due to the small flows of cycles encountered. Unfortunately no data are available at present covering higher flows.

Parking: A few parked vehicles per mile of road can have a very big effect. On a 26-ft wide carriageway four-parked vehicles per mile reduced the traffic speed by 2 mile/h. Within the range of 10 to 100-parked vehicles per mile the average effect is smaller, about 3.5 mile/h. per 100 veh./mile, on carriageways between 25 and 35 ft wide. It is very probable that additional parked vehicles upto the limit for kerbside parking of about 500 per mile produce a proportionately smaller effect.

Pedestrians: Pedestrians using "zebra" striped crossings reduced car speeds by about 2.7 mile/h. for each thousand pedestrian per hour per mile. This means that one pedestrian using a crossing per mile per hour is equivalent to 0.4 car speeds. Pedestrians crossing the road at other places had a negligible effect on car speeds on the road studied.

Other Factors in Rural Areas

Curvature: The effect of curvature on speeds has been measured but not its effect on the speed/flow relation. While curvature can reduce speeds by large amounts at relatively low levels of flow, the effect is almost certainly less when speeds are already reduced by congestion. More work is required on this point.

Gradient: Similar remarks apply to the effect of gradient. However, observations on a gradient of 1 in 20, about one mile long, 22 ft wide, and with only slight curvature, showed that the average uphill speed of cars was reduced by 1.1 mile/h. for each 10 medium or heavy goods vehicles ascending the hill. This is about $5\frac{1}{2}$ times the effect of similar vehicles and 11 times that of a car on a level road. Thus the effect of goods vehicles on the capacity of up gradients is much greater than that of level roads.

Capacity of Intersections: The capacity of an intersection is easier to define than that of a road, since with given proportions of entering and turning traffic there is a definite maximum flow which the intersection can handle. This can normally be observed when there are permanent queues on all approaches.

Traffic Signals: In towns, intersections controlled by signals or police are usually the main bottle-necks on the road. In Central London, one major intersection per mile reduces the capacity of the streets

* Assuming 60% cars, 10% light goods, 20% medium goods, 10% heavy goods vehicles.

as a whole at 15 mile/h. by 10 to 25%, and three per mile reduce it by 25 to 50%, the greatest effect being on the narrowest streets. Observations have shown that the capacity of a traffic signal is about 1,300 to 1,400 cars per hour of green per 10 ft of carriageway width in the absence of right-turning traffic (slightly less on wide roads). Each 1% of right-turning traffic in a stream reduces its maximum flow by at least ½% Medium and heavy goods vehicles have little effect if they form less than 20% of the traffic, but each additional 1% above this level reduces the maximum flow by about two-thirds per cent. The effect of these factors at typical intersections is to reduce the capacity to 1,150 to 1,200 vehicles per hour of green. A vehicle parked 15 ft from the stop line can reduce the capacity of an approach by 30% and by lesser amounts at greater distances; beyond 120 ft it has little effect.

These values of maximum flow per hour of green lead to capacity values for a major controlled 4-way intersection. At such an intersection about 45% of the time will be "green" on each approach, so that for normal conditions the maximum volume is about 550 vehicles per hour per 10 ft lane. If the traffic entering the intersection exceeds this level on one approach, and is so high on the others that proportion of green time allotted to it cannot be increased, the queue of vehicles waiting to enter the intersection will increase steadily as long as the conditions persist. In practice, delays tend to become excessive when the volume exceeds 90% of the maximum value.

Roundabouts: The capacity of a roundabout is difficult to estimate because it depends on so many factors. However, some tests were made on an experimental layout, including a large weaving section (representing one side of a roundabout), 200 ft long and varying in width between 30 and 60 ft. They showed that the capacity of the weaving section was about 830 vehicles per hour per 10 ft of width if all the traffic was weaving, and the entries to and exits from, the section were of a fairly standard type. The traffic consisted of about 80% cars and taxis, and 20% mixed goods vehicles. The capacity increased by 5% for each 10% of non-weaving traffic. By adding buses to the traffic it was found that one bus was equivalent to about three cars.

The accident rate during these experiments was exceptionally high, although almost all the accidents only involved damage, and it is felt that volumes on roundabouts should be well below these maxima for safety and comfort.

An example of the Use of Economic Capacity: As an illustration of the economic approach, consider the case for widening a straight level two-lane rural road (24 ft carriage way) to three lanes (30 ft) For any particular flow the saving in hours per mile per vehicle can be found, and hence the annual saving in vehicle-hours. This annual saving can then be expressed in money terms, and compared with the capital cost of the widening. Assuming that a vehicle-hour is worth 5s. and that the widening costs 10s. per sq. ft. the savings amount to 5% of the cost at a flow-level of 470 vehicles per hour during busy periods or about 5,000 vehicles per day. On these assumptions if 5% is the rate of return on capital investment generally, 5,000 vehicles per day is the economic capacity of a two-lane road.

Thirtieth Highest Hourly Volume: In practice, traffic volume varies from hour to hour, and in discussing capacity it is very useful to define a particular volume which is to be used for planning purposes. The concept of the "thirtieth highest hourly volume", or the volume which is equalled or exceeded in only 30 hours throughout the year, was given prominence in the American Highway Capacity Manual. There has since been a fairly wide acceptance of this idea, both in the United States of America and in Europe. It is stated in the Manual that this volume tends to be very stable for a given road, and that it is the volume for which the ratio of benefit to expenditure is near the maximum. It is clearly uneconomic to attach too much importance to the exceptionally high peaks which occur on only a few occasions throughout the year. On the other hand, much of the benefit to a driver would be lost if reasonable provision were not made for normal peak traffic.

To obtain the thirtieth highest hourly volume for a given road requires a continuous count of traffic through out each of the 8,760 hours of the year. This can be done as regards the total number of vehicles of all kinds by means of automatic traffic counters, but it is quite impracticable to obtain this information in respect of the various classes of vehicles.

The "Busy Week": An alternative approach which has been adopted in Great Britain is to base capacities on the conception of a "busy week". This is analogous to the procedure adopted by the British Post office in determining the amount of equipment required in a telephone exchange, which is based on the provision of a given grade of service during the "busy hour". Carriageway capacities are expressed in terms of the volume which can be passed safely and without too great a reduction in speed during a 16-hour day (6 a.m. to 10 p.m.). By averaging the traffic over consecutive days during the summer (a busy week) a 16-hour volume is obtained which will only be exceeded on exceptional occasions. In determining the capacity, allowance must be made for the hourly variations which occur during the busy week. Generally the traffic flow during the peak hour in the same week is about 10% of the 16-hour daily average, but as will be seen later, there is a fairly big variation on individual roads.

Recommended Standards: In order to allow for the greater effect of slows and heavy vehicles on traffic speeds both on straight level roads and where there are moderate amounts of gradient and curvature, the following weights are given to the various classes of vehicles :—

Motor cycles ...	1.0
Cars ...	1.0
Light goods vehicles ...	1.0
Medium and heavy goods vehicles* ...	3.0
Buses and coaches ...	3.0
Pedel cycles ...	0.5

Increased weights for medium and heavy goods vehicle on gradients of 1 in 25 or more are being worked out.

Carriageway capacities are expressed in passenger car units in a 16-hour day, for roads in which design features which affect capacity, such as lateral clearances, width of verges, curvature, sight distances and gradients, conform to certain minimum standards. The standard lane width now recommended is 12 ft on all important roads, except on three-lane roads where an overall carriageway width of 33 ft is recommended.

The following figures have been recommended as the capacities of the various types of carriageway:

	Passenger car units per 16-hour day
Two-lane carriageways	Upto 4,500
Three-lane carriageways	4,500 to 9,000
Dual two-lane carriageways	9,000 to 25,000
Dual three-lane carriageways	Over 25,000

In terms of mixed traffic these capacities are equivalent to the following values :—

	Capacity-vehicles per 16-hour day — Percentage of medium and heavy goods vehicles, buses and coaches: 15%	22½%	30%
Two-lane ...	Up to 3,250	Up to 2,900	Up to 2,600
Three-lane ...	3,250 – 6,500	2,900 – 5,800	2,600 – 5,200
Dual two-lane ...	6,500 – 19,000	5,800 – 17,000	5,200 – 15,000
Dual Three-lane ...	Over 19,000	Over 17,000	Over 15,000

Conclusions

The following conclusions are drawn :—

1. Estimates of the capacity of roads should ideally be based on economic considerations. In any case, they should take into account losses of speed produced by increases in traffic.
2. In the absence of sufficiently detailed information on costs and the value of time saved, it is nevertheless possible to give reasonable values for capacity.
3. The capacity of controlled intersections can be determined without any difficulty.

(From "Road Safety in India" April, June, 1961.

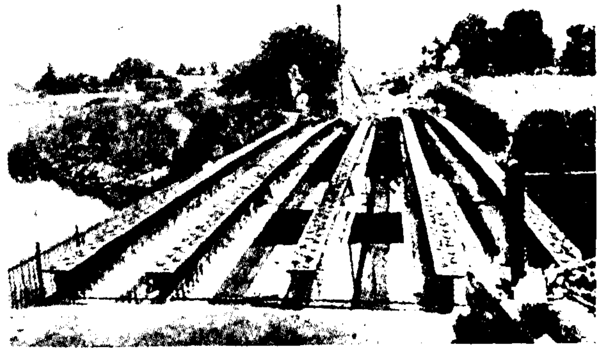
* These vehicles are normally grouped together in census work.

PREFLEX BEAMS

PREFLEX beams have been adopted by the Wiltshire County Council for the reconstruction of a bridge over the Wiltshire Avon at Kellaways, near Chippenham, the design of the new bridge having been approved by the Fine Arts Commission. In the issue of " Highways and Bridges and Engineering Works " for December 14, 1960, an article was published describing the working principle and the method of manufacture of Preflex beams, which are now being produced by the Boulton and Paul Group at their works at Lenwade, near Norwich.

In brief, Preflex beams consist of high tensile rolled-steel joists carefully prestressed by hydraulic jacking to give the stress which would be produced by the full working load. While in this condition the tension flange is encased in high quality concrete, suitably reinforced, and when the concrete has hardened the load is slowly released. Elastic recovery of the steel then takes place and the concrete is thus compressed. Under the actual working load the compression is reduced but the controlled process ensures that cracking does not occur.

Lowering one of the Preflex beams for the Chippenham Bridge



The five Preflex beams in place

Weight Saving

The Preflex system, in conjunction with the use of high tensile steel, has the advantage that for any chosen span and loading the construction depth and weight are less than for normal prestressed concrete beams, and it follows, therefore, that for a given constructional depth and loading longer spans can be bridged.

It is estimated for this Chippenham bridge, the weight of a normal prestressed concrete beam to give an equivalent performance would have been about 16-17 tons against the 10 tons weight of the Preflex beam.

The new Kellaways Bridge replaces an old cast-iron structure and has been designed for the Standard Ministry of Transport loading type HA. Both prestressed concrete and Preflex beams were considered and the latter were chosen on the grounds of economy, appearance and ease of erection. The span measures 64 ft between the centres of the beam bearings.

Five Beams

Five Preflex beams have been used, each consisting of a 24-in. by 12 in. by 160 lb U.B. with an additional half-inch plate 10 in. wide welded to the lower flange. The concrete encasement to this flange is 20 in. wide and 8 in. deep, with longitudinal and transverse reinforcement.

The decking consists of class C *in situ* concrete, suitably reinforced, 7 in. thick, and continued downwards to encase the webs of the steel beams. The width of the encasement, excluding fillets, being approximately 1 ft 4 in. Provision was made at the time of manufacture for the insertion of transverse tie rods connecting the beams. Andre rubber blocks have been used for the beam settings. The road surfacing is tar macadam, 2 in. thick.

The abutments and wing walls of the old bridge have been retained and the parapets consist of light steel handrailing, with a $6\frac{1}{2}$-in. protective kerb on the side remote from the footpath.

The Preflex beams, each weighing approximately 10 tons, were conveyed from Boulton and Paul's Preflex works, near Norwich, to the site on special road vehicles and were lifted into place by two cranes, one of 25 tons and the other of 35 tons capacity.

(From " Highway and Bridges and Engineering Works ", July 26, 1961.)

FOR UPGRADING ROADS FOR THE MODERN HEAVY TRAFFIC

The Indian Roads Congress has recommended to the Government of India for the survey of the following two National Highways to ascertain their deficiencies in respect of bridges, etc., with a view to strengthening or replacing them for the movement of heavy modern loads. The idea behind the selection of these two roads is that the entire length of two continuous National Highways is surveyed at the same time instead of surveying different National Highways.

(i) **East to West Road :** Calcutta - Barhi - Varanasi - Allahabad - Kanpur - Agra - Delhi - Ambala - Jullundur - Amritsar - Pakistan border, consisting of National Highway No. 2 passing through the States of West Bengal, Bihar, Uttar Pradesh, Delhi and National Highway No. 1 passing through Delhi and Punjab.

(ii) **North to South :** Agra - Indore - Bombay - Poona - Bangalore - Madras consisting of National Highway No. 3 in Uttar Pradesh, Madhya Pradesh, Maharashtra State, N.H. No. 4 Maharashtra, Mysore Andhra and Madras State.

HERE AND THERE

1. THE BRITISH ROAD TAR ASSOCIATION

Activities in the Year 1959–60

● Mr. J. Davidson Pratt, C.B.E., M.A., B.SC., F.R.I.C., M.I. Chem. E., then General Manager and later Director of the Association of British Chemical Manufacturers, was appointed part-time chairman of the Association in 1937. He was seconded to the Ministry of Supply for approximately five years during 1940/1945, but apart from four years during this period, he occupied the Chair of the Association until 1957 when, on retirement from the Association of British Chemical Manufacturers, he was appointed full-time Chairman of the B.R.T.A., his special task being to co-ordinate and consolidate the Association's activities. This object having been achieved Mr. Davidson Pratt retired on September 30 last after serving the Association ably and with untiring energy for over nineteen years.

Mr. S. A. Stewart, C.B.E., A.M.I.C.E., M.I. STRUCT. E., who retired from the Royal Engineers with the rank of Brigadier at the end of 1959, was appointed Director of the Association as from June 8, 1960, since when he has been actively engaged in meeting members and Government and other officials.

Research Programme: The programme of research for the year 1960, which has been agreed with the Road Research Laboratory of the Department of Scientific and Industrial Research through the Road Tar Research Committee, covers the following main points:—

(a) To determine the principal properties of tar likely to influence its behaviour on the road.

(b) The full-scale development of dense tar surfacing and in particular the study of methods of improving its properties and workability.

(c) To access the value of tar macadam as a base material and to study its use, when made with a high viscosity tar, as a base course for rolled asphalt.

(d) To continue the study of tar-bitumen mixtures for use in the production of asphalt.

Full-scale road experiments to be carried out during 1960 include the following:—

(a) Tarmacadam base course under hot rolled asphalt wearing surfaces.

(b) Tarmacadam base mixtures with a tar binder and with various aggregates, to be laid in comparison with uncoated aggregates in order to compare ease of laying, general performance, etc.

(c) Medium-textured tar carpets using tars from the main types of carbonisation.

(d) The extension to heavily trafficked city roads of experiments with dense tar surfacing using blast-furance slag and crushed rock coarse and fine aggregate.

(e) Dense tar surfacing with other types and gradings of aggregate.

(f) The laying of sections of dense materials with tar-bitumen mixtures and the comparison of tar-bitumen mixtures with similar materials using bitumen only.

(g) The performance of different roadstones in surface dressing.

Motorway Construction: The decision of the Ministry of Transport, referred to in the last annual report, to change the base course for the London-Yorkshire Motorway from tarmacadam to asphalt was considered by the B.R.T.A. Council in the light of reports received from different parts of the country as to the effects of this decision on work for which tarmacadam had been successfully used in the past. It was

decided to ask the Ministry to receive a deputation.

Points made by the deputation were that, in the light of past experience, the Association was not convinced that there was any necessity for the use of the more expensive asphalt in place of tarmacadam as a base course for motorways, and that there was no reason for a change in the existing policy of using tarmacadam on other heavily trafficked roads It requested the Ministry to make clear to its own engineers and surveyors and to others concerned with road construction that tarmacadam, made to the appropriate specification, is a perfectly satisfactory material for base course work.

The deputation was well received. The Ministry explained that the decision regarding the London-Yorkshire Motorway was not intended to c— any reflection whatsoever upon tarmacadam, which was regarded as a well-proved material. The past successful and extensive use of tarmacadam base courses on heavily trafficked roads was admitted, but it had been felt by the Ministry that the strongest possible material should be used on the new motorway to give an additional reserve of strength. The Ministry would be prepared to use alternatives to asphalt for motorways and roads of that class of construction as and when the experiments being conducted by the R.R.L. showed that a material of comparable strength, load-spreading properties and long life could be produced with tar or bitumen. The Ministry pointed out that they had shown their confidence in D.T.S. by authorising its use for both base course and surfacing in the construction of three by-passes in Yorkshire. The Ministry also agreed that there was no justification for the argument that a tarmacadam base course should not be used if the surface was to be asphalt.

The deputation felt that there was no discrimination between the different binders and that the Ministry would endeavour to correct any wrong impression.

Road Note No. 29: The Pavings Committee of the Road Research Board and the Road Research Laboratory have been occupied for some time with the construction and design of flexible and rigid pavements and have recently produced a memorandum on alternative methods of road construction to serve as a guide for road engineers. The Ministry of Transport has asked the Road Research Laboratory to publish the contents of this memorandum as a Road Note and it is expected that the new Note will be published shortly. In the design charts, roads are placed into different categories according to the number of commercial vehicles carried per day. The design charts specify tarmacadam or dense tar surfacing for base courses and wearing courses for the different categories of roads carrying upto 4,500 commercial vehicles per day. Tarmacadam will be considered for motorways and the heavier trafficked roads (i.e., those carrying over 4,500 commercial vehicles per day) as soon as the results of experiments being carried out by the Road Research Laboratory are known. A separate Road Note will be published on the new dense tar or bitumen coated granular bases referred to in the next paragraph.

Tar Bound Granular Bases: Following earlier successful work with more open-graded materials as road bases, trials have been laid in Warwickshire and Lancashire, using close-graded local aggregates. The trials included both tar and bitumen binders; the aggregates were gravel, limestone and slag. The results are being watched with interest so that the specifications can be varied in order to give the best results with tar and local aggregates. Coated bases of this type have several technical advantages, one of which is their special flexible nature for use in areas liable to mining subsidence.

Tarmacadam Base Courses: The Road Research Laboratory are conducting a series of experiments to find out whether a tarmacadam base course is comparable in load-spreading properties with an asphalt base course. At the urgent request of the B.R.T.A. the R.R.L. are comparing hot-laid tarmacadam base course to Table 2 of Appendix D of the B.R.T.A. D.T.S., specification with asphalt to Table 7 of Schedule 4 of B.S. 594, the latter being the same material as that used on the London-Yorkshire Motorway. An interim report on work done in tests during winter weather indicates that D.T.S. compares favourably with asphalt under such conditions. Further experiments have been carried out simulating hot weather conditions and while there is much evidence to be collated, present indications are that this D.T.S. base course compares favourably with asphalt as a base course material.

Hard Shoulders: The B.R.T.A. has kept in close touch with the Ministry of Transport Panel dealing with specifications for hard shoulders on motorways and trunk roads. There are proposals that the hard shoulders on two of the four sections of the London-Yorkshire Motorway at the northern end shall be constructed with D.T.S., and it is learned that D.T.S. is specified for hard shoulders on the Birmingham-Preston Motorway. D.T.S. is being used for hard shoulders on both the Doncaster and Maidenhead By-passes. The two service areas of the London-Yorkshire Motorway are being laid with two course D.T.S.

Setting Performance Investigation: The investigation into the setting performance of tar, which was commenced in 1957, continues. The B.R.T.A. Technical Committee has studied a document produced by the Coal Tar Research Association on the classification of road tars. The C.T.R.A. examined 27 tars which had been supplied for the setting performance investigation with a view to considering the possibility of classifying road tars according to the level of certain of their properties (namely, specific gravity and oils boiling below 300 degs. C) rather than classification according to the methods of carbonisation by which the crude tar was produced. This interesting study still continues.

Pitch/Bitumen and Tar/Bitumen Mixtures: The R.R.L. has been investigating for the past few years the use of mixtures containing substantial proportions of pitch or tar with bitumen for the production of asphalt type surfacings. The objective is to utilise the weathering properties of the tar or pitch to give a surfacing less prone to slipperiness and which should also have important economic advantages.

The work has now reached the stage at which demonstration or specification trials on a commercial scale are necessary to prove the practical merits of the proposals. The Ministry of Transport has willingly co-operated and has now made available a number of sites in the South, the Midlands and the North.

Surface Dressing: Some surface dressings which were carried out during the abnormally hot summer of 1959 failed in the following winter. The failures were not extensive—in fact there were no more than normal—and were mostly confined to lightly trafficked roads. A detailed investigation has been made by the B.R.T.A., the R.R.L. and the Association of Road Surface Dressing Contractors. It was found that the failures were due to a combination of one or more factors but the major cause appears to be lack of sufficient tar to hold the chippings. This might be due to an unusual degree of absorption into the very dry road or the use of too large a chipping for the amount of tar applied. It was the general conclusion that tar surface dressings had proved satisfactory in spite of the excessive hot weather over such a long period.

International Road Tar Conference: Mr. C. E. Carey, the immediate past-president of the B.R.T.A., has been appointed President of the International Road Tar Conference for the years 1960 and 1961. The plenary session of the Conference will be held in May, 1961, at Harrogate.

Road Tar Manual: A number of additions have been made to the Road Tar Manual during the year. They included four British Standards (1,707 on Hot Binder Distributors ; 598 on Sampling and Examination of Bituminous Mixtures; 812 on Sampling and Testing of Mineral Aggregates and a revision of 1,241 on Tarmacadam with Gravel Aggregates). Sections which have been completely revised are Road Tar Bulletin No. 2 on Viscosity, the Technique of Surface Dressing and the Preparation of Tarmacadam. A new section on Fillers has been added. The Dense Tar Surfacing publication has been reprinted incorporating amendments to date, and a leaflet has been added dealing with tarred chippings for surface dressing.

(From "Roads and Road Construction", November, 1960.)

2. ROAD-BUILDING IN THE FEDERAL REPUBLIC OF GERMANY

New Techniques and Inventiveness Keep Pace with Extension of Mileage

● ROAD-Building in Post-war Germany has made remarkable progress under a Twelve-Year Plan which is being financed under a law passed last year. A feature of the development programme is that modern methods and machines are employed so that costs could be kept down.

For years after the last war, Germany, first had to dispose of its ruins, was not in a position to concern itself with its roads as much as it would have liked. But when it had recovered its economic strength sufficiently, it redoubled its efforts to cope with the problem. Tremendous progress has been made in the last few years and, so far as the extension and improvement of the road-network is concerned the Federal Republic is at the moment the second country in the world, being surpassed only by the United States.

The basis for this remarkable development is the Twelve-Year Plan, which lays down not only the programme for building the great highways but also regulates the operations to be carried out, down to the smallest detail. This Plan was approved by Parliament in 1957 and a start was made with its implementation two years later.

The first phase of road-building covers four years, and is to be followed by two further phases. Whereas during the first year of peace the main concern of the authorities was to remove the destruction and damage to the road-network caused by the war, the next and larger aim was to extend the autobahn that gives the German highway its characteristic feature. Both the expenditure and the length of roads to be built provide evidence of the Federal Republic's efforts in this field. In 1950 the budgetary expenditure on road maintenance was 200 million DM. Ten years later the amount had grown to 2,500 million DM, more than ten times as much. These

A modern bridge of huge dimension on an autobahn in the State of Westphalia

A fully mechanized repair unit at work on an autobahn

figures do not include the further 3,000 million DM found annually by the "Laender" (States), the towns and the communes for road repairs and for building new roads.

The financing of this Twelve-Year Plan was assured by a law passed in 1960. The sums earmarked for the three phases of road-building are 7,000 million DM, 12,500 million DM and 15,500 million DM respectively, making up a total of 35,000 million DM. In 1945 there were 2,100 kilometres of autobahn in existence; it is intended to extend the autobahn system to 5,000 kilometres by 1970. Actually, there will be 8,000 kilometres, since, over the same period, a further 3,000 kilometres of "Federal" roads are to be reconstructed to form four-lane highways, so that in their case, too, they will become "regular" autobahns. In this manner the delays occasioned by the war will be made good and the startling development of motorisation will be matched by road-building, thereby providing a healthy balance between traffic and economy as a whole.

To form an appreciation of these figures there is one fact that must be specially emphasized; it is the remarkable stability of road-building from the points of view of both cost and financing. Over the last ten years road-building costs have not materially changed, with the result that the increases constantly budgeted for have been able to take full effect. The stabilisation of road-building costs is due to the technician's efforts to rationalize. The most modern methods and machines have been employed, making substantial saving possible.

Engineering Biology

The process of rationalisation has helped those concerned to take full advantage of the inventiveness of the engineers and technicians. Together with the empirical and natural methods, the new-type processes lead to the most efficacious solution of problems. One example of these pioneering ideas is "engineering biology", a field of road technique that has developed over the last 25 years. Sinking slopes have been planted with vegetation and shrubbery, the roots becoming firmly embedded in the ground with the soil held fast through the absorption of the rainwater. The vegetation forming a green carpet on the craggy soil prevents this from crumbling away. The same purpose is achieved by planting vegetation on riverbanks. By these methods of "technical biology" road safety is improved every year. Not only are these methods cheaper than purely mechanical ones, but they also represent original and remarkable solutions to road-building problems.

(From "Weekly German News", May 6, 1961. Bulletin of the Embassy of the Federal Republic of Germany—New Delhi.)

3. TUNNEL UNDER THE FRASER RIVER IN GANADA

● BETWEEN Vancouver and the eastern part of Canada and U.S.A. the road traffic had increased so much that it rendered both—Pattullo project and the ferry service Deas Island, inadequate. This necessitated a trench-type tunnel at Deas Island, built up of a six reinforced concrete elements each 344 ft long, 78 ft wide and 23 ft 6 in. high weighing approximately 18,700 tons.

The factors leading to the choice of the tunnel in preference to a bridge were as follows :—

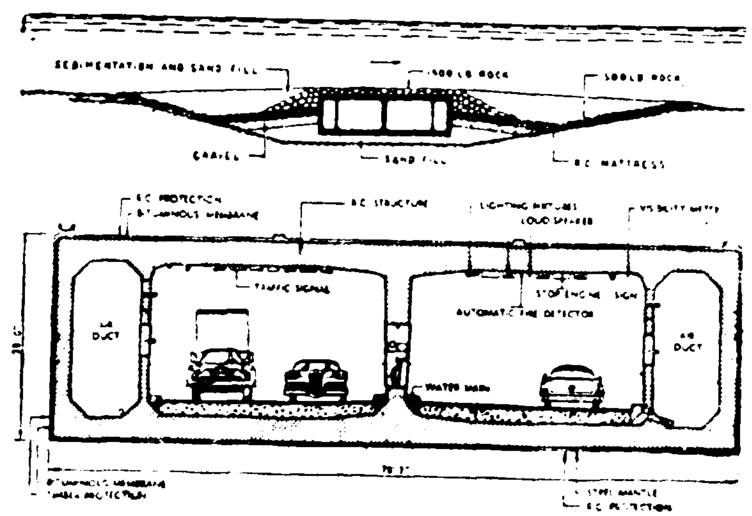
(a) No obstruction to river traffic and

(b) The lowest point of the tunnel lies about 78 ft below these areas, whereas it would have necessitated raising the roadway for a possible bridge about 156 ft above them.

The tunnel has a length of 2,160 ft with a ventilation building on either side of the river at the transition between approach and tunnel proper, gradient adopted in the tunnel is 4.5 per cent and the navigable depth secured at low tide is 42 ft.

protection. In order to protect the river bed on both sides of the tunnel against scour, the bed protection was supplemented by prefabricated reinforced concrete mattresses.

The tunnel each 12 ft wide, has a vertical clearance of 14 ft. The two ventilation ducts which run along the entire length of the tunnel have been placed at the sides of the roadway tubes. By this arrangement it was possible to limit the overall height of the tunnel to 23 ft 6 in. The tunnel ventilation is provided by four axial flow fans capable of handling 1,000,000 cu.ft. min. The ventilation system is a semi-transverse system, fresh air being supplied and vitiated air exhausted via ducts located along the roadway tubes. Each ventilation building contains one fresh air and one vitiated air fan. The maximum lighting intensity inside the entrance portals is 100 foot-candles. This intensity decreases gradually to 10 foot-candles at a distance of 720 ft from each entrance. Rain-water from the approaches is mainly led to catch basins at the ventilation building, while water carried into the tunnel is led to a sump at the mid-river point.

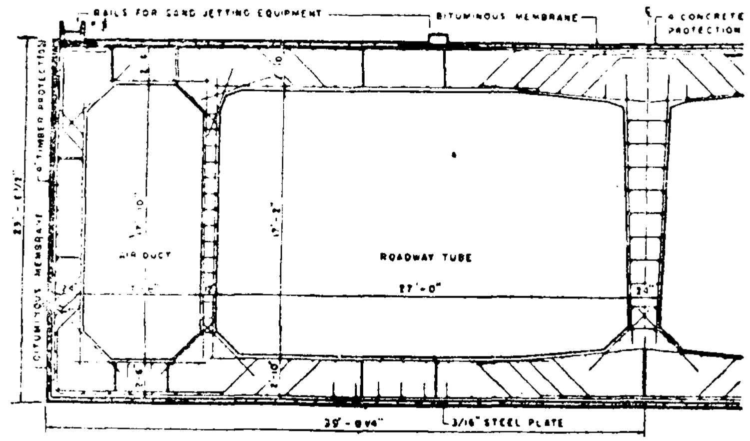


Section showing bed protection and cross-section through tunnel

After each element was sunk, sand was jetted into the space beneath it. Sand fill, protected by gravel and rock fill, was placed on both sides of the tunnel and the top of the tunnel was provided with rock

The tunnel elements were constructed in dry dock dredged for the purpose north the river and near the tunnel line.

The tunnel elements were joined



Part-section showing typical reinforcement

pressing the outer edge of the end surface of one element provided with a rubber gasket designed for the purpose, against the free end of the other element. The two elements were pulled against each other with a force of 150 tons by means of a hook arrangement on one of the elements, operated hydraulically from the interior of the element. By opening a valve in one of the temporary bulkheads the water pressure in the joint chamber between the two bulkheads was reduced and thus was forced together by a hydrostatic pressure which amounted to about 3,000 tons.

The construction of the tunnel took 2½ years. Drag lines, well points buldozers and scrapers were used in excavations. (Civil Engineering and Public Works Review, Vol. 55, No. 647, June, 1960, pages 779—785.)

From "Bulletin of Central Board of Irrigation and Power", October, 1960.)

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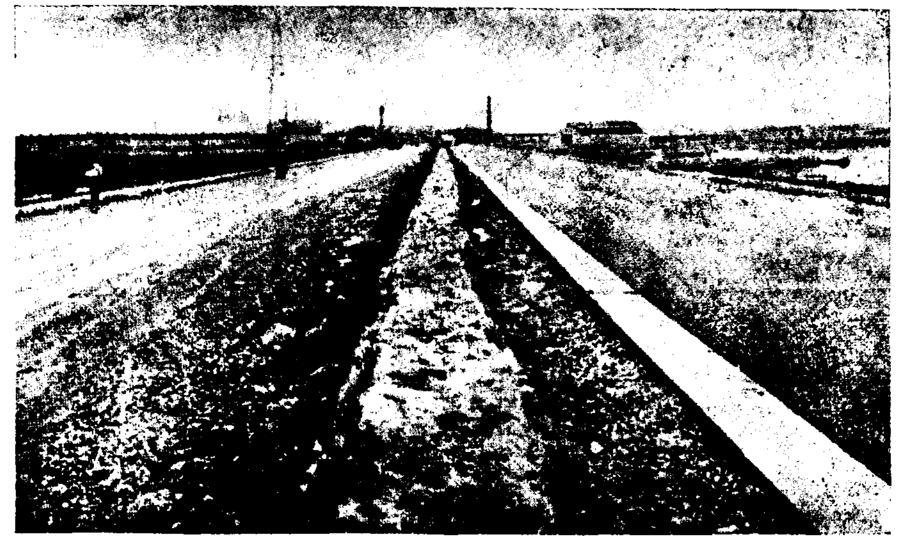
4. ULSTER'S MOTORWAY

(Contributed)

● THE first section of the South Approach Road—Ulster's first high-speed motorway—will be completed by June of this year. As yet, it is not known whether vehicles will be allowed to use the section pending the introduction of special "motorway legislation" which will control the use of this highway.

The 40-mile-long motorway will eventually link Belfast City with Dungannon and will relieve the very heavily congested roads between the two points. The first section starts at Donegall Road, close to the central area of the city, and finishes at Stockman's Lane, on the outskirts. By early next year the motorway will reach Lisburn—eight miles out. Next stage will be a further eight-mile section to Moira. The final stage of 22 miles to Dungannon will be constructed through mainly bog-lands, which have posed a problem for many years. The entire road is expected to be completed in six or seven years.

For more than a mile across the slob land of the Bog Meadows the ground had to be excavated to a depth of 8 ft to provide firm foundations for the motorway. At Stockman's Lane a 150-yd. long viaduct carries the Approach Road over a huge roundabout where entry and exit from the motorway



General view of the almost completed first section of the motorway

A section of the viaduct at Stockman's Lane on the South Approach Road, near Belfast

can be made. Some miles away the River Lagan is being diverted as part of the overall project.

The first flyover to be constructed—at Dunmurry—caused some anxiety when the entire structure began to sink, but this was later corrected and was attributed to the subsoil at the site.

The biggest headache will undoubtedly be provided by the section through the bogs to Dungannon. The existing roads are like switchbacks because of the foundations sinking. Many different methods have been tried but none has yet been adopted. A German method of blasting the turf out to leave firm foundations has been tried. There has been an almost complete standstill on this section for some years because of this.

The new motorway will be 100 ft from edge-to-edge and the two carriageways will be 24 ft wide each.

(From "Roads & Road Construction", May, 1961)

5. AMERICAN AUDIBLE WARNING SAFEGUARDS PEDESTRIANS

● A new pedestrian safety device is now in use in the U.S.A. called the "Vocalite", the unit is a fully automatic audio pedestrian traffic signal which is adaptable to any standard traffic controller.

By delivering a pre-recorded message at each cycle of the traffic light it appeals to the dual sensory perception of people, sight with sound. The Vocalite voice is directional and the sound intensity can be adjusted from a localised whisper to any volume required according to the sound of traffic.

Circuitry of the unit is fully transitorized, and the message will automatically synchronise itself with the traffic lights within one signal cycle.

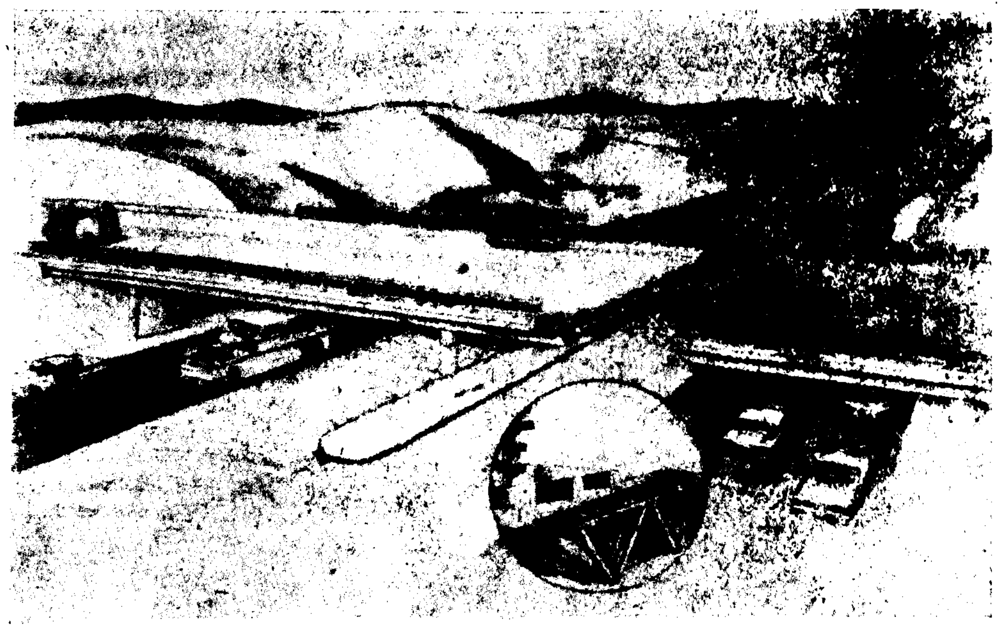
Its effectiveness as an aid to pedestrian safety has been demonstrated by studies which shows a 90 per cent reduction in jay-walking after installation at crossings which already had illuminated pedestrian control signals, as well as conventional traffic signals. It is especially valuable at intersections having a high rate of physically handicapped or blind persons. The device is made by Arnold Products Co., Long Island City, New York.

(From "Highways and Bridges and Engineering Works", October 19, 1960.)

6. STRESSED SHEET ALUMINIUM BRIDGE

● TWO aluminium highway bridges scheduled for completion this summer at Amityville, Long Island, U.S.A. will be the first ever placed in service utilising an aircraft-type, stressed-sheet design.

The Unistress Bridge, as it has been named, is composed of triangular-shaped beams bolted together edge-to-edge to form a roadway base. Each beam is a "cell" fabricated in the shop from aluminium sheet and stiffened inside with aluminium extrusions for maximum strength per pound of metal used. Standard concrete paving, poured directly on the deck, works integrally with the aluminium components.



Called the Kaiser Aluminium Unistress Bridge, the triangular-shaped components utilise an aircraft-type, stressed-sheet design. Bolted together edge-to-edge, the cells form a roadway base or any desired width (see inset for details)

Because of its highly efficient unitised, stressed-sheet design a pound of aluminium in the bridge is claimed to do the work of from four to six pounds of steel in a conventional bridge, the exact ratio depending on dimensions and design factors.

Under the name of the Fairchild Aluminium Bridge, a prototype was submitted to a series of tests in 1958 by Lehigh University's Department of Civil Engineering which established the ability of such a structure to withstand more than 100 years of normal service.

All of the assembled triangular beams of a Unistress bridge work together in supporting a load in contrast with a standard steel stringer bridge where each structural member must be designed to support at least one full wheel load.

The aluminium sheet forming the roadway base has corrugations running the length of the bridge which not only enhance strength of structure but eliminate the need for concrete formwork.

Other features of the Kaiser aluminium Unistress bridge are that the components lend themselves to mass production, can be easily transported from fabrication shop to job site and, because they are assembled with lockbolts, installation can be accomplished in a relatively short time.

The two structures in Amityville will be identical, measuring 212 ft in length and 86 ft in width. Each bridge will comprise four spans made up of 76 ft and 30 ft beams.

(From "Highways and Bridges and Engineering Works", May 17, 1961.)

7. FACTS ABOUT STEEL PLANTS AT BHILAI, DURGAPUR AND ROURKELA

Statement of Monthly rated Capacity of Iron and Steel and the rate of Production on 1-1-1961

	Bhilai		Durgapur		Rourkela	
	Monthly rated capacity on completion	Monthly rates as on 1-1-61	Monthly rated capacity on completion	Monthly rates as on 1-1-61	Monthly rated capacity on completion	Monthly rates as on 1-1-61
	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes
1. Pig Iron ...	92,500	61,600	1,04,800	35,400	82,500	39,500
2. Saleable Steel						
(i) **Semis for Sale**						
Blooms	—	—	3,500	1,300	—	—
Slabs ...	—	—	—	—	—	7,700
Billets	12,500	26,700	17,800	19,100	—	—
(ii) **Finished Steel**						
Structurals & rails	30,400	3,000	16,900	—	—	—
Merchant Bars	21,300	300	20,300	—	—	—
Sleepers ...	—	—	5,100	400	—	—
Wheels & Axles	—	—	4,700	—	—	—
Plate ...	—	—	—	—	16,700	4,100
Strips (Hot rolled)	—	—	—	—	25,000	—
Strips (Cold roll)	—	—	—	—	14,200	—
Tin Plant ...	—	—	—	—	4,200	—
Total saleable steel	64,200	30,200	68,300	20,800	60,100	11,800
3. Pipe Plant ...	—	—	—	—	12,500	200

Statement 'A'

Steel Plant	Date of approval of the final report	Date of commencement of construction	* Total cost of works in crores			Remarks
			Main Plant	Ancillia-ries	Total	
Rourkela	February, 1956	April, 1956	177.86	43.47	221.33	* Recoveries amounting to Rs 1.54 crores have been excluded from the total.
Bhilai	March, 1956	November, 1956	145.57	53.75	199.32	
Durgapur	October, 1956	October, 1956	172.37	27.97	198.81	

Date of putting into commission

Steel Plant	First Blast Furnace	First Rolling Mill
Bhilai Steel Plant	4-2-1956	7-11-1956 (Blooming Mill)
Durgapur Steel Plant	24-12-1959	9-5-1960 (Blooming Mill)
Rourkela Steel Plant	3-2-1959	11-1-1960 (Blooming & Slabbing Mill)

(Figuration supplied by Hindustan Steel Ltd.)

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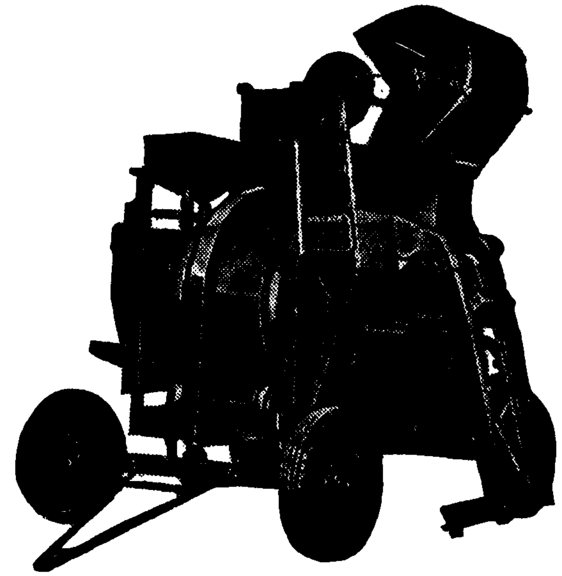

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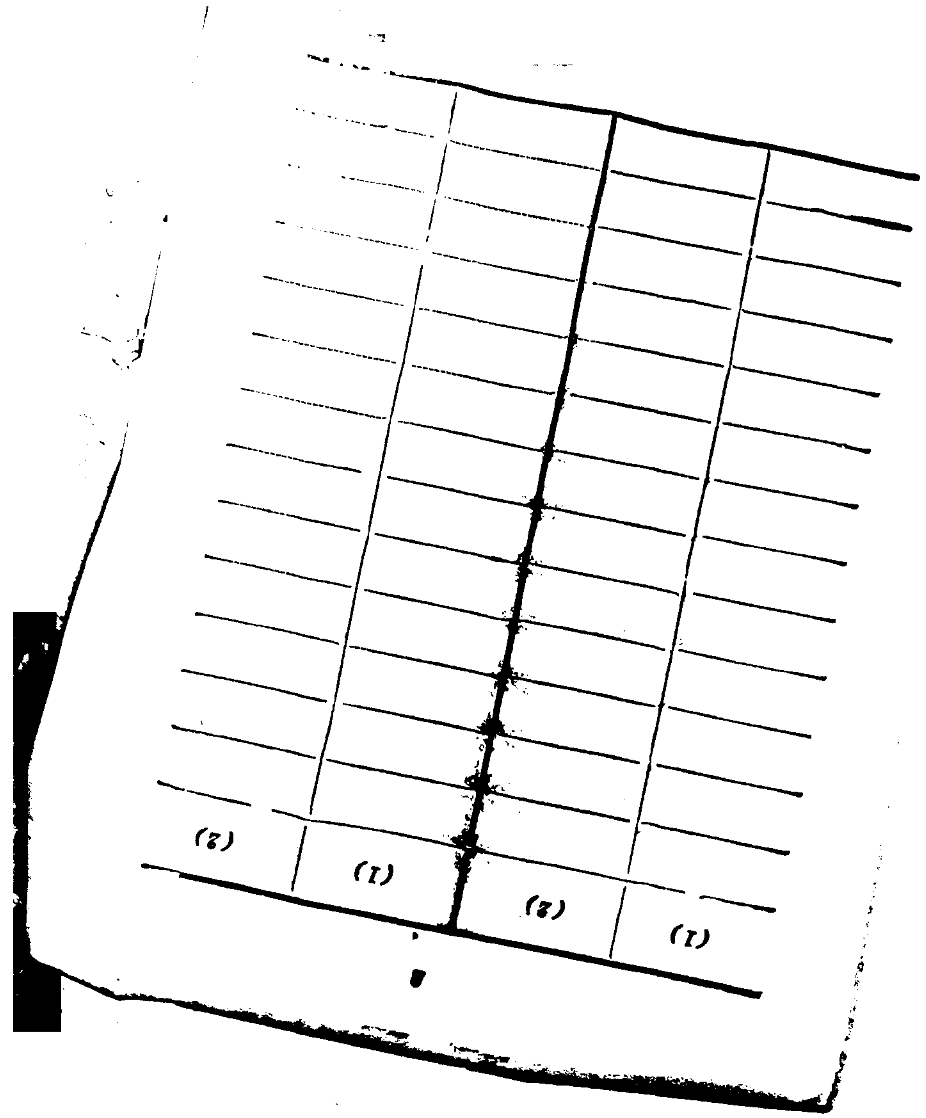

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