TRANSPORT-COMMUNICATIONS

MONTHLY REVIEW (TCMR)

JULY 1961—No. 171

INDIAN · ROADS · CONGRESS ·
TRANSPORT IS CIVILIZATION

INDIAN ROADS CONGRESS, NEW DELHI.

AVAILABLE FOR SALE

ROAD RESEARCH
BULLETIN NO. 7

REPORT ON THE EXPERIMENTAL PERFORMANCE OF DIFFERENT TYPES OF BASE COURSES FOR ROADS UNDER ADVERSE MOISTURE CONDITIONS TESTED ON THE ROAD TEST TRACK AT MAJHERHAT, ALIPORE, CALCUTTA
(1949-1958)

CONTENTS

Part I Series A: Tests on comparative performance of three different types of base courses made of boulders, laterite and moorum commonly in use.

Series B: Tests on stability of different stabilized base and sub-base courses over clay embankment in water-logged areas. (Series 1949—51)

Part II Tests on comparative performance of various thicknesses of stabilized soil base courses under adverse moisture conditions. (Series 1952—54)

Part III Tests on relative behaviour of four different types of stabilized soil base courses of equal thickness under adverse moisture conditions. (Series 1955—56)

Part IV Tests on performance of one inch thick asphalt stone chips carpet laid over different types of stabilized soil base courses. (Series 1957—58)

Price (including Postage):

Rs Seven or Ten Shillings.

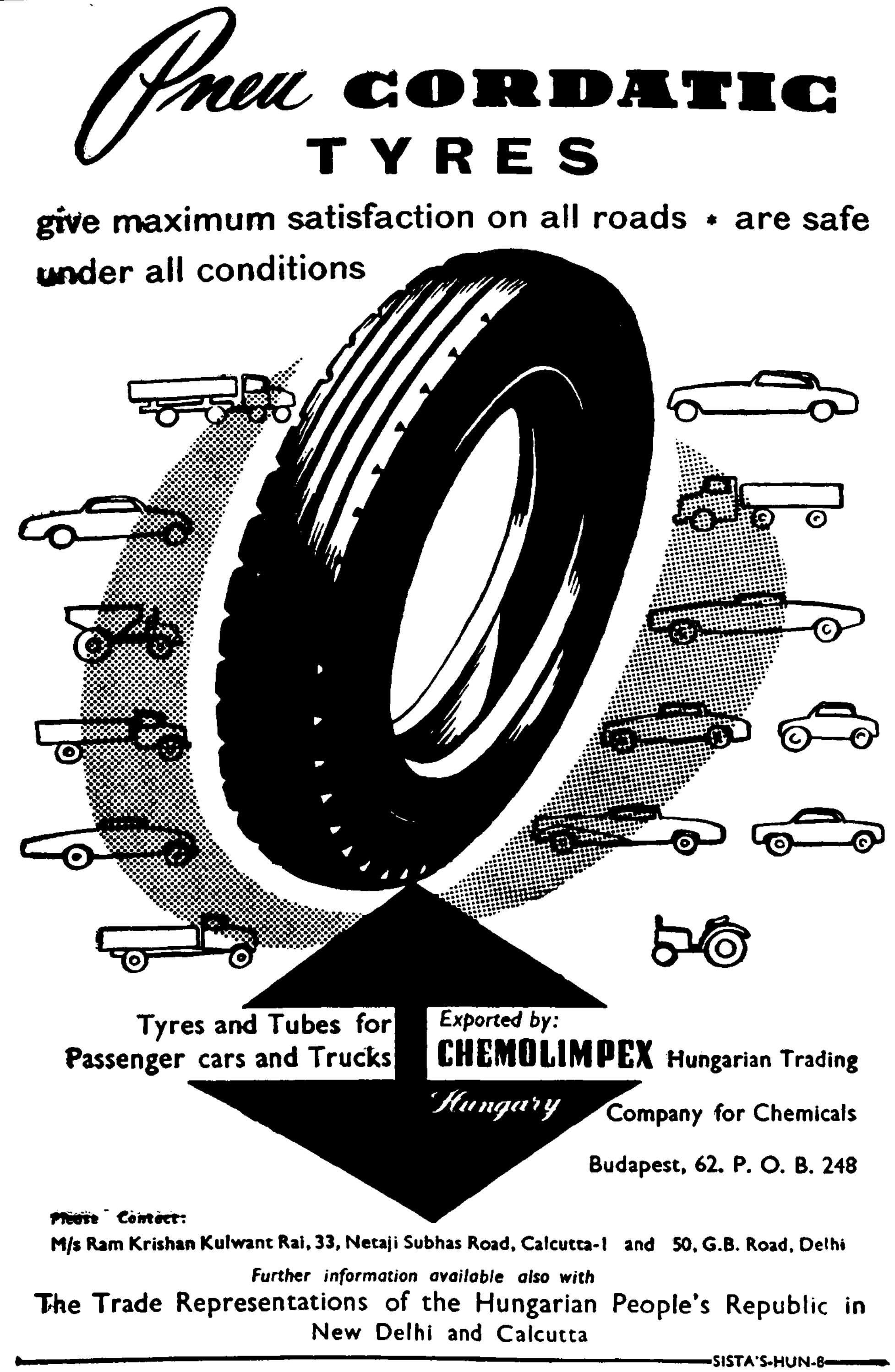
"BRIDGING INDIA'S RIVERS"

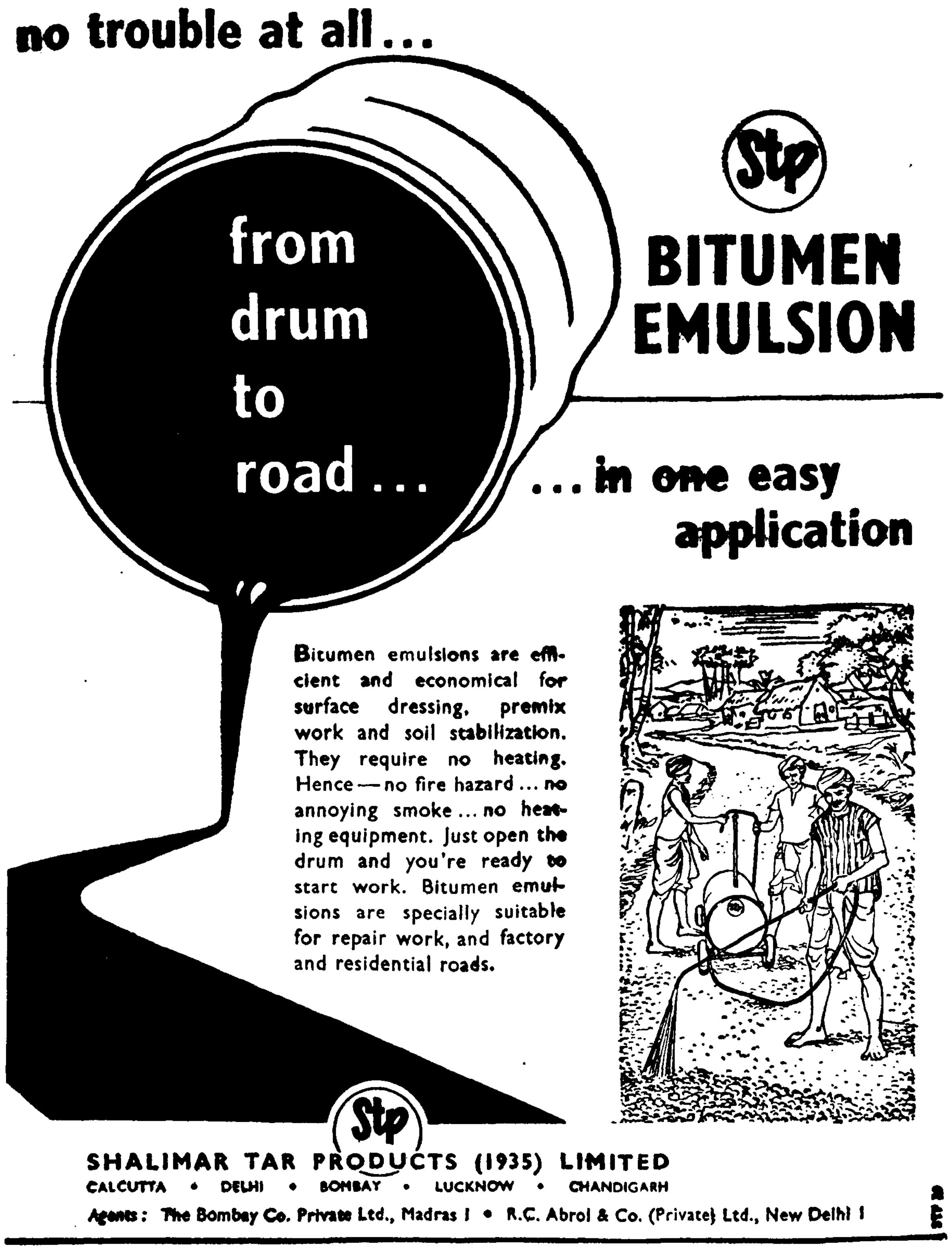
A very useful guide for road and bridge engineers giving an account of *fifty* major road bridges built in India during the First and Second Five-Year Plans.

Illustrated with Photographs and Drawings.

256 Pages, size 9″ × 11″ – Price Rs. 7 (including postage).

A limited number of copies of the above-mentioned publications are available. Those interested may apply at once to the SECRETARY, INDIAN ROADS CONGRESS, JAMNAGAR HOUSE, MANSINGH ROAD, NEW DELHI-11.—**Copies will be sent by V.P.P.**





TRANSPORT-COMMUNICATIONS
MONTHLY REVIEW
JULY 1961—No. 171

LIST OF CONTENTS

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

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

Subscriptions. Annual subscription including postage is Rs Fourteen. Single copy including postage is Re one and twenty-five naye Paise.

To members of the Indian Roads Congress, Engineering Personnel below the rank of an S. D. O. and Engineering students, a special reduced subscription rate of Rs eight per annum is offered. Students are required to apply through the Principal of their College.

Advertisements. Advertising rates per insertion

	Full Page	Half Page
Inside front cover	Rs 100/-	—
Inside back cover	100/-	—
Outside back cover	120/-	—
Ordinary position	75/-	45/-

Detailed rate card can be had from the Secretary, Indian Roads Congress, Jamnagar House, Mansingh Road, New Delhi-11.

TRANSPORT-COMMUNICATIONS
MONTHLY REVIEW

A REVIEW OF
ROAD ENGINEERING, DEVELOPMENT & TRANSPORT

JULY 1961

THE WRITING ON THE WALL

ROAD and road transport in every country make a great contribution towards the development of its economy in all fields, i.e., agriculture, commerce, industry, social life, education, maintenance of law and order and defence.

The basic advantages of road transport are its ability to reach remote places, quick transit without transhipment, or loss in transit, door to door delivery, and flexibility. They have influenced most of the advanced countries to utilise more and more road transport. The following data will show that road transport is one of the major means of inland transport of goods in other countries :—

Country	Share of road transport out of all surface transport.
1. U.S.A.	20 per cent
2. Australia	52 ,,
3. Great Britain	55 ,,
4. Italy	69 ,,

In India, the Planning Commission estimated that the total long distance traffic in the year 1960-61 would come to about 182 million tons. Out of it the railways were expected to carry about 162 million tons. The balance of 20 million tons would be moved by other means of transport.

Our gross production of all commodities which stood at about 165 million tons at the end of the First Five-Year Plan, is expected to be about 245 million tons at the close of the Second Plan, and is likely to swell to about 370 million tons by the end of the Third Five-Year Plan. Since about 25 million tons of goods will also be imported, the total demand for transport by the end of the Third Five-Year Plan will be about 395 million tons, out of which the railways are now being geared to carry about 245 million tons. Allowing about 70 million tons to be carried by bullock-carts, 15 million tons by sea and waterways, there will still be about 65 million tons to be carried by road transport. This will be in addition to about 135 million tons of feeder traffic for the railways excluding quantities of coal and iron ore which go from siding to siding and about 15 million tons of feeder traffic for water transport.

In 1980-81, the long-distance transport is likely to be of the order of 800 million tons against which the railways may be carrying about 500 million tons, leaving a gap of about 300 million tons of the long distance traffic, i.e., about 15 times that required to be transported in 1960-61 by other modes of transport.

By the end of the Second Five-Year Plan, even in the case of National Highways 14,900 miles in length, only 2,003 miles will have two-lane width of carriageway; there will be 400 miles of missing links; 1,000 miles will have the lower type of surface; 84 bridges, each costing Rs 5 lakhs and above, shall have to be built (47 will be under construction), and 11,300 miles of National Highways will have only one single lane surfaced carriageway. The position of our State Highways and District Roads is no happier.

From the above it will be seen how unprepared we are for the situation facing us and even to cope with the situation likely to be created by increase in production during the Third Five-Year Plan.

During the first two Plans greater attention was paid to the development of the railways than to the development of road transport. This was sought to be justified on the ground that the railways would have to carry all coal and other raw materials for the steel plants. Yet in 1960-61 the railway capacity was found to be about 10 million tons short on coal alone.

For it other means of transport will have to be used. Sea transport is expected to carry about 2 million tons. For the rest road transport will have to be considered for nearby places in Bihar, Bengal and Orissa which may be within a radius of about 250 to 300 miles from pit-heads.

The production of coal is expected to be about 97 million tons in 1965-66 and about 400 million tons in 1980-81. A good portion of these quantities can be carried by providing suitable roads near collieries and by employing heavy truck-trailer combinations. The present average cost of carriage by ordinary trucks by roads is about 13 nP per ton-mile. It can be reduced to about 4.5 nP per ton-mile if truck-trailer combinations with a pay-load of about 21 tons are used for the transport of coal and other raw materials. Hence, this alternative is worth serious consideration.

To be able to cope economically with increased demand on the roads we should go in immediately for truck-trailer combinations of up to 21 ton pay-loads on those roads or roads in specified areas where traffic conditions warrant it. For doing so, we must improve the road surfaces to carry heavier loads, widen the roads to two-lanes where justified by traffic, construct immediately missing links, strengthen the weak bridges to carry heavy loads where required, provide missing bridges and provide enough money for increasing the manufacture of motor vehicles, truck-trailer combinations, etc., in India.

A beginning has got to be made and initially the States of Bengal, Bihar and Orissa which are near collieries should be considered.

India can no longer afford to postpone these essential road development works, postponing them will cost us much more in the long run.

Money invested in roads and road transport in addition to being a very profitable investment, which brings in quick return, also has a great employment potential, both of which are the need of the day in our country.

BRIDGING INDIA'S RIVERS

CONSTRUCTION OF BOWDARA BRIDGE OVER THE GOSTANADI ON VIZIANAGRAM-BOWDARA ROAD IN ANDHRA PRADESH

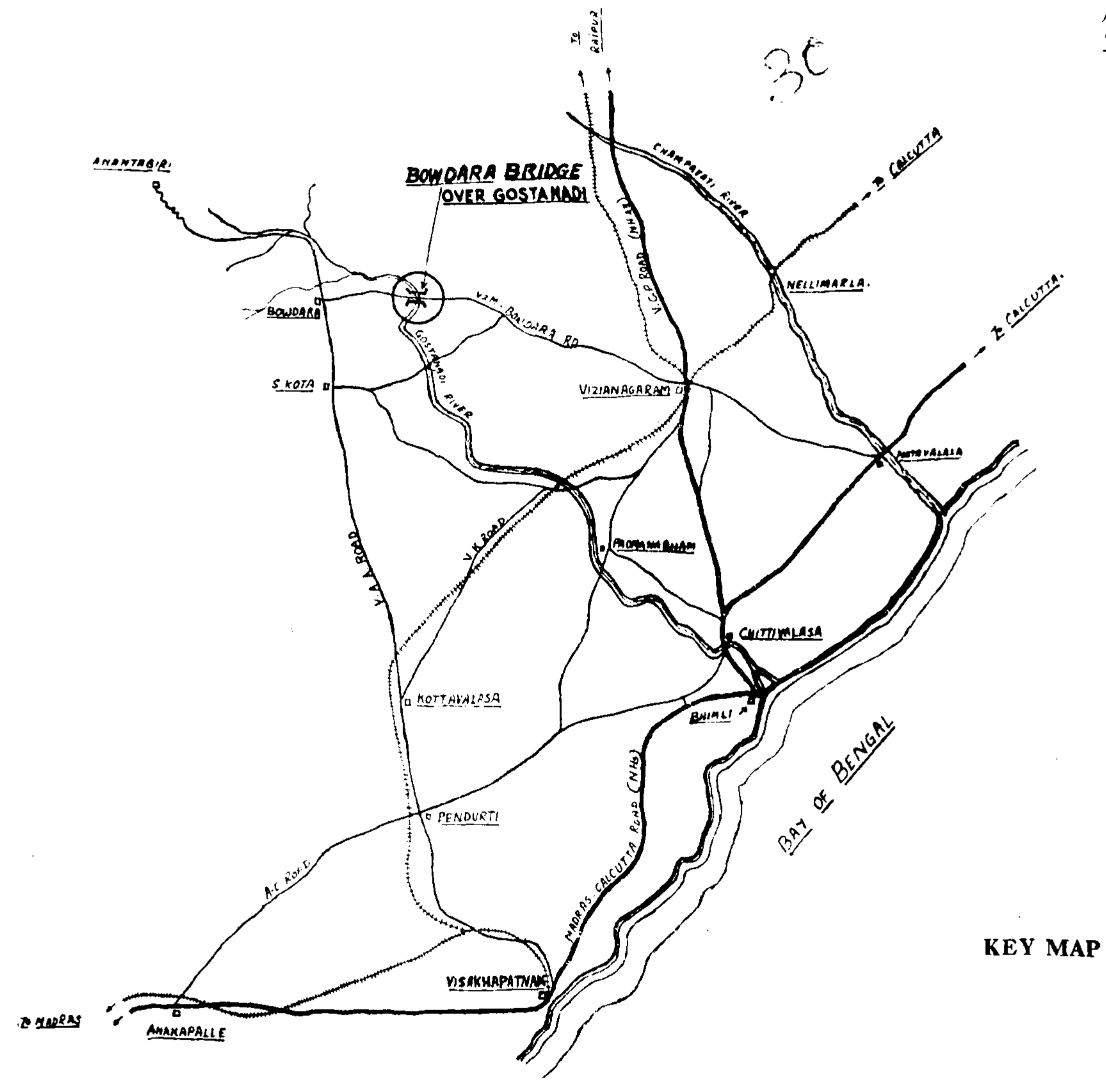
By

SHRI N. SESHAGIRI RAO, B.E.,*

SRI ABDUL RAHMAN, B.E., A.M.I.E.†

GENERAL

VIZIANAGRAM is an important commercial centre for the produce of the valley and Machkund agencies. The traffic from Machkund and Araku had to take a circuitous route through Visakhapatnam to reach Vizianagram during the period Gostanadi



KEY MAP

*Divisional Engineer (Highways), Visakhapatnam

†Assistant Engineer, Highways Special Sub-Division, Vizianagram

river was not fordable. By the construction of this bridge at mile 14/6 of Vizianagram-Bowdara road, the route from Araku to Vizianagram has become shorter by 56 miles, see Key Map.

The present site is about 75 feet upstream of the site of an old bridge washed away in 1896.

The River Gostanadi has its source in the Eastern Ghats of Araku Valley and flows towards the south-east; is 60 miles long and falls into the Bay of Bengal. It is said that the river starts at its source in the form of a trickle from a hillock which resembles the cow's udder. "Gostana" means cow's udder. Hence, the name Gostanadi. It runs along the ghats for a distance of about 20 miles, and enters the plains at the bridge site. In its entire course of about 60 miles, there is only one bridge at Chittivalsa on the National Highway No. 5.

The M.F.L. observed at site is 90.20 with reference to a local temporary bench mark. The discharge based on area-velocity method with Kutter's formula works out to 28,420 cusecs. The maximum run-off as per Ryve's formula works out to 29,360 cusecs, which was finally adopted for the design. Assuming velocity of 8 feet per second, linear waterway of 300 feet was required. The average bed level is 77.70 and the summer water level is 78.00.

General View of the Bridge

The bridge has been designed to carry one lane of I.R.C. Class 'AA' or two, lanes of I.R.C. Class 'A' loading, whichever created greater stresses.

BRIEF DESCRIPTION OF THE BRIDGE

This bridge is 309 ft long from abutment column to abutment column, has 5 spans each 60 feet clear with 5 simply supported precast prestressed concrete beams. Roadway between the wheel guards is 22 ft. Galvanised iron pipe handrail was provided. At each end full width 15

feet long R.C.C. approach slab was provided.

Foundations consist of two independent circular wells each 11 feet external diameter, 2 feet thick steining, placed 6 ft apart. The wells were capped with 28 ft × 11 ft × 2 ft 6 in. thick R.C.C. slab with its top 9 inches above the low water level.

Substructure for piers and abutments consist of two R.C.C. circular columns, 3 feet dia. 17 ft centre to centre, concentric with the wells, or rigidly connected to the well cap and at the top by a 5 ft 6 in × 3 ft 0 in deep horizontal beam which supports the girders, the whole unit acting as a pier bent.

Bearings :—Each prestressed concrete beam has one end free and the other fixed. Fixed ends of two adjacent spans are on one pier bent, so is the case for the movable or free ends.

Superstructure :--There are 5 prestressed simply supported concrete beams in each span. Each beam is provided with 7 cables each with 12 wires of 5 m.m. high tensile steel (cold drawn) except the central beam which has got only 6 cables. 13-1/2 in. wide space between the upper flange of adjacent beams was filled with cast-in-situ cement concrete and the deck was transversely prestressed. There are five diaphragms one at each end and three spaced at 15 feet apart.

CONSTRUCTION DETAILS

(Foundations and Substructure). The kerb of each of the two circular wells under each abutment was taken down to R.L. 57.00 and the top of well caps was kept at R.L. 78.70. The sills of all piers and abutments were kept at the same level. All the wells under the piers were taken sufficiently down into hard clay and are founded on hard brown clay at levels shown in Plate I. For the right abutment, brown clay was met with from top to bottom.

The well curb consists of 4 feet 6 inches high 1 : 2 : 4 reinforced concrete with 3/4 granite aggregate and by 4 in. × 1/2 in. angle iron cutting edge (See Plate No. I) After the wells were sunk to the required depths, the same were plugged with 5 ft 6 in. thick 1 : 2 : 4 cement concrete laid under water by Tremie method. The wells above the concrete plugs were filled with sand and the top 2 feet was filled with 1 : 4 : 8 cement concrete. These wells were connected by reinforced concrete capping slab (see Plate No. I). The top 5 feet of steining was provided with 1 in. dia. rods carried into the cap for anchorage. The circular columns are 3 feet dia. There is a heavily reinforced beam over the two columns on which the prestressed concrete beams rest.

Superstructure :— The superstructure consists of 5 beams of T. Section 56 in. deep with 48 in. wide top flanges. The prestressed concrete design generally conforms to the draft criteria for prestressed concrete prescribed by the Indian Roads Congress. The ultimate strength of concrete cubes made of concrete used was 5,000 lb per sq. in. and the working stress in H.T.S. was limited to 114,000 lb per. sq. in. after losses.

Shuttering :—As the concrete had to be vibrated both internally and externally, steel shutters were used. The side shutters are allowed to rest on the wooden beam on the pedestals and the top end of the shutters was supported laterally by bracings anchored into the ground and provided with adjustable screw pipes. This made the shutters perfectly vertical and properly aligned. The other side shutters were also supported on the wooden beams and tops were connected to the tops of the shutters already fixed, by angle irons. The bottoms of these two shutters of opposite sides were tied by bed bolts with the wooden troughs forming the bottom flange of the beam.

Casting the Beams :—After fixing the shutters on one side of the beam, nominal reinforcement was fixed and the cables, inserted in the sheaths in the required shape. The ends of these cables were inserted in their respective holes in the precast end-blocks which were cast in advance with the required numbers of Freyssinet's female cones with suitable anchorage reinforcement behind these cones.

The concreting was done without a break, Poker vibrators and one Form vibrator on either side of the beam were used. Form vibrators were fixed to the shuttering. The concrete used was (high grade) 1 : 1½ : 3 mix, with 3/4 in. granite chips. Water cemen ratio of 0.4 was adopted to get a crushing strength of 5,000 lb per sq. in. after 28 days on 6-in. cubes.

Prestressing

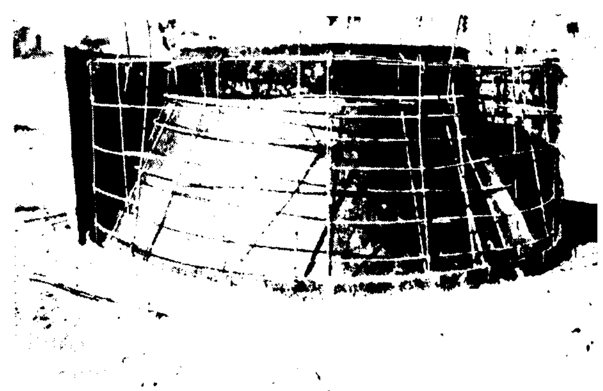
To induce a permanent tensile stress of—114,000 lb per sq. in., each cable was stretched to the required elongation by a Freyssinet prestressing jack exerting predetermined pressure. While stretching the cables, the total elongation only was taken as the criterion whenever it was found that elongations do not agree with the calculated jack pressures. The maximum variation, however, was only about 5%. Prestressing was done only from one end of the beam after 7 days of casting the beams or when the concrete had attained strength of 3,000 lb per sq. in. To facilitate early movement of beams from the casting bed, only 3 cables were prestressed after 7 days of casting and the beams shifted. After 14 days of casting, the remaining 4 cables (3 in the case of central beam) were tensioned from the other end of the beam and the cables grouted with cement slurry consisting of 6 gallons of water per bag of cement under 60 lb/sq. inch pressure till the grout came out at the other end of the cable. The cable holes were then blocked with cement mortar and the extra lengths of cables cut with special scissors. The small ends of cables were bent outward radially like Sun's rays. The face was covered up with cement concrete with small aggregate. Thus, the beam was completely prestressed and ready for launching.

While casting the beams transverse holes 30 in. apart in the top flange were left for transverse prestressing. Two holes in the web for prestressing each of the diaphragms at heights of 13 in. and 19 in. respectively from bottom of the beam were left.

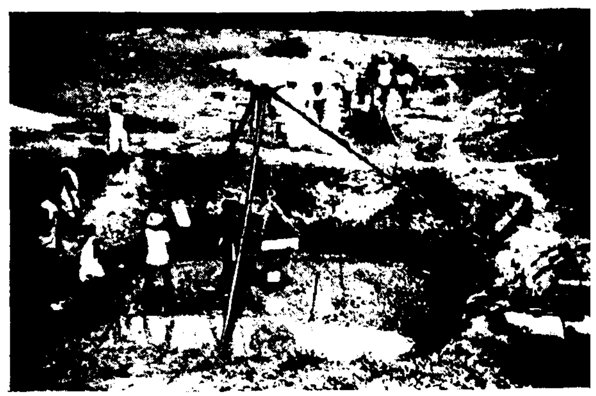
Launching of beams

Movement of beams

Two rail tracks were formed under each beam. Each beam was lifted on to 4-wheeled trolleys, these were pulled by means of wire rope and winch and brought to main line, lowered and again allowed to travel on a bigger trolley on the main big line. Thus the beams were moved to the rear of the abutment. Bottom of beam



Grill for curb of well



Bottom plugging by Tremie

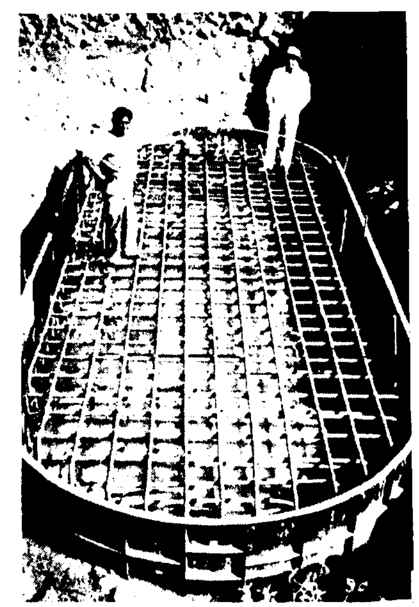
was kept at 1 foot above the top of pier bent on which it has to finally rest.

Launching

The beam was allowed to be cantilevered about 5 feet beyond the abutment. Rail track was laid in the river bed; and a crib was made on four trolleys on the ground rails. On top of crib the projecting end of the beam was allowed to rest with its end projecting. The beam was then pulled by wire rope and winch. The beam travelled with one end on the crib and the other end on the trolley on the main line. When the beam reached the first pier the height of the crib was reduced and the beam placed on the first span and then shifted by rollers to the correct place. In the same manner other beams were brought on the first span and fixed in position. A track was laid on top of these beams at 10 ft-3 in. centres and two trolleys, each fitted on 4 wheels, were allowed to

move on this track and the same process was repeated for other spans.

For finer movements of the beams:—The two cable holes in the bottom of end diaphragms of every beam and the gap of thirteen and half inches between beams were taken advantage of, 2 No. one-in. dia rods were inserted in the holes with a clear projection of 6 in. on either side. Two brackets with steel plates were fixed on either side of the beam to these rods. The bottom side of the bracket was flat (1 foot by 1 foot) and the vertical side which butted against the diaphragm was also flat. Jacks were placed just below these brackets and the beam was lifted by two jacks at each



Reinforcement of Well capping slab

end and allowed to rest on rollers for finer movements. When the beams were brought to final position the same were lowered in positions.

Cast-in-situ work

Diaphragms: The top flange of each beam was 4 feet wide whereas the centre to centre distance of beams was 5 ft $1\frac{1}{2}$ in. Therefore, there was a gap of thirteen and half inches between the ends of flanges of T beams. The two end diaphragms were cast with the beams to the full width of 4 feet at top. There were intermediate diaphragms at 15 feet centres which were slanting. Hence, there was a gap between diaphragms which formed the cross beam. The bottom width of the gap was 4 feet $1\frac{1}{2}$ inches and top width was thirteen and half inches and the thickness 9 inches. Steel shutters in a trapezoidal in shape were allowed to hang from bolts fixed to small channels resting on the flanges of the beams. There was a separate bottom plank attached to side shutters and bolted. The whole thing was allowed to hang from top by bolts, and cables were inserted through all the five diaphragms and diaphragms were then concreted.

Slab:—A wooden plank wider than thirteen and half inches are fitted with bolts which were supported on the beam flanges and the gaps were concreted. After the concrete had hardened the bolts were removed and their holes grouted.

Seven days after casting the intermediate diaphragms and end diaphragms and cast-*in-situ* slab work, they were transversely prestressed. While casting the outer side beams, female cones at 30-inch centres were fixed. There were two cables in the bottom of each cross beam and 25 cables in the slab, totalling to 35 cables for transverse prestressing for the whole span.

Bearings

M.S. plate sliding bearings were provided at the free end and mortar pads with M. S. rods at the fixed end.

The top M.S. plate of a free end consists of 12 in. × 6 in. × $1\frac{1}{2}$ in. M.S. plate with 6 legs of 3 U-shaped rods 3/8 in. dia. welded to the plate and anchored into the beam. The surface of bearing plate was machined. This plate was placed in position while concreting the beam itself. The counterpart of this was also of M.S. plate 12 in. × 6 in. × $\frac{3}{4}$ in. On this plate 12 in. × 2 in × $1\frac{1}{2}$ in. machine faced flat iron was welded. This machined surface was in contact with the bottom of top-bearing plate. Graphite powder and grease were applied on the machined surfaces of the bearing set which came in contact with each other.

At the fixed end every beam was fixed to the pier with 2 No. 1-in. diameter rods each

1 ft 6 in. long. These rods are embedded in the pier bents. There were two bigger holes left in the beam. The holes were vertical and extended from top to bottom. When the beam was brought in position and allowed to rest on 12 in. × 6 in. × 1¼ in. thick concrete grout pad, the holes were grouted with cement mortar from top. Thus the beam end was fixed to the pier-bent, and the narrow strip of mortar pad served as a plastic hinge for the beam.

R.C. Kerbs:—After all the beams were placed in position, the cast-*in-situ* work completed and transverse prestressing done, 1 ft. 2 in. × 9 in. thick kerbs were laid over the whole span.

R.C. Hand posts: Six inches by 6 in. by 3 feet were fixed at every 3 feet 6 inches centres with reinforcement from the kerb. Half inch dia. rods at four corners with ¼ in. dia. hoops are provided for each post.

Hand-rails:—Four rows of 2 inches internal diameter G.I. pipes were provided on either side for hand-rails.

Wearing coat: Two and a half inch thick at ends and three and a half inches thick at centre concrete wearing coat was provided.

Expansion joints were provided at the free end of the span with copper plate, 14 gauge, and 9 in. wide with a central circular groove 3/4 in. dia. and asphalt grout pad, 1 in. thick. Construction joints at 31 ft-6 in. intervals are also provided.

R.C. approach slab 24 ft wide, 15 ft long and 6 in. thick level with the top of the bridge was laid at each end.

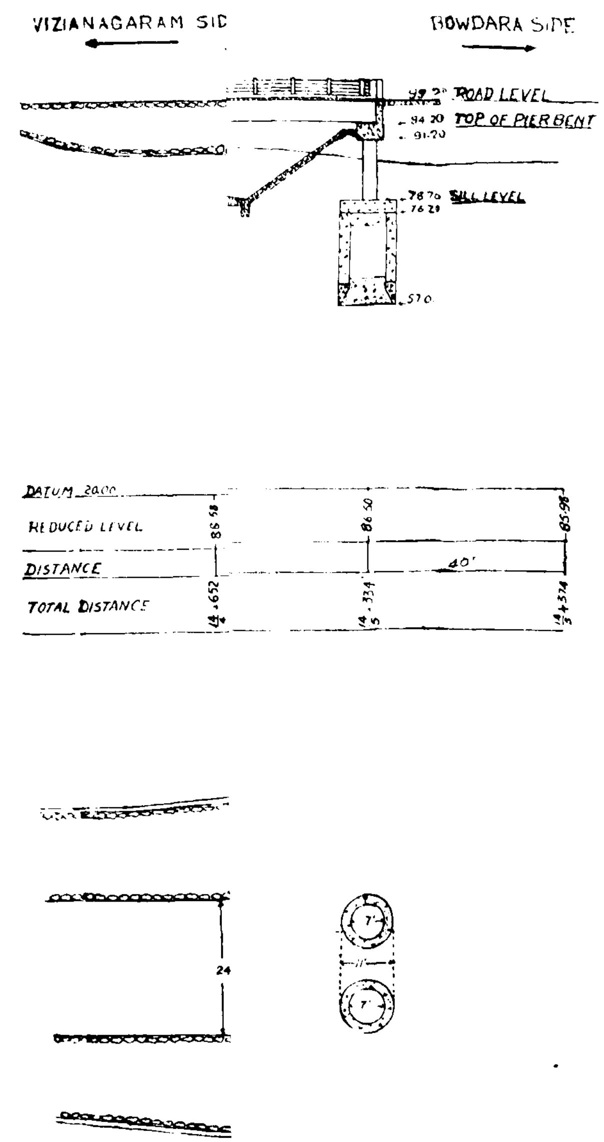
Field tests:—Water cement ratio (0.3 by weight) has been strictly followed, while the beam concreting was going on some 6 inches sample cubes were prepared in moulds. These were tested and found to give minimum strength of 3,000 lb/sq. in. after 7 days and minimum of 5,000 lb/sq. in. after 28 days.

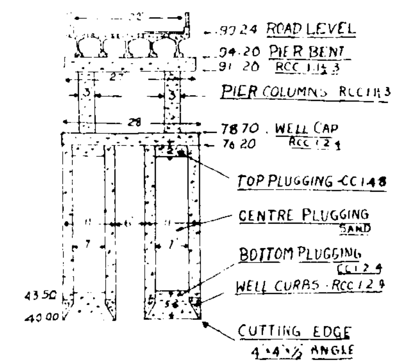
All M.S. steel used for the bridge walls was tested mild steel. High tensile steel was imported from Belgium. Special Freyssinet jacks and cones are imported from France.

Cost of foundation and substructure:—The cost of substructure including foundations, etc., was Rs 1,72,000 which works out to 43% of the total cost of the bridge.

Cost of superstructure was Rs 1,32,900 which works out to 33% of the total cost. The balance of 24% was for the approaches, revetments, establishment, etc. The total cost was Rs 3.96 lakhs, this works out to Rs 1,250 per foot run of the bridge.

PLATE I





SECTION ON AB

1 ft 6 in. long. These rods are embedded in the pier bents. There were two bigger holes left in the beam. The holes were vertical and extended from top to bottom. When the beam was brought in position and allowed to rest on 12 in. × 6 in. × $1\frac{1}{4}$ in. thick concrete grout pad, the holes were grouted with cement mortar from top. Thus the beam end was fixed to the pier-bent, and the narrow strip of mortar pad served as a plastic hinge for the beam.

R.C. Kerbs:—After all the beams were placed in position, the cast-*in-situ* work completed and transverse prestressing done, 1 ft. 2 in. × 9 in. thick kerbs were laid over the whole span.

R.C. Hand posts: Six inches by 6 in. by 3 feet were fixed at every 3 feet 6 inches centres with reinforcement from the kerb. Half inch dia. rods at four corners with $\frac{1}{4}$ in. dia. hoops are provided for each post.

Hand-rails:—Four rows of 2 inches internal diameter G.I. pipes were provided on either side for hand-rails.

Wearing coat: Two and a half inch thick at ends and three and a half inches thick at centre concrete wearing coat was provided.

Expansion joints were provided at the free end of the span with copper plate,

14 ga
circul
grout
joints
provic

R.C
and 6
bridge

Fiel
weigh
beam
inches
mould
give n
after 7
in. aft

All
was t
was i
Freyss
from 1

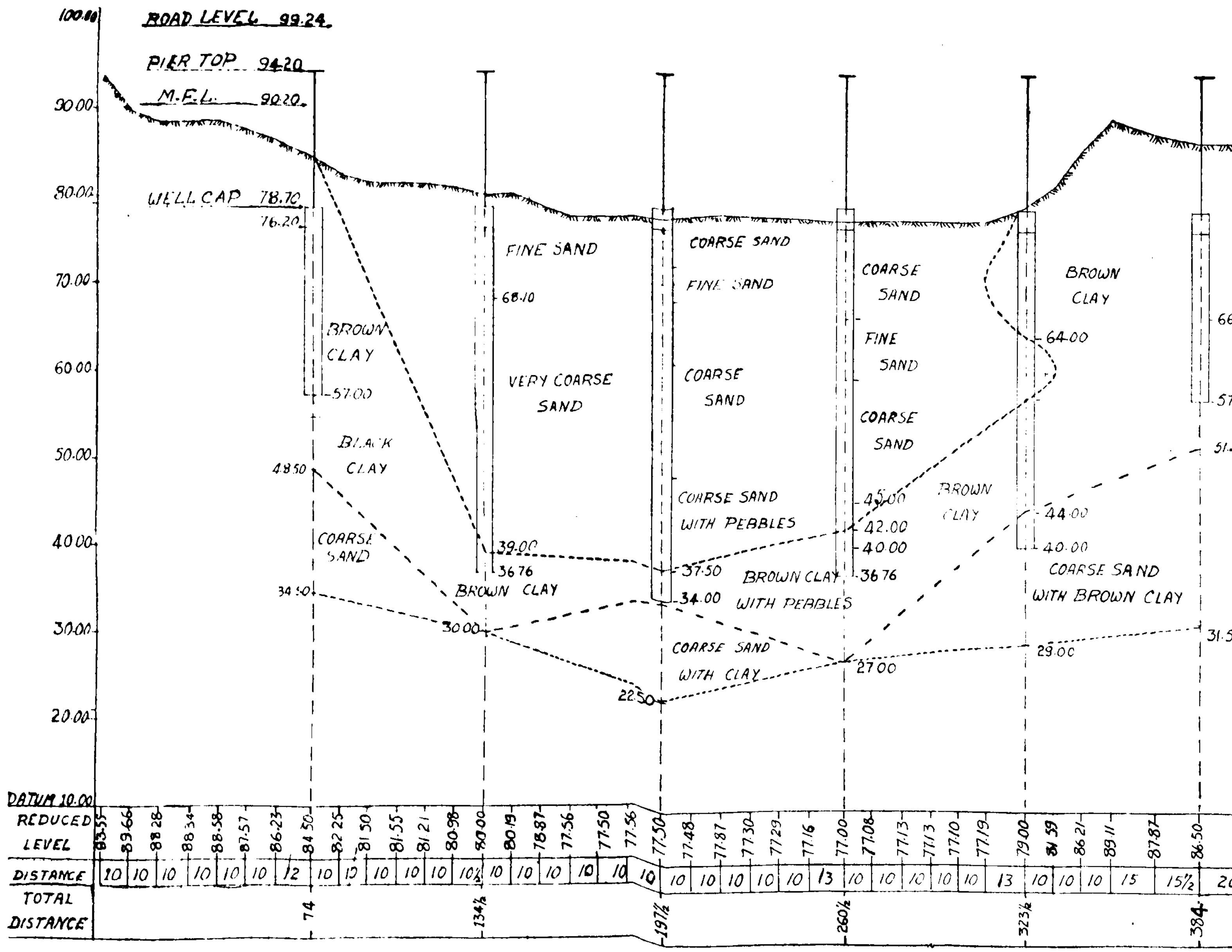
Cos
ture:-
found
works
bridge

Cos
which
The ba
revetm
cost w
to Rs

TRANSPORT-COMMUNICATIONS ANNUAL NUMBERS FOR

(Containing very useful material on Road Enginee
Each issue is priced Rs 2 plus Rs 1-2
Copies will be sent by V. P. P. direct to the
Alternatively the amount may be remitted by

Copies can be had from the Secretary,
INDIAN ROADS CONGRESS,
JAMNAGAR HOUSE, MANSINGH ROAD,
NEW DELHI-11.



'ternoon
ays the
1 for a
iggle to
on play
inst a
ma, he
k end—

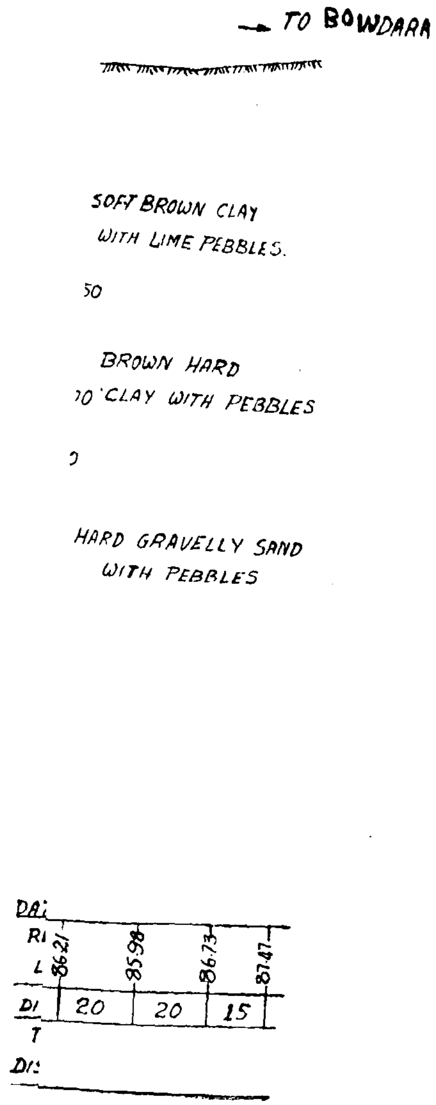
n more

o have
en done
r that I
lo some
nething
furiates

nanage-
on. He
ith him
ganisa-
inually
e work
and not
a bank,
ve long
entirely

ve just
ittering
morrow.
1961")

PLATE II



PLAIN WORDS

By

CAPRICORN

IT seems to be a modern occupational disease to take work home. The executive with his bulging brief case is a familiar and depressing image. Contrary to popular belief, the brief case does not contain oranges, sandwiches, a novel, or presents for his wife, but copious quantities of tiresome documents, reports to read, examination papers to be marked, a slide rule, engineering drawings, notes for a lecture, all the portable paraphernalia of human and administrative overheads.

Do not imagine that the brief case needs to bulge. Its slave will only work upon a fraction of its contents. But on Friday night, when he gathers his papers together, he is always far too tired to make decisions or plan a reasonable and limited working programme. He therefore takes the lot. So every week-end hanging over him is a superhuman task—or a guilty conscience.

Because the week-end seems so full of potential working sessions—mornings, afternoons and evenings, two of each—he never quite gets down to it. On Saturday morning he feels jaded and puts it off till later; Saturday afternoon—well, he must have some fresh air, and goes off to watch the "extra", three men short, defeated by enormous odds. Television with "Candid Camera" or the captivating satire of Anthony Newley claims his attention in the evening. But all the time, just beneath the surface, he is worrying.

On Sunday he doesn't quite get up in time to catch the early service; the morning passes with very little done; the afternoon his wife puts down her foot and says the children (or the dog) must be taken for a walk. The evening is a frantic struggle to finish something before the television play begins. He fails. Working against a background of low-volume melodrama, he curses himself for running the week end—and finishes at midnight.

The following week he gets even more behind:

I know just how he feels. I *too* have worked at home, indeed, I have often done so, for no better reason than the fear that I may waste the week-end; but if I do some office work I shall at least have something to show for it. This argument infuriates my wife.

My friend Jelks says it's just bad management—or a sign of mental exhaustion. He works in a bank. I have to agree with him to some extent; but in a growing organisation where new systems are continually being created, there is always more work than can possibly be accomplished—and not much can be delegated. No doubt in a bank, where systems and procedures have long been formulated, the situation is entirely different.

Out of the corner of my eye, I've just seen the Sunday play draw to its shattering conclusion I bet I feel like death tomorrow.

(From "Engineering, 17th, March, 1961")

RIVER TRAINING FOR BRIDGES BY THE GUIDE BANK SYSTEM

C. RAMAKRISHNA RAO, M. TECH.

Department of Civil Engineering, Indian Institute of Technology, Kharagpur

ABSTRACT

River training for the construction of bridges across the Indo-Gangetic and other flood plains, where the width of the river may extend to several miles, has been a vexatious problem to the engineers for a long time. In the present day a method successfully adopted is to build guide banks to direct the flow through the bridge. The paper deals with the evolution of the modern river training system, the principles and the features of its design and an example to illustrate them. A list of important references on the subject is furnished at the end.

1. Introduction

The alluvial plains of the Himalayan rivers are very wide, often running into several miles. During the dry season, the river occupies a minor portion of the entire width, whereas in flood season it is in full spate. For the construction of bridges over such rivers it is found uneconomical to provide the entire width as waterway; because for a major part of the year, the river flows in a single narrow channel at the centre and almost all the end spans will behave as landspans. It has also been the experience in many cases that in a bridge with constricted water-way the tendency to meander is lessened. Hence constriction of the width has been generally recognised as the first step towards bridging the river. Various methods have been devised to achieve this objective, of which the guide bank system is the one that is mostly in use.

2. Development of the Guide Bank System

2.1. Before attempting to make a review of the gradual evolution of the guide bank system, the present-day method of river training and control, it is better to quote here the definitions of a spur, a groyne and a *bund* as given by Mr. E. Wooley Dod[1].

"A *bund* is a solid mass, generally of sand faced with earth, made for the purpose of entirely intercepting water. The face of the *bund* is usually protected at intervals by *groynes* about 200 feet long, run out at right angles, with heads pitched with stone. The line of the *bund* should be so located as to let the water flow into the space above and deposit silt, and then escape without causing excessive scour.

A *spur* is a mass of alternate layers of trees and stone, capable of sinking unevenly without being broken up; it is used to form a limit to the main stream by preventing it from cutting away the bank; and also by causing a scour to keep the deepest part of the channel just outside the end of the spur and so prevent the stream from wandering about. The outer end of a spur is often 10 or 15 feet below water and the water is allowed to flow freely over it. By making a series of spurs, deep holes are scoured at each of them, and if the spurs are near enough to one another, a continuous channel is thus formed. It is believed that this will take place when spurs are half a mile apart, if there are no obstacles in the way. At the upper part where, so to speak, the river has to be caught and collected in one channel, the spurs must of course be closer."

2.2. The prevailing idea in the minds of the engineers of the past as regards the training of an errant river was that it should be given " a kick here and a pat there " so as to make it flow through the bridge abutments. Training works mainly were temporary in nature, consisting of a mixture of

stone with perishable materials and requiring heavy annual maintenance.

The development of the modern training system has been diagrammatically shown in Figure 1. If no training works are provided, there is every possibility of the river cutting through the approach embankments and finally the bridge may be outflanked as shown in Figure 1 (*a* to *d*). The early method of training a river consisted of spurs, run out at right angles to the banks of the river, Figure 1 (*e*). Later spurs with retired *bunds* have been adopted as shown in Figure 1 (*f*). In both the cases, heavy pitching is required to protect the shank and the riverward end of the spur from the violent attack of the river. Denehy evolved the *T*-headed spur, Figure 1 (*g*), which is merely an ordinary spur with an arm at the riverward end parallel to the river current, to minimise the quantity of stone required for protection. But its success depends on many factors such as a control on the upstream and a flattened flood gradient. These are the very factors which contributed to the success of Denehy's spurs at Narora. The credit for the invention of the modern system of river training goes to Mr. J. R. Bell. Two artificial embankments (called the guide banks), properly armoured, with their ends curved, are provided so as to guide the flow through the bridge abutments, Figure 1 (*h*). Sir Francis Spring perfected the design of the guide banks.

3. Principles of Guide Bank

3.1. It is found that in its course a river, which at some places is very wide, may often pass through a narrow gorge with a cross-section much less than the normal one and yet with no appreciable velocity. When the river passes through a wide bottom and there is no rocky gorge in the vicinity of the bridge alignment, it is imperative to build an artificial gorge for bridging the river. A pair of embankments, at a distance apart so as to pass the flood discharge of the river with no more than its natural fall of bed, will be constructed. The slope of the bank is covered upto low water level with rip-rap of such thickness that the sand is not sucked out by the current. At low water level, a horizontal apron of stones is provided so that as scour occurs, the apron launches itself to the slope of the exposed sand surface. The design of the various components of a guide bank will be dealt with subsequently.

3.2. It may in the first instance appear that narrowing results in undue scour or undue afflux. But it has been found that, if the river bed consists of erodible incoherent sand, the bed scours out easily and improves in section, thereby reducing the afflux. That is, the bottom will be scoured out as fast as the rate at which it rises. However, the scour will not be uniform all over due to the differences in the quality of the bottom and there is a tendency for the deeper places to become still deeper. Observations taken in actual rivers justified this.

3.3. Another important point to be considered is that there is a limit for narrowing. The greater the narrowing, the deeper will be the scour and therefore more expensive is the stone protection. Further, construction of guide bank in deep water is uneconomical. Spring recommends that narrowing in practice may be limited to what will cause an overall scour of 8 to 16 ft between abutments for falls of 18 inches per mile and less[1]. The principal advantage of constriction is that the river hugs to the new channel and the tendency to meander is reduced because of the deep scours produced.

4. Design Features of Guide Banks

The design of the guide banks shall be such that, on plan, they shall not give rise to serious and deep scours. Provision has to be made to reduce the attack at the end of the straight portion of the guide banks. The upstream end shall have to be curved back so as to provide a smooth entry and shall be heavily protected so as to make it impregnable. The downstream portion will also have a curved head so as to reduce the intensity of swirls created there. The design features of guide banks will now be considered.

4.1. Form in plan

Guide banks can be either divergent, convergent upstream or parallel (Figure 2). The actual layout depends upon the local conditions. Bell, the originator of the guide bank system, recommended that the guide banks should be brought closer at their upstream ends so that the distance between

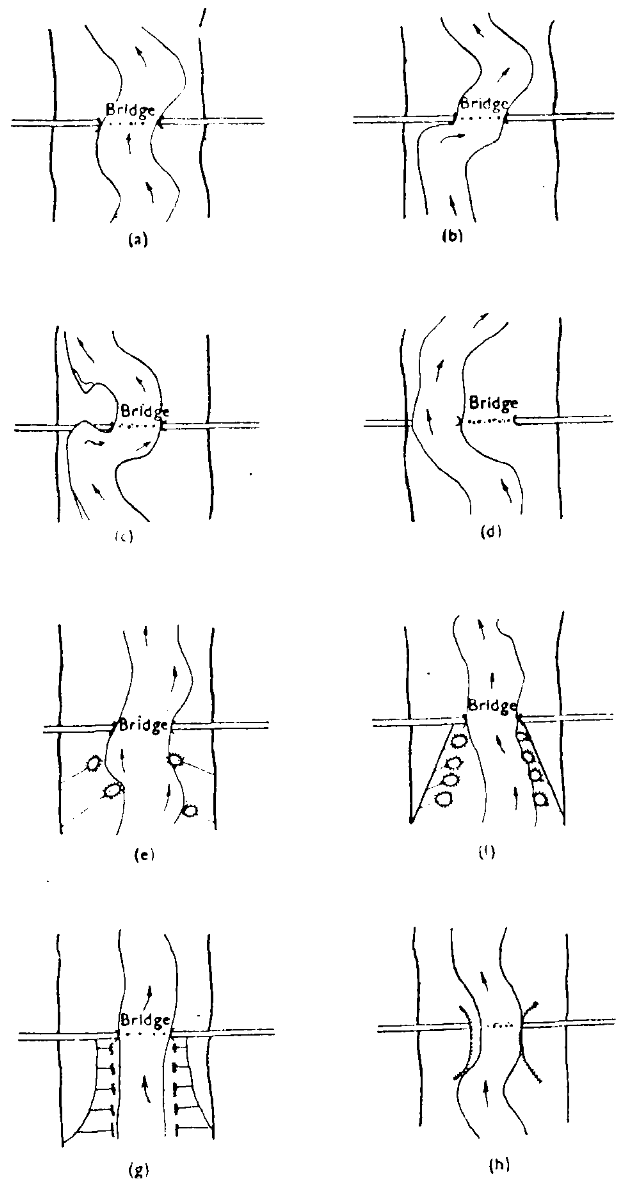


Figure 1: *Showing the development of the modern system (a) Bridge erected; (b) Left approach threatened; (c) Left approach breached; (d) Bridge quite outflanked; (e) Early spur training; (f) After spurs with retired* bunds; *(g) Denehy's spurs with retired bunds and (h) Latest improved 'Bell' system.*

the two ends equals the effective area at the bridge site[2]. This would make the current to flow straight through the bridge, instead of obliquely. But in some cases the narrowing as recommended by Bell may not be possible due to construction difficulties. Spring, however, was of the opinion that the guide banks should be symmetrically laid so as to attain uniform flow through the bridge and uniform scour. If an outcrop of hard material is met with on one bank of the river, one of the guide

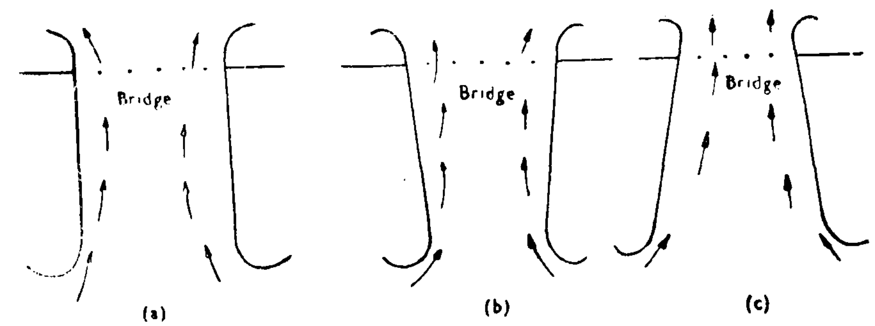


Figure 2: *Showing form in Plan of guide banks; (a) Parallel (b) Convergent upstream and (c) Divergent upstream*

banks can be dispensed with. The other guide bank is designed to be a facsimile, on plan, of the permanent river bank.

4.2. Width apart of guide banks

The guide banks should be spaced such that the improved cross-section would be able to carry the flood discharge of the river without appreciable afflux and undue scour. An overall deepening of 8′ to 16′ depending upon the type of material can be allowed. Table 1 gives the scour depths to be allowed for, in designing the narrowing of a river by means of guide banks.

The method in deciding the waterway of the bridge is as follows:

(*i*) Three fairly representative cross-sections of the river are taken and the average bed slope applicable to each cross-section is ascertained.

(*ii*) Curves showing velocity-depth of water relationship for various bed slopes are drawn from Kutter's formula or from Mississipi formula in which,

$$V = [\sqrt{225\, R \sqrt{S}} - 0.0388]^2$$

where V = velocity in ft/sec, S = Slope of the river

$$R = \text{Mean radius} = \frac{\text{Area}}{\text{Wetted border} + \text{Surface}}$$

(*iii*) The total flood discharge is then calculated for each section and either by averaging or by judgment the discharge of the river is obtained.

(*iv*) On the section where the river is to be narrowed, a revised ideal section, deeper all over than the existing one by the depths indicated in Table I, is drawn.

(*v*) The best part of this deepened section is then taken and, applying the velocity diagrams, the width required to carry the entire river is determined. The remainder can then be blocked up.

(*vi*) If further refinement is required, it may be assumed that instead of the river deepening equally all over, its deepest part

TABLE I

Sand Classification and allowable Scour depths for narrowing

No.	Classification	Description	Allowable Scour
1	*C* or Coarse	80% of the whole is stopped by the 40-wire and coarser sieves.	10
2	*VC* or Very Coarse	Coarse sand when 25% of the whole has been stopped by the 16-wire and coarser sieves.	8
3	*F* or Fine	80% of the whole passes through the 75-wire sieves.	14
4	*VF* or Very Fine	Fine sand when 20% of the whole passes through 100-wire sieve.	16
5	*M* or Medium	Between Coarse and Fine.	12

may probably become 20 or 30 feet deeper instead of the assumed depths, while its shallower parts may probably deepen a foot or two.

(*vii*) Then applying the velocity diagrams, the extent of waterway is arrived at.

4.3. Length of guide bank

The length of the guide bank is based on two considerations: first, the distance necessary to secure a straight run for the river through the bridge; and second, the length necessary to prevent the river cutting into the approach bank.

The length of guide bank depends to a certain extent on the length of bridge. Figure 3 shows the effects of an unduly long guide bank as compared to one of just the sufficient length. In Figure 3 (i) the plan shows how askew the current is and the section indicates how irregularly the scour takes place in the case of unduly long guide banks. Figure 3 (ii) shows the section and

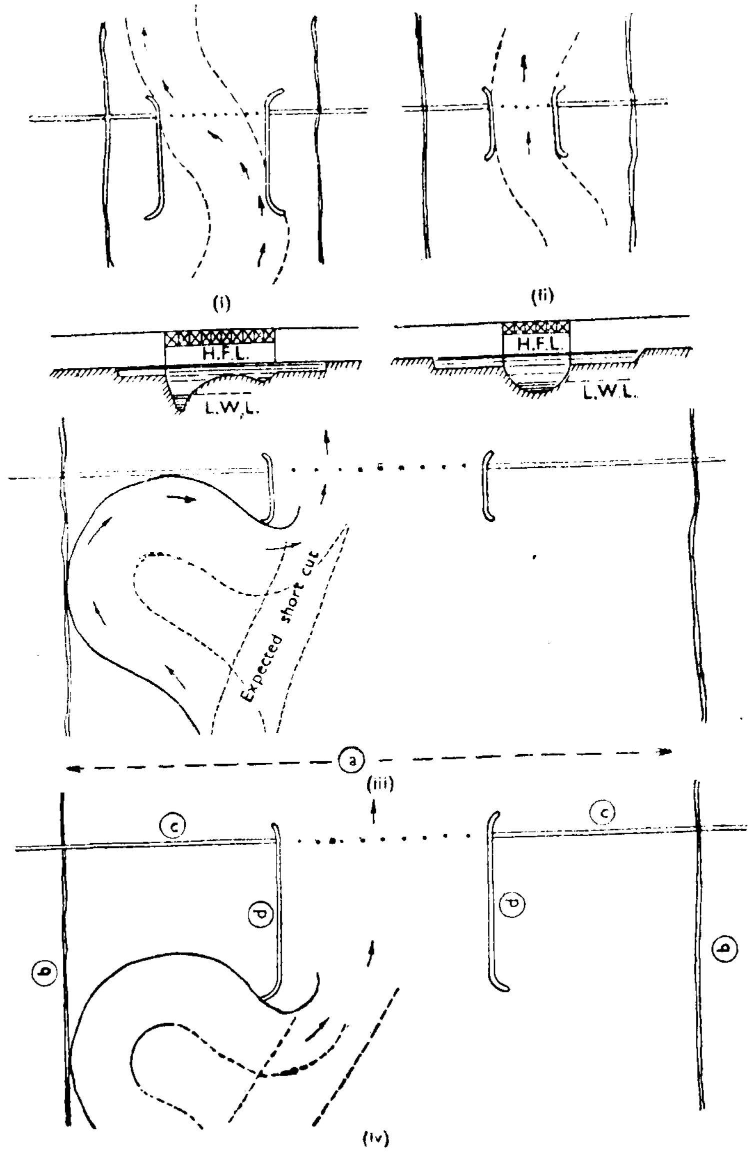


Figure 3 (i) to (iv): *Showing the design of guide banks: (a) Extreme breadth of untrained rivers; (b) Extreme edge of river; (c) Railway approach bank; (d) Guide bank*

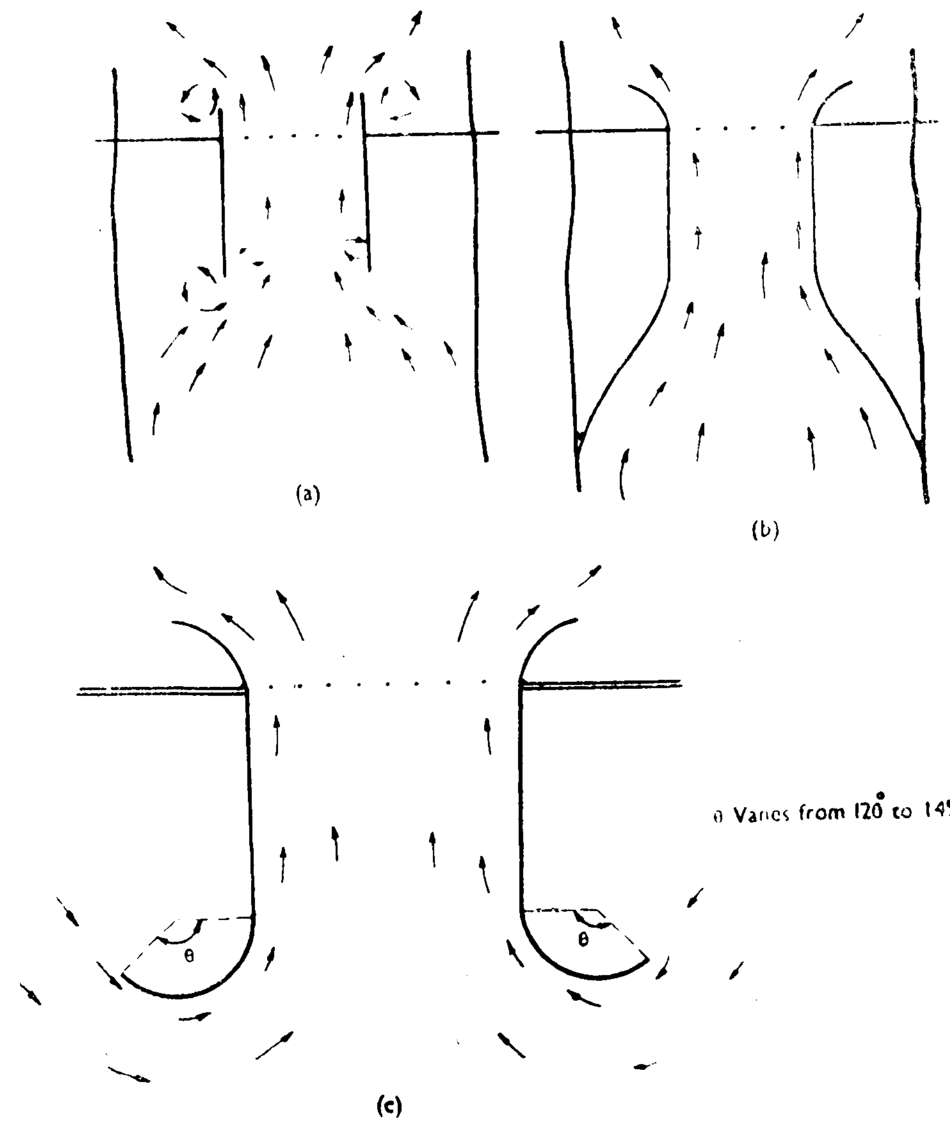


Figure 4 (*a*) to (*c*): *Curves for heads of guide banks*

plan in the case of guide bank of sufficient length. Uniform deepening has taken place all over and the river flows straight through the guide banks.

The primary consideration influencing the upstream length of the guide bank is the breadth of the untrained river and the radius of its worst bend, prior to the development of a cut-off. If the length is less, the bend may occur near the head of the guide bank, in which case the river cuts through the approach embankment, as shown in Figure 3 (iii). A substantial margin should therefore be left between the region of probable embayment and the approach embankment by the provision of a suitable length of guide bank as shown in Figure 3 (iv).

According to Spring[1], the length of the upstream part of the guide bank is equal to or 10 per cent longer than the length of the bridge. The downstream length of the guide bank is generally 1/10th to 1/5th the length of the bridge, with due regard to the activity of the swirls or disturbances likely to be caused by spreading out of the flow on leaving the bridge-curved heads are provided at ends of straight guide bank so as to reduce the activity of the swirls. The design of these curves is subsequently explained.

Gales[3] has recommended lengths on the basis of river discharges, having given due regard to the angle of obliquity also. For discharges between 0·25 to 0·75 million cusecs, the upstream length is given as $1\frac{1}{4}$ times the length of bridge with a convergence of 1 in 20 and limiting the angle of attack to less than 34°, which is considered reasonable. For discharges between 1·5—2·5 million cusecs, $1\frac{1}{2}$ times the length of bridge has been recommended to be the length of the upstream part of the guide bank. For intermediate discharges, a length of $1\frac{1}{4}$—$1\frac{1}{2}$ length of bridge is adopted.

4.4. Radius of curvature appropriate to guide bank heads

If the ends of the guide banks have been left square, due to the obstruction to flow, deep scours will occur as a result of the formation of swirls as shown in Figure 4 (a). To eliminate their occurrence, the ends should be curved in plan. If, as shown in Figure 4 (b) the guide banks are carried right upto the banks of the river, the cost involved nullifies the saving reckoned from narrowing of the bridge. The usual practice is to provide a curved head as shown in Figure 4 (c) the angle to which it is curved back being in the range of 120°—145°.

The radius that can be adopted depends upon the velocity with which the water moves in the river. According to Spring[1], water with a velocity of 8 to 10 feet per sec., which usually occurs, can easily follow a curve of 600 to 800 feet. Also the radius adopted should further conform to the requirement for easy movement of the rolling stock for carriage of materials during construction. Gales[3] recommended a 7° curve (radius 819 ft) for discharges between 0·25—0·75 million cusecs and a 3° curve (radius 1,910 ft) for discharges in the range of 1·5—2·5 million c/s. For intermediate discharges, the radius to be adopted can be interpolated.

The values of radius of curvature, as recommended by Spring, depending upon the bed material, probable maximum scour and the fall of the river, are summarised in Table II.

TABLE II

Radius of Heads of guide banks

Sand Classification	Probable Max. abnormal scour	Fall per mile of river in inches: 3	6	9	12	18
		Radius of upstream curved end of Guide Bank				
VC	Under 20 feet	200	250	300	350	400
VC	Over 20 feet	250	310	375	440	500
C	Under 30 feet	300	360	425	490	550
C	Over 30 feet	350	430	510	590	670
M	Under 40 feet	400	425	550	625	700
M	Over 40 feet	450	550	650	750	850
F	Under 50 feet	500	590	675	760	850
F	Over 50 feet	600	725	825	925	1,020
VF	Under 60 feet	600	700	800	900	1,000
F	Over 60 feet	800	900	1,000	1,000	1,200
Radius of curve of downstream ends of guide bank.		Half the above width for minimum radius, that on which maintenance trains can be shunted.				

4.5 Shanks

The water level at the rear of the guide banks will be higher than that at the bridge, due to the conversion of the kinetic energy of the water into the potential energy; because the area between the guide bank and the river bank serves as a still water area and soon silts up. Therefore adequate free board has to be provided with respect to the water level at the rear of the guide bank, instead of the maximum water level in the river.

As regards the section of the guide bank, the top width shall be a minimum of 20 feet and side slopes 2 to 1, carried down to the low water level. On the rear slope of the bank, a good coating of a foot or two of earth shall be given to encourage the growth of vegetation. An allowance of 20 per cent of the height has also to be made for settlement.

4.6 Slope protection for shanks

The upstream face of the guide bank has to be armoured with stone pitching to protect it from every conceivable kind of attack. Stones weighing 80 to 120 lbs are generally used and these are not moved even at velocities of 18 feet per second. The thickness of stone pitching to be provided is dependent upon the grade of the river and the size of the bed material. The values recommended by Spring[1] are given in Table III. These can be reduced if small size stones are used between sand and the larger stones. The slope protections shall not slip downwards under any circumstances. At the upstream head, the thickness is increased by 25 per cent because of the severity of the attack. Further, as pitching dropped through deep water will not launch uniformly about 25 per cent more stone should be used.

Gales[3] recommends the following thickness of stone pitching for the head, body and tail depending upon the discharge (*Vide* Table IV).

However, Inglis[4] is of the opinion that discharge is the proper criterion for determining the thickness of stone pitching. He considers that slope and grade of the material are dependent variables. He gives the following formula, taking the available data into account.

$T = 0{\cdot}06\, Q^{\frac{1}{3}}$ where T is the thickness in feet

Q is the discharge in cfs.

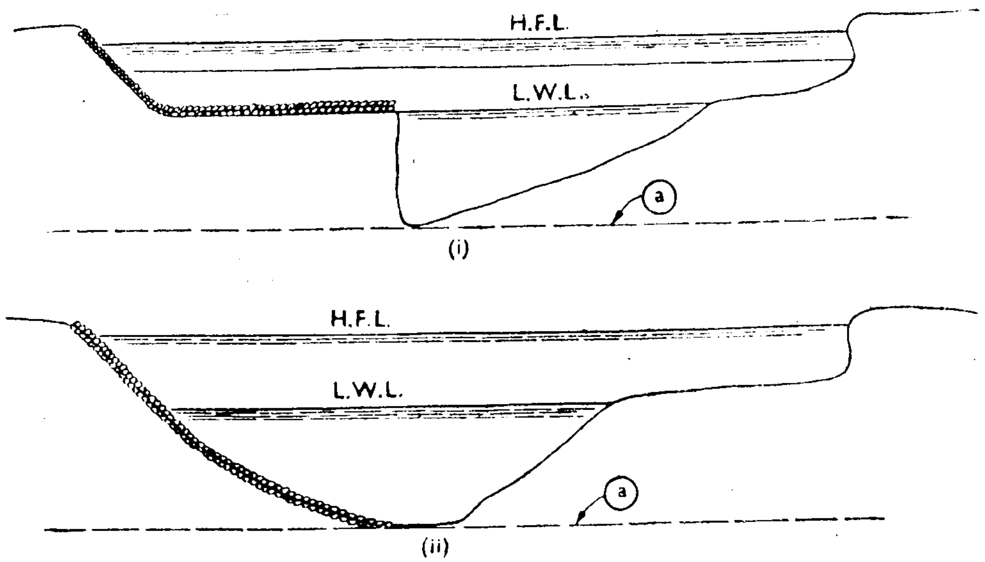
4.7 Horizontal apron

To protect the slope stone pitching from undermining due to scour, an apron of stones, extending from the toe of the slope towards the river, is provided horizontally at the low water level. The apron is expected to launch to the scoured slope as it occurs from the outer end. Its length is dependent upon the maximum depth of scour likely to occur. The apron, as laid in Figure 5 (i) launches as shown in Figure 5 (ii) when scour occurs, and forms a

TABLE III

Thickness of stone pitching on the slope (According to Spring)

Fall per mile of river in inches	3	9	12	18	24
Sand classification	Thickness of slope stone pitching in inches				
Very Coarse *VC*	16	19	22	25	28
Coarse *C*	22	25	28	31	34
Medium M	28	31	34	37	40
Fine *F*	34	37	40	43	46
Very Fine *VF*	40	43	46	49	52



Launching of apron

Figure 5 (i) to (ii) : *Launching of apron (a) Deepest Known Scour*

continuous carpet below the slope of the guide bank.

The design of the apron will now be considered—

(i) Estimation of Scour depth

Due to the constriction and rigidity of the structure, more scour occurs than in a straight reach of an unobstructed river. Spring recommends that the guide banks should be designed for the worst abnormal scour to be found in the river.

Gales(3) method of arriving at the probable scour depth is given in Table V.

Khosla(5) has suggested the following values for the design of flexible loose stone aprons of guide banks in terms of Lacey's scour depth D where

$$D = 0{\cdot}47 \left(\frac{Q}{f}\right)^{\frac{1}{3}}$$

in which

D = Scour depth below high flood level (ft)

f = Silt factor = $1{\cdot}76\sqrt{m}$

m = Size of the material (mm).

Location	*Range of Scour depth*	*Mean depth to be adopted*
Nose of guide bank	$2D$ to $2.5D$	$2.5D$
Transition from nose to straight portion	$1.25D$ to $1.75D$	$1.5D$
Straight reaches of guide bank	$1D$ to $1.5D$	$1.25D$

Experiments conducted at the Poona Research Station (4) showed that for the portion of the shank in the vicinity of the piers, the maximum scour would be $2D_{Lacey}$. For large radius of the guide banks, the scour depth was of the order of 2.75 D_{Lacey}.

(ii) Thickness of the launched apron

The thickness of the apron has been variously proposed as follows :—

Spring suggested that the thickness of stone, after launching, should not be less than the thickness of the slope stone pitching ; and as it is not certain that the stone may not lump itself, during launching, in

TABLE IV

Thickness of Stone pitching on the slope according to Gales

Rivers / Part of guide bank	Rivers with 0·25—0·75 million cusecs		Revers with 0·75—1·5 million cusecs		Rivers with 1·5 to 2·5 million cusecs		Remarks
	Head	Body & Tail	Head	Body & Tail	Head	Body & Tail	
Permanent slope							
Pitching stone thickness, Soling ballast.	3′ 6″	3′ 6″	3′ 6″	3′ 6″	3′ 6″	3′ 6″	To be hand set Ballast broken to pass 2½″ ring.
Total thickness of stone covering.	4′ 1″	4′ 1″	4′ 2″	4′ 2″	4′ 3″	4′ 3″	

TABLE V

Gales' method of arriving at deepest scour to be adopted in design

	0·25—0·75 million cusecs	0·75—1·5 million cusecs	1·5—2·5 million cusecs
Observed deepest scour below L.W.L. along a soft cutting bank in the bend at 3/4 falling flood	x_1	x_2	x_3
Add 33% to convert these depths to those obtainable at a rigid bank	$0{\cdot}33x_1$	$0{\cdot}33x_2$	$0{\cdot}33x_3$
Deepest known scour	$1{\cdot}33x_1$	$1{\cdot}33x_2$	$1{\cdot}33x_3$
Percentage addition to deepest known scour to be made for contingencies such as unlikelihood of finding absolutely deepest scour, narrowing of the river and for severe attack on the guide bank head—			
For body and tail of the bank	25%	32%	45%
For head of guide bank	50%	63%	90%
Deepest scour to be adopted, below L.W.L.—			
For body and tail of the bank	$1{\cdot}66x_1$	$1{\cdot}75x_2$	$1{\cdot}92x_3$
For head of the bank	$2{\cdot}0x_1$	$2{\cdot}17x_2$	$2{\cdot}53x_3$

some places, a thickness of 1·25 times the slope thickness may be taken as a minimum. A larger thickness than this may be given if the river is turbulent and liable to great alterations of depth. The minimum length of apron at low water level has been taken at 1·5 times the maximum depth of scour. The distribution of apron stone, as suggested by Spring, is shown in Figure 6 (i). The reason for giving extra thickness at its outer edge is that it seems probable that more of it may be dissipated when undermined by the deep scours that attack it at that place than by the shallower scours to which its inner parts are in their turn exposed.

The slope the launched apron takes, has been found to be ranging from 1·5 : 1 to 3 : 1 and in most cases, the average approximates to 2 : 1. To satisfy this requirement, the distribution suggested by Spring is not completely satisfactory. While the amount of stone in the full length of the apron is sufficient to cover the launched slope to a thickness of 1·24 T (where T is the thickness of stone pitching on the slope), if the first half of the apron length only is considered, the amount of stone that has been provided in this length is insufficient to cover the launched slope to the stipulated thickness.

To overcome this difficulty, Gales[3] has recommended a uniform apron and provision of a berm which is merely an additional length of apron to ensure permanence to the stone pitching on the slope, Figure 6 (ii). Based on his experience, he gave the thickness of the apron as shown in Table VI.

T. S. N. Rao[6] has suggested an improved distribution of stone with the same quantity of stone as suggested by Spring. He assumes that the additional thickness of stone to be provided over the normal thickness T depends upon the depth to which the apron is required to launch. For the launched apron to be 1·25 T in thickness, the distribution has been indicated in Figure 6 (iii).

Additional stone has to be provided at the head for the fanning out of the apron during launching. The quantity of stone to be provided at the head is arrived at as follows :—

From Figure 7 :

Surface area to be covered by the apron after launching $\Big\} = \pi r \sqrt{5} D$

TABLE VI

Gales' method for the determination of apron thickness

Prospective Slope	Rivers with Q = 0·25 to 0·75 million cusecs (a)		Rivers with Q = 0·75—1·5 million cusecs (b)		Rivers with Q = 1·5—2·5 million cusecs (c)		Remarks
	Head ft.	Body & Tail ft.	Head ft.	Body & Tail ft.	Head ft.	Body & Tail ft.	
Pitching Stone	3·50	3·50	3·50	3·50	3·50	3·50	
For absence of soling 33% ...	1·17	1·17	1·17	1·17	1·17	1·17	
Add 11% & 22% for discharges (b) & (c) respectively ...	...	...	0·375	0·375	0·77	0·77	Silt content was found to be 33% in Hardinge Bridge Sand.
Add for high silt content 11% & 22% for discharges (b) & (c) respectively	...	...	0·375	0·375	0·77	0·77	
For head 22%	0·77	...	0·77	...	0·77	...	
Thickness of stone pitching T_1 ...	5′ 5″	4′ 8″	6′ 2″	5′ 5″	7′ 0″	6′ 3″	Design for 1 in 2 slope.
Apron thickness 1·5 T_1 ...	8′ 3″	7′ 0″	9′ 3″	8′ 3″	10′ 6″	9′ 3″	
Berm Thickness	Same as apron thickness						

Where $r = \frac{r_2 + r_1}{2}$ and

D = Depth of scour below low water level which is the same as the bed level.

Volume = $\pi \; r \sqrt{5} D \times 1{\cdot}25 \; T$ where T = Thickness of stone pitching on the slope.

This quantity has to be laid in an area.

$$= \frac{\pi}{2} (r^2_3 - r^2_2)$$

For the successful launching of the stone, model tests have shown that the bed material should scour evenly and easily [7]. Aprons on river beds of alternate layers of sand and clay do not launch satisfactorily. Graded mixtures are found to be more resistant than stones of single size.

bank to account for any further unforeseen factors.

5.0. A Typical design of a guide bank

The above principles are now illustrated by means of a problem, the data for which are taken from an actual river.

5.1. Available data

Total river width—8,600′.

River discharge—13,00,000 cusecs.

Surface slope—1 ft/ 1 mile.

Bed sand—Coarse sand with a silt factor of 1.6.

Waterway—30 spans of 150′.

5.2. The configuration of the river is such that only one artificial guide bank is

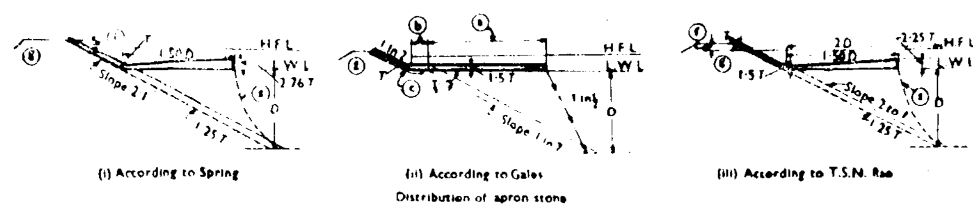


Figure 6 (i) and (iii) : *Showing distribution of apron stone width of berm : 5 ft for Class A rivers (Discharge between 2½ and 7½ lakh cusecs)*
20 ft for Class B rivers (Discharge between 7½ and 15 lakh cusecs)
25 ft for Class C rivers (Discharge between 15 and 25 lakh cusecs)

(a) *Apron.* (b) *Berm.* (c) *Clay backing.*
(d) *Deepest known scour.* (f) *Free Board.* (g) *Guide bank section.*
(T) *Thickness of slope stone.* (S) *Probable section of worst attack.*
(s) *Prospective slope.* (T_1) *Designed thickness of developed apron.*

4.8. Approach banks

The approach banks should be in the same alignment as that of the bridge till the *Khadir* is crossed (*Khadir* is the strip of low land within which a river meanders and over which its floods rise). If the approaches beyond the *Khadir* are running parallel to the river, they should be sufficiently far away ; because there is possibility of the river swinging under post-bridge conditions. The approach bank should therefore be so located that sufficient margin is allowed between the extreme edge of the river swing and the approach

necessary. Model experiments revealed that the guide bank should be

(*i*) 2,500 ft in length,

(*ii*) provided with a curved head of radius 600′ on the upstream and a sweep of 140°,

(*iii*) provided with a downstream head of radius 400′ and sweep of 90°.

5.3. Thickness of stone pitching on the slope

According to Spring, the thickness of stone pitching required for coarse sand and a slope of 1 ft/mile is 28″ (*Vide* Table III).

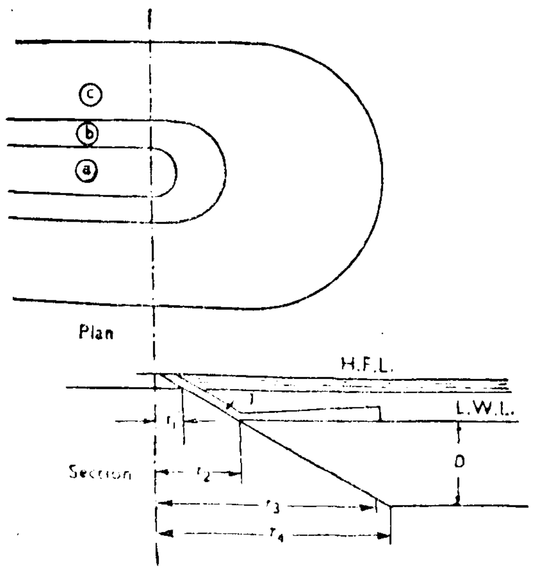


Figure 7 : *Apron Design at head—*

(*a*) *Top of spur.*
(*b*) *Slope.*
(*c*) *Apron.*

D = Depth of scour below water level assumed at bed level (L.W.L.)

r_1 = *radius of the nose at the top*

r_2 = *radius at the toe of the slope*

r_3 = *radius at the toe of the laid apron*

r_4 = *radius at the toe of the launched apron*

r = Mean of r_3 *and* r_4

T = Thickness of stone pitching on slope.

According to Gales, thickness is 50″ (*Vide* Table IV).

According to Inglis, $T = 0{\cdot}06\ (1.3\times 10^6)^{\frac{1}{3}}$

$= 6{\cdot}54' = 78{\cdot}48''$

The Inglis formula gives too high a value while the value suggested by Spring is too low. Normally the value given by Gales will be adopted.

Hence thickness of stone pitching on the slope = 50″.

5.4. Apron Design

The deepest observed scour below L.W.L. is 28′.

(*a*) *Depth of Scour—estimation*

(*i*) According to Spring—

Free scour observed at the shank = 28 ft below L.W.L. Allowing 33 per cent for arriving at equivalent scour, Greatest discovered scour = 28+9 = 37 ft below L.W.L.

At the head of guide bank—

The thickness of apron should be 25 per cent more than at the shank and the breadth twice the depth of scour instead of 1·5 times the scour-depth. This means that the design should be based on 1·70 times the greatest discovered scour below L.W.L. Greatest discovered scour = 37 ft below L.W.L.

∴ Deepest scour at head below L.W. L = 1·7 × 37 = 63 ft.

(*ii*) According to Gales—

	At Shank	*At Head*
Max. depth of scour below L.W.L. ...	28	28
Add 33 per cent for hard bank ...	9	9
	37	37
Deepest known scour Allowance for contingencies at 32 per cent and 63 per cent for shank & head respectively ...	12	24
Deepest anticipated scour below L.W.L. ...	49	61

(*iii*) According to the Lacey formula—

$$D_{(\text{Lacey})} = 0{\cdot}472\left(\frac{Q}{f}\right)^{\frac{1}{3}}$$

$$= 0{\cdot}472\left(\frac{1{\cdot}3\times 10^6}{1{\cdot}6}\right)^{\frac{1}{3}}$$

= 44′ below H.W.L.

At shank, add 50 per cent : At head, add = 150 per cent.

Scour depth at Shank

= 66′ below H.W.L.

= 29′ below L.W.L.

Scour depth at head

= 110′ below H.W.L.

= 73′ below L.W.L.

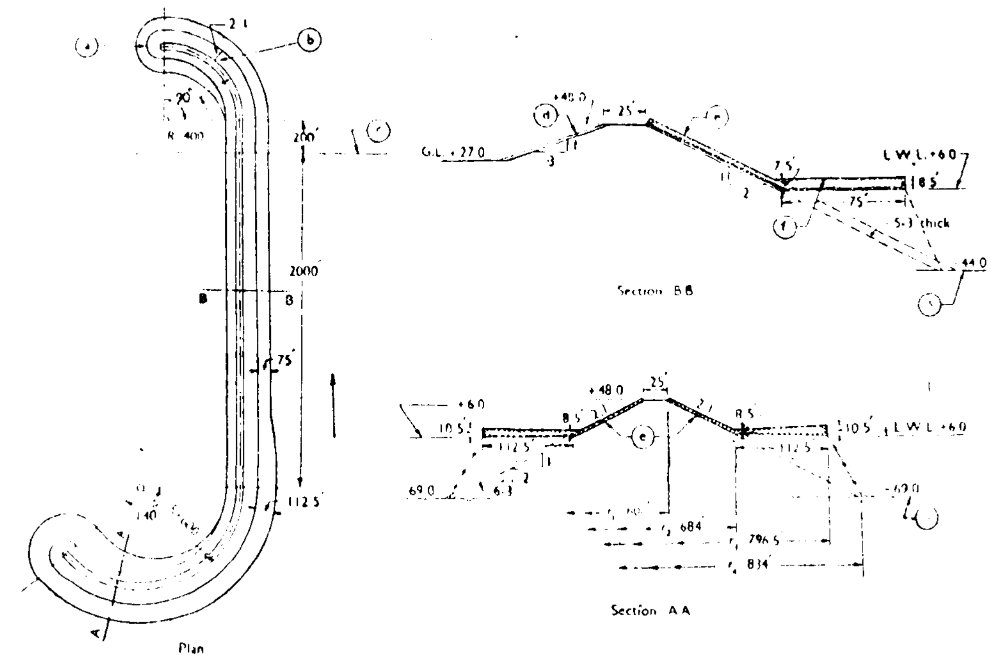


Figure 8: *Showing the typical section of the designed guide bank.*

(*a*) *Horizontal apron reduced uniformly to nothing at start of curve.*
(*b*) *2 : 1 front slope.*
(*c*) *Bridge alignment.*
(*d*) *Rear slope covered with clay.*
(*e*) *Front slope (3′—6″ thick boulder revetment over 8″ shingle packing)*
(*f*) *Horizontal apron 75′ wide.*
(*g*) *Deepest scour.*

Summarising,

Scour depth below L.W.L. according to	*At Shank*	*At Head*
Spring	37	63
Gales	49	61
Lacey	29	73
Adopted figures ...	50	75

In the portion of the shank in the vicinity of the abutment, scour depth cannot be less than round the piers which is generally provided at 2 D_{Lacey}, *i.e.*, 88′ below H.W.L. or 51′ below L.W.L. The adopted figure at shank is very nearly equal to this and hence what is provided is enough even at the abutment.

(*b*) *Thickness of apron stone*

(*i*) According to Spring—

Apron thickness to be 1·25 times stone thickness on slope

i.e., 1·25 × 50 = 62·5″ or 5′-3″

(*ii*) According to Gales, (*Vide* **Table VI**)

Appron thickness at head = 9′-3″
and at shank = 8′-0″

The average thickness actually provided is 5′ 3″ for shank and 6′3″ (*i.e.*, 1.5 times the stone thickness on slope) for the head.

(*c*) *The slope the launched apron is expected to take, is 2 to 1.*

(*d*) *Quantity of apron stone works out as below:*

(*i*) For the shank—

= $\sqrt{5}$ × depth of scour × Apron thickness

= $\sqrt{5}\times 50\times 5{\cdot}25$

= 585 cft./rft.

(*ii*) For the head—

Allowance for fanning out has to be considered.

Surface area to be considered $\frac{\pi}{2} r\sqrt{5}D$

where

$$r = \frac{r_2 + r_4}{2}$$

Now $r_1 = 600'$

$r_2 = 684{\cdot}0$

$r_3 = 796{\cdot}5'$

$r_4 = 834'$

$\therefore$ Surface area to be covered

$$= \pi \times \tfrac{1}{2}\left(\frac{r_2 + r_4}{2}\right) \times \sqrt{5} \times 75 \text{ Sq. ft.}$$

with a thickness of $6{\cdot}25'$ it comes out to

$$\text{Total quantity} = \frac{\pi}{2} \times 759 \times \sqrt{5} \times 75 \times 6{\cdot}25'$$

$$= 12{\cdot}45 \times 10^5 \text{ cft.}$$

(e) *Width of apron laid to 1·5 times the depth of scour*

Along the shank $= 1.5 \times 50 = 75'$

Along the head $= 1.5 \times 75 = 112.5'$.

(f) *Average thickness of the laid apron*

It is given by the quantity of the laid apron divided by the width of the apron.

Thus, along the shank, thickness

$$= \frac{585}{75} = 7{\cdot}8'$$

Actually 8′ average depth is provided.

Along the head—

Length over which the apron is laid

$$= \frac{\pi}{2}\left(\frac{\gamma_2 + \gamma_3}{2}\right)$$

$$= \frac{\pi}{2} \times 740{\cdot}25$$

$$= 1{,}165'$$

Volume/Unit length

$$= \frac{12{\cdot}45 \times 10^5}{1165}$$

$\therefore$ Thickness along the head

$$= \frac{12{\cdot}45 \times 10^5}{112{\cdot}5 \times 1165}$$

$$= 9{\cdot}5 \text{ ft.}$$

(g) *Thickness of apron at the junction with slope.*

Against the slope stone thickness of 4′ 2″, at the junction of slope and apron, a thickness of 5′ 8″ and 5′ 0″ is provided at the head and the shank respectively. Further a 50 per cent increase of this has been made as stipulated. Therefore thickness of the laid apron at the junction of the slope and apron is 8′ 6″ and 7′ 6″ respectively. The thickness of the apron at the outer end will therefore be 10′ 6″ for the head and 8′ 6″ for the shank.

The downstream head of the guide bank has been provided with the same thickness of stone pitching as that of the shank. Typical Sections are shown in Figure 8.

6. ACKNOWLEDGEMENTS

The writer is working under a Junior Research Fellowship offered by the Council of Scientific and Industrial Research, on the problem of river training for bridges. The material presented in this paper forms a review of the literature, prior to the choice of the research problem.

The writer is thankful to Prof. J. Visweswara Rao, Professor of Civil Engineering, Indian Institute of Technology, Kharagpur, for his helpful suggestions.

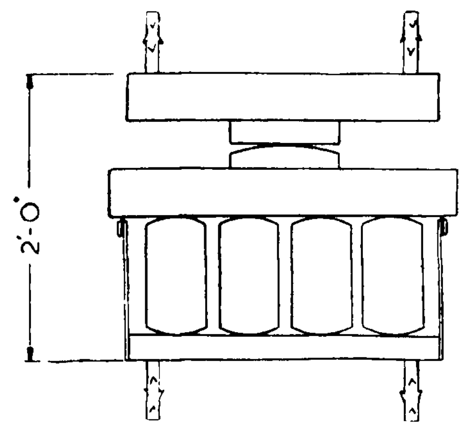
7. BIBLIOGRAPHY

1. Francis J. E. Spring: "River Training and Control on the Guide bank system".
2. James, R. Bell: "The continuous *bund* and apron method of protecting the flanks of bridges for rivers in the Punjab". Technical Section paper of the Railway Board, dated 25th August, 1890.
3. Galos, R.: "The principles of river training for Railway Bridges and their application to the case of the Hardinge Bridge over the Lower Ganges at Sara". Journal of the Institution of Civil Engineers, December 1938, paper No. 5167.
4. Inglis, C. C.: "The behaviour and control of rivers and canals." Research Publication No. 13, Central Water, Irrigation and Navigation Research Station, Poona, 1949, Parts I & II.
5. Khosla, A. N., Bose, N. K., and Taylor, E.: "Design of weirs on permeable foundations", Central Board of Irrigation, New Delhi, Publication No. 12, 1936.
6. Rao, T. S. N.: "History of the Hardinge Bridge upto 1941", Railway Board, Government of India, New Delhi, Technical paper, No. 318. 1946.
7. Joglekar D. V.: "Manual on River Behaviour, Control and Training", Central Board of Irrigation and Power, New Delhi, Publication No. 60, 1956.

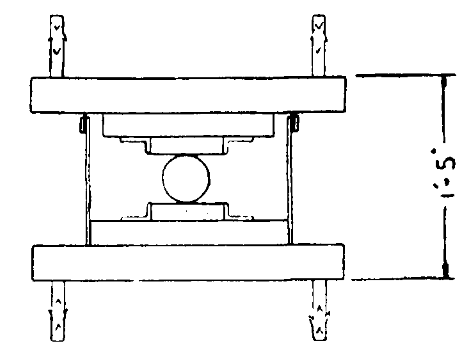
(Reproduced from "Irrigation and Power", Vol. 18, No. 3, March 1961 with kind permission of the Central Board of Irrigation and Power).

WESTWOOD'S "HI-LOAD" 25-TON PER INCH BRIDGE BEARING

MODERN bridge design calls for bearings capable of sustaining much heavier loads than previously. A new extra high tensile steel bearing of compact design known as the "Hi-Load" Bearing, capable of sustaining a load many times that previously used for single rollers in U.K. is being marketed.



600 Ton Mild Steel Bearing



600 Ton Westwood "Hi—Load" Bearing

The single roller, which has been standardised at 4 in. diameter, and the top and bottom plates immediately in contact with the rollers, are made from an alloy steel of a special composition suitably heat treated for the purpose.

Tests have been carried out by an independent testing house, and the results obtained are generally in agreement with the theories propounded by Hertz. These tests have proved that these rollers and plates are capable of withstanding a load of 65 tons per lineal inch without evidence of surface cracking and without undue permanent distortion.

A working load of 25 tons per inch run has, therefore, been adopted, which compares with 2 tons per inch for steel to B.S. 15 and 2.8 tons per inch for H.T. steel to B.S. 968 for the same size roller.

When the "Hi-Load" bearing is intended for use on steel bridge and piers, the outer top and bottom plates can be omitted, resulting in an even shallower bearing.

(From "Highways and Bridges and Engineering Works", (February 22, 1961).

Above the Grill of a coffee shop in London, Ontario, is this sign :

Accuracy
Is Our
Watchword

We Never Make
Mistakes

USE OF RUBBER IN BRIDGE BUILDING

THE direct substitution of rubber pads in place of bridge roller bearings is proving simple and economic. Not only is the need for re-machining the castings and bed plates avoided, but maintenance is reduced to visual inspection and the painting of a small amount of extra steel-work which is easily accessible.

The rubber pads are in fact sandwiches of steel plates interleaved with rubber and having a minimum cover of $\frac{1}{4}$ in. of rubber around the edges so there is no possibility of these steel plates rusting. The pads can often be of the same depth as the rollers which they displace and, of course, this greatly simplifies the work on site.

The compression rating of a 3-in. pad is 3,750 tons per inch of compression. The corresponding figure for a 6-in. pad is 1,800 tons; and since the maximum working pressure is generally less than a $\frac{1}{4}$ of a ton on each square inch of pad, the vertical compression is negligible.

But the rubber pads must not be fitted without giving due consideration to lateral and longitudinal displacements under load. A 6-in. pad will push over $\frac{1}{2}$ in. sideways under a horizontal load of some 20 tons.

While such freedom of movement is desirable in the longitudinal direction as the girder expands or contracts, lateral movement has to be restricted within very close limits and for this purpose some additional steel work is necessary to locate the knuckle casting in its proper position over the centre line of the bed plate.

(From "Highways and Bridges and Engineering Works", February 22, 1961)

A LIST OF STANDARDS PUBLISHED BY THE INDIAN ROADS CONGRESS

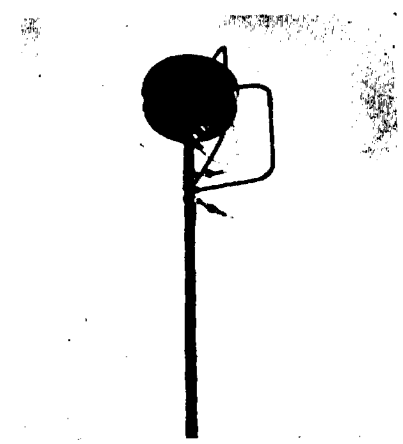
I R C Standards.

(1) Route-Markers Signs for National Highways. (2) Dimensions and Weights of Road Design vehicles. (3) Type Designs for Highway Mile-stones. (4) Type Designs for Furlongs and Boundary Stones. (5) Recommended Practice for Location and Layout of Roadside Motor-Fuel Filling Stations. (6) Recommended Practice for Numbering Bridges and Culverts.	Price 50 nP per copy plus postage & packing etc.
(7) Type Designs for Highway Kilometre-Stones. Copies can be had from the Secretary, Indian Roads Congress, Jamnagar House, Mansingh Road, New Delhi 11.	Price 75 nP per copy plus postage & packing etc.

HERE AND THERE

1. TV EYE KEEPS MUNICH ON THE MOVE

● IN THE HEART OF MUNICH, Germany, a sprawling, subwayless city of 1,100,000 people, lies one of the busiest intersections in all of Europe, the Karlsplatz. It is crisscrossed by sixty-two different walking and driving lanes that are clogged daily by upwards of 85,000 motor vehicles, 3,000 streetcars, and more bicyclists and pedestrians than anyone has yet counted. The city's traffic engineers have tried various means of bringing order to this moving chaos over the years,



The TV camera, protected by a shield, transmits a bird's-eye view of the Karlsplatz

but none has been so successful as the latest, and most ingenious, device: a small television camera perched discreetly atop a fifty-foot pole off in one corner of the square.

The man who operates the camera is an officer in police headquarters half a mile away. He is the sole audience for the telecast and also, in a sense, the director of the real-life drama he photographs, for he is in charge of all the traffic signals at the intersection. Seated before a control panel beneath a large map of the city dotted with blinking lights, and watching his television screen like a benevolent Big Brother, he regulates the flow of traffic through the Karlsplatz with the flick of a switch.

The use of closed-circuit television to keep an eye on traffic is relatively new, but is not unique to Munich. A number of cities, including Detroit and Boston in the United States, have experimented with it in tunnels or on short stretches of expressway. Munich, however, beset by a threefold increase in traffic volume since 1939, pioneered the technique in Germany two years ago and has perhaps carried it to its highest level of sophistication.

By manipulating a single lever on his thirteen-foot control desk, the officer in Munich's traffic-direction headquarters can tilt the television camera on the Karlsplatz up and down, swivel it horizontally through an arc of 270 degrees, and adjust the focal length of its special zoom lens. The latter feature enables him to behold either a panormic view of the square or a closer-up of, say, a stalled Volks-wagon or the licence number of a speeding Mercedes-Benz. Upon provocation, during the mid-day lull, he may even zoon down on a fraulein or two.

The camera has an effective range in daylight of over three hundred yards. After dark, it sees traffic as streams of light moving back and forth over the Karlsplatz.

Actually, the officer is in command of traffic far beyond the view of his television eye. Rows of buttons on his desk permit him to control not only the 34 signal lights on the Karlsplatz but also 203 of the other 318 signals throughout the city. He can operate them individually, at his discretion, to clear the way for ambulances, fire engines, police cars, parades, visiting dignitaries, and so on; or he can select any one of five preset, automatic switching patterns designed to handle traffic of different densities.

Munich's Traffic is kept moving smoothly from this control room at police headquarters. Visible on the TV screen is the Karlsplatz, one of the busiest intersections in Europe. It can be seen on the map at the right end of the street cutting horizontally through the city.

Police in patrol cars provide the central control officer with information he needs on traffic conditions. In emergencies, he clears their way through the city with green lights.

The TV screen at police headquarters shows the passage of traffic over the Karlsplatz. By moving a lever, the officer in charge is able to turn the camera on the square horizontally through an arc of 270 degrees and tilt it up or down 30 degrees. By adjusting the camera's special zoom lens, he can get a panoramic view of the intersection or close-ups of any portion of it. The lens is so sensitive that he can easily spot a coin on the pavement at a distance of 100 yards. After dark, traffic appears as streams of moving lights.

Each of the traffic signals in the system is represented on the 100-square-foot map of Munich by three coloured lights. White indicates that the signal is in operation, green shows its "phase length", and flashing red warns of a malfunction. Talking by means of short-wave radio and telephone with men in patrol cars and at the police stations and traffic posts in the municipal area, the officer warns of trouble, dispatches emergency service trucks, and receives the information he has to have in order to keep the streams of traffic moving smoothly.

the results of their initial experiment to proceed with the installation of additional equipment. Three new cameras over-looking another intersection, the Marienplatz, and three more at the Munich railroad station, are scheduled to be ready for operation early this summer. Eventually eighteen cameras spotted strategically around the city will flash traffic scenes to a battery of television sets in the remote control centre.

Satisfied that their experience has demonstrated the potential of centralized traffic control through television, the police

Pedestrian as well as vehicular traffic on the bustling Karlsplatz is observed by television and directed from the remote control centre. In the background beyond the woman standing at the right end of the crowd can be seen the police television camera atop its 50-foot pole.

Munich's traffic engineers concede that their television camera has not solved the problem of the Karlsplatz completely. Only the construction of an overpass, they believe, which would separate vehicles travelling north and south from those heading east and west, could do that. But they have been sufficiently encouraged by officials of Munich confidently predict that more and more cities will be turning to this electronic aid as an effective and economical way of untying traffic knots.

(*From "Traffic Engineering, January, 1961"*)

2. TOLL ROADS—"INDEFENSIBLE SUGGESTION"

● SPEAKING at the annual dinner of the Birmingham Sub-Area of the Road Haulage Association on January 18th, Mr. G. K. Newman, Secretary-General of the Association, said that any suggestion for toll roads was indefensible. In his speech he said :

Road users pay in special taxes many times over for the roads, and this will continue to be the position if the road programme is very substantially augmented, as we all hope it will be.

In spite of this there are not wanting suggestions from some quarters that road users should be made to contribute additional amounts towards the cost of certain special projects by having to pay tolls for their use.

Such a proposal is indefensible. One of the main supporting arguments is that road users pay tolls for certain roads in other countries, but such an argument has no validity. It will be found that in those countries the financial relationship between the road users and the Government is very different from what it is here.

To increase the already heavy financial burden which lies on road users would be a blatant example of robbing Peter to pay Paul.

(*From "British Road Federation Bulletin", February, 1961*)

3. HIGHWAY EXPENDITURES FOR 1960

● HIGHWAY expenditures in the free world in 1960 totalled 19.3 billion dollars—figures are based on statistical data from 161 countries and territories.

The 1960 increase over 1959, is 3.75 per cent—1959 expenditures totalled 18.3 billion dollors.

United States topped the list for highway expenditures with 11.8 billion dollars. Canada was in second place with a total of 1.35 billion dollars. Third place went to West Germany, the only other country with expenditures in excess of a billion dollars, with a total of 1.2 billion dollars.

(*From "Roads and Engineering Construction", February, 1961*)

4. A WORLD TRAFFIC ENGINEERING CONFERENCE

● A WORLD Traffic Engineering Conference will be held in Washington, D.C., August 21 to 26, 1961, sponsored by the Institute of Traffic Engineers, the World Touring and Automobile Organisation, the Permanent International Association of Road Congresses, and the International Road Federation. A tentative program calls for discussions on "Objectives in the Development of Metropolitan Areas", "Urban Transportation and Its Future", "Traffic Engineering Research and Its Promotion by International Co-operation", "Design of Rural Freeway Interchanges", "Highways Traffic Accident Research", "Electronics in Traffic Control", "Freeway Traffic Operations and Contro l".

(*From "World Construction", February, 1961*)

5. LESS IDLING, LONGER ENGINE LIFE

● LABORATORY tests and field experience show that more engines are ruined by too much idling than by overloading. So reports the service department of International Harvester Company's Construction Equipment Division.

A well-designed engine should deliver its rated horsepower for thousands of hours, until normal wear of the high-mortality parts (pistons, rings, sleeves, bearings and valves) necessitates an overhaul. Symptoms which indicate an overhaul are lack of power, excessive oil consumption and rough running.

The same signs of trouble may appear in a "loafing" engine after a few hundred hours' operation. But, when the unit is disassembled, the pistons, rings, sleeves and valves will not be worn.

Instead, you' will likely find heavy concentrations of sludge in the lubrication areas. Also carbon deposits in the intake manifold, at the intake valves and on the pistons. The cylinder walls may be glazed, and poor spark plug performance can be expected on carburetted engines. Sludge and carbon deposits tell a story : the engine has not been operated at the most efficient temperature.

Light loads, also do not generate enough firing pressure to force the piston rings against the cylinder walls. The lack of proper ring contact is the direct cause of glazed walls, lubricating oil contamination, and excessive oil consumption.

Of course light engine loads are sometimes necessary, and some idling unavoidable. It is possible, however, to prevent damage and insure normal life by observing the following points:

(1) Have right sized engine. Buying one too large for the job, with the thought it will give longer life, is false economy. An engine should be allowed to develop its rated horse-power and speed.

(2) Idling time should be reduced, especially during the break-in period. Most modern diesels, even the largest, start easily, and should be shut off when not working.

(3) Proper operating temperature should be maintained through use of correct thermostats corresponding to ambient temperatures and loads. The radiator core should be covered, if necessary.

(4) The correct oil should be used. Light loads with long periods of idling are considered severe conditions and require the use of heavy-duty oils. High-detergent oil and frequent changes are necessary to prevent formation of power-robbing sludge and carbon deposits.

International Harvester reminds : it is not the size of the load that counts, but how nearly it meets the specified rating of the engine. If the engine runs under normal loads, then all parts operate at ideal temperatures and clearances to give the most efficient operation and long life.

(From " World Construction ", February, 1961.)

Police in New Canaan, Connecticut, found an abandoned 1940 model car. A note attached to the conked-out car read : " Please give it a decent burial ".

This Notice is Displayed in a London restaurant : " Five o'clock tea served at any time of day."

LIST OF PUBLICATIONS ADDED TO THE ROADS WING LIBRARY DURING DECEMBER, 1960 TO APRIL, 1961

1. **Central Warehousing Corporation Annual Report, 1959-60.** Published by the Central Warehousing Corporation.
2. **[Gazette of India Extraordinary, Part II—Section 3—Sub-section (ii)—Subject]—Central Civil Services (Revised Pay)—Sixth Amendment Rules, 1960.** Published by the Manager of Publications, Delhi.
3. **Aerial Photographic by Lucder, Interpretations, Principles and Applications.** Published by McGraw Hill Book Company Inc., New York, London.
4. **Geology in Engineering by John R. Schultz and Asthur B. Cleaves.** Published by Chapman & Hall Ltd., London, and John Willy Sons Inc., New York.
5. **Concrete and Soil-Cement Roads by W. P. Andrews.** Published by London Contractors Record Ltd.
6. **Der strabenbau Teil 2 by Kaotl.**
7. **Highway Construction in Frost Affected Areas by Stavac.** Published by Ahura Printing Press, Dalal Street, Fort, Bombay.
8. **Annual Report of Highway Research Station, 1956-57, 1957—58.** Published by Government of Madras Highway Department.
9. **IS : 1398—1960 : Indian Standard Specification for Packing Paper, Waterproof, Bitumin Laminated.** Published by I.S.I., New Delhi.
10. **IS: 1081—1960 : Code of Practice for Fixing and Glazing of Metal (Steel and Aluminium) Doors, Windows and Ventilators.** Published by I.S.I., New Delhi.
11. **IS: 1600—1960 : Code for Type Testing of Constant Speed Internal Combustion Engines for General Purposes.** Published by I.S.I., New Delhi.
12. **IS: 1602—1960: Code to Type Testing of Vehicle Speed Internal Combustion Engines for Automatic Purposes.** Published by I.S.I., New Delhi.
13. **IS : 1609—1960 : Code of Practice for Laying Damp-proof Coursing Using Bituminous Felts.** Published by I.S.I., New Delhi.
14. **IS : 190—1960 : Specification for Coniferous Sawn Timber Intcorered for Further Conversion, 2nd Edition.** Published by I.S.I., New Delhi.
15. **IS : 1631—1960 : Methods of Test (physical) for Industrial Water.** Published by I.S.I., New Delhi.
16. **Statesman Year-Book, 1960.** Published by Macmillan & Co., Ltd., New York.
17. **Times of India Directory and Year-Book including Who's Who,** 1960-1961. Published by Bennett, Coleman & Co., Ltd., Times of India Office, Bombay, Delhi and Calcutta.
18. **Creen of Engineering Materials: Jane** FAINNIC AND WILLIAM R. HELBER. Published by McGrawHill Book Company Inc., New York.
19. **(Road Research Technical Paper No. 39. Traffic Signal Setting):** F. V. WEBSTER. Published by Her Majesty's Stationery Office, 1958, London.
20. **Field Studies of the Movement of Soil Moisture** (*Road Research Technical Paper No. 41*)**:** W. P. M. BLACKETE. Published by Her Majesty's Stationery Office, London.
21. **Refler Reflectors** (*Road Research Technical Paper No. 42*) : K. H. CHANDLER & J. A REID. Published by Her Majesty's Stationery Office, London.

22. **Polishing of Road Stone in Relation to the Resistance to Skidding of Bituminous Road Surfacing.** (*Road Research Paper No. 43*): MACLEAN and SHERGOLD. Published by Her Majesty's Stationery Office, London.

23. **Investigation of the Performance of Pneumatic Tyred Rollers in the Compaction of Soil.** (*Road Research Technical Paper No. 45*): LEWIS. Published by Her Majesty's Stationery Office, London.

24. **Road Junctions in Rural Areas.** (*Road Research Technical Paper No. 47*): CHARLESWORTH and TANNER. Published by Her Majesty's Stationery Office, London.

25. **Manual on Uniform Traffic Control Devices for Streets and Highways:** A.A.S.H.O. Published by Public Roads Administration Federal Works Agency.

26. **Proceedings of the Twelfth Meeting of All-India Council for Technical Education held at New Delhi on 13th April, 1959.** Published by Ministry of Scientific Research and Cultural Affairs.

27. **Reinforced Concrete with Brick Ballast.** Published by Sahu Cement Service, India.

28. **Annual Report of Highway Research Station, 1958-59.** Published by Highway Department, Madras.

29. **National Register of Scientific and Technical Personnel (Indians Abroad) Series E. No. 9, September, 1960.** Published by Council of Scientific and Industrial Research, New Delhi.

30. **National Register of Scientific and Technical Personnel.** Published by Council of Scientific and Industrial Research, New Delhi.

31. **(Highway Research Board Bulletin No. 6) Report of Committee on Uses of Highway Planning Survey Data including special papers, 1946.** Published by Highway Research Board, Division of Engineering and Industrial Research National Research Council, Washington.

32. **Hand-book of I.S.I. Publication, 1959.** Published by Indian Standards Institution, New Delhi.

33. **Summaries of Road Research Notes—No. 73, September, 1960.** Published by Road Research Laboratory.

34. **Madras State Warehousing Corporation Annual Report and Accounts, 1959-60.** Published by Madras Warehousing Corporation.

35. **National Register of Scientific and Technical Personnel.** Published by Council of Scientific and Industrial Research, New Delhi.

36. **Financial Condition and Fiscal Operations of the Highway Trust Fund—Fiscal Year 1959.** (*Fourth Annual Report*). Published by Council of Scientific and Industrial Research, New Delhi.

37. **Fourth Progress Report of Highway Cost Allocation Study Letter from the Section of Commerce.** Published by United States Government Printing Office, Washington.

38. **National Co-operation Development Warehousing Board—Annual Report, 1959-60.** Published by National Co-operative Development and Warehousing Board.

39. **Concrete and Soil-Cement Roads:** W. P. ANDREW. Published by Contractors Record Ltd., London.

40. **Prestressed Concrete, Vol. II—Statically Indeterminate Structures:** Y. GUYON. Published by Contractors Record Ltd., London.

41. **Manual of Civil Engineering Plant and Equipment, First Edition, 1958.** Published by Contractors Record Ltd., London.

42. **Prestressed Concrete, Vol. I**: GUYON. Published by Contractors Record Ltd., London.

A BRIEF REVIEW OF THE BUDGET OF THE GOVERNMENT OF MADHYA PRADESH FOR 1960-61 WITH REFERENCE TO CIVIL WORKS

THE Budget estimate of revenue receipts for the year 1960-61 is Rs 6,467.49 lakhs and the expenditure on revenue-account is estimated at Rs 6,530.44 lakhs with a consequent deficit of Rs 62.95 lakhs. The revised estimate for the year 1959-60 showed a revenue of Rs 6245.41 lakhs and an expenditure on revenue account of Rs 5,996.45 lakhs indicating a surplus of Rs 248.96 lakhs. In 1958-59 actual revenue and expenditure amounted to Rs 6,061.65 lakhs and 5,490.82 lakhs respectively, which showed a surplus of Rs 570.83 lakhs.

Expenditure on Civil Works during the year 1960-61 is estimated at Rs 450.77 lakhs which forms 7.0 per cent of the total State Revenue. The corresponding ratio for the previous year was 6.7 per cent.

Out of the total revenue expenditure on Civil Works, Communications (original works and repairs combined) account for 4.7 per cent of the estimated total State Revenue for 1960-61, while the percentage for the same for 1959-60 was 4.3 per cent.

Expenditure on Civil Works outside the Revenue Account for the year 1960-61 is estimated at Rs 766.24 lakhs. Revised estimate for the year 1959-60 is Rs 66.849 lakhs.

LIST OF APPROVED WORKS ON NATIONAL HIGHWAYS

S. No.	Job No.	Name of the work	Amount (Rs in lakhs)
		ANDHRA PRADESH	
1.	2615-AH-7	Providing sanitary fittings in the Inspection Bungalow at Shawshabad in Hyderabad—Kurnool Road, N.H. No. 7.	0.02
2.	2616-AH-7	Providing Sanitary fittings in the Inspection Bungalow at Palamkole in Hyderabad—Kurnool Road, N. H. No. 7.	0.02
		GUJERAT	
3.	2618-GR-8B	Construction of approaches to the bridge across Minsar river near Rana Kondana on Porbander Kutiyna section of N.H. No. 8B.	1.85
4.	2623-GR-8	Providing two lanes of traffic on Ahmedabad-Baroda section of N.H. No. 8.	40.28
5.	2626-GR-8A	Reconstruction of minor bridges at miles 83/3-4, 65/4-5 and 66/56 on N.H. No. 8A in section of Rimbdi.	0.37
6.	2627-GR-8A	Widening the existing minor bridges on Dolia-Bamanbore section of N.H. No. 8A and providing new structures in place of the existing C.D. Works.	1.16
7.	2632-GR-8	Laying a layer of 3-inch metal with $\frac{3}{4}$ asphalt carpet and sealcoat on the existing surface of Raigadh-Ratanpur Road, section of N.H. No. 8, length 4.25 miles.	1.52

S. No.	Job No.	Name of the work	Amount (Rs. in Lakhs)
		KERALA	
8.	2620-KR-47	Construction of bridge across Dhawpadi thordu in Q.A. Road, section of N.H. No. 47—miles 31/0 to 34/0.	1.78
		MAHARASHTRA	
9.	2619-MR-4	Construction of a diversion in miles 33/2 to 33/4 of Poona-Bangalore Road, N.H. No. 4.	0.53
10.	2624-MR-4	Widening formation to 38 feet and to make road width to 150 feet in miles 50 to 70 of Poona-Bangalore Road N.H. No. 4.	5.62
11.	2625-MR-4	Widening the formation width to 38 feet including acquisition of additional land to make up road land width to 150 feet in miles 70 to 110 of Poona-Bangalore Road, N.H. No. 4.	5.28
12.	2628-MR-6	Construction of high level bridge across Kedar Nalla near Naigaon village in mile 6/4 of Nandura-Malkapur Road, section of N. H. No. 6.	1.30
13.	2629-MR-7	Construction of bridge No. I with approaches on Kongra Nallah in mile 2/1 of Umri-Wani Pandharkawada Road, section of N.H. No. 7 in Yeotmal Distt. on Karanji side with 3 spans of 20 feet each.	0.82
14.	2630-MR-7	Construction of a bridge No. 2 on Pandharkawada side with 9 spans of 20 feet each over Kongru Nallah in mile 2/1 of Umri-Wani Pandharkawada Road, section of N.H. No. 7 in Yeotmal District.	1.54
		MYSORE	
15.	2621-MY-4	Widening the formation to 38 feet of Poona-Bangalore Road from miles 288 to 316.	2.68
16.	2622-MY-4	Widening the formation to 38 feet of Poona-Bangalore Road from mills 316/0 to 353/0.	2.91
		PUNJAB	
17.	2631-PB-2	Widening formation width of Delhi-Mathura Road formation 32 feet to 38 feet in miles 12 to 58 in Gurgaon Distt.	1.19
		WEST BENGAL	
18.	2617-BH-6	Construction of a bridge over Nanakhal (Kola Khal) in the western approach of the Rupnarayan Bridge on N.H. No. 6.	0.85

SOME SELECTED PUBLICATIONS OF THE INDIAN ROADS CONGRESS available for sale :

No.	Name of publication		Price (including postage, etc.)	Rs	nP
1.	Vol. XII-1 to 3 (Bound)	—	1947-48	6	00
2.	Vol. XIII-3	January	1949	3	00
3.	Vol. XIII-parts 1 & 2 (Bound)	—	1948-49	5	50
4.	Vol. XIV (Bound)	—	1949-50	8	00
5.	Vol. XV (Bound)	—	1950-51	9	00
6.	Vol. XVI (Bound)	—	1951-52	8	00
7.	Vol. XVII (Bound)	—	1952-53	9	00
8.	Vol. XVIII-3	January	1954	3	00
9.	Vol. XVIII-4	March	1955	3	00
10.	Vol. XIX (Bound)	—	1954-55	10	00
11.	Vol. XX (Bound)	—	1955-56	9	00
12.	Vol. XXI-1	February	1957	3	00
13.	Vol. XXI-2	March	1957	3	00
14.	Vol. XXI-3	April	1957	3	00
15.	Vol. XXI-4	December	1957	3	00
16.	Vol. XXI (Bound)	—	1956-57	10	00
17.	Vol. XXII-1	November	1957	3	00
18.	Vol. XXII-2	December	1957	3	00
19.	Vol. XXII-4	November	1958	3	00
20.	Vol. XXII (Bound)	—	1957-58	13	00
21.	Vol. XXIII (Bound)	—	1958-59	15	00
22.	Vol. XXIII-4	October	1959	3	00
23.	Vol. XXIV-1	October	1959	3	00
24.	Vol. XXIV-2	November	1959	3	00
25.	Vol. XXIV-3	December	1959	3	00
26.	Vol. XXIV-4	January	1960	3	00
27.	Vol. XXIV-5	November	1960	3	00
28.	Vol. XXV-1	November	1960	3	00
29.	Vol. XXV-2	December	1960	3	00
30.	Vol. XXV-3	December	1960	3	00
31.	Road Research Bulletin No. 2			3	00
32.	Road Research Bulletin No. 3			5	00
33.	Road Research Bulletin No. 4			5	00
34.	Road Research Bulletin No. 5			5	00
35.	Road Research Bulletin No. 6			5	00
36.	Road Research Bulletin No. 7			5	00
37.	Recommended Practice for Numbering Bridges and Culverts			7	00

No.	Name of publication	Price			
38.	Dimensions and Weights of Road-Design Vehicles	Re	0	50	Plus packing and postage
39.	Recommended Practice for Location and Layout of Roadside Motor-Fuel Filling Stations	Re	0	50	
40.	Type Designs for Furlong & Boundary Stones	Re	0	50	
41.	Type Designs for Highway Milestones	Re	0	50	
42.	Route-Marker Signs for National Highways	Re	0	50	
43.	Type Designs for Highway Kilometre Stones	Re	0	50	
44.	Standard Specifications and Code of Practice for Road Bridges, Section I—General Features of Design (1960)	Re	0	75	
45.	Standard Specifications & Code of Practice for Road Bridges, Section II (1958)—Loads & Stresses	Rs	1	50	Including postage
46.	Bridging India's Rivers	Rs	2	50	
47.	Paper No. 167—Design of Small Bridges and Culverts by Goverdhanlal	Rs	7	00	
		Rs	2	00	

Concession : Some of the publications are available to Members of Indian Roads Congress on concession. Details on application.

Copies can be had from the Secretary,

INDIAN ROADS CONGRESS,
JAMNAGAR HOUSE, MANSINGH ROAD,
NEW DELHI-11

Printed by K. S. Krishnan at The Progressive Printers, 17, Coral Merchant Street, Madras-1 & Edited and Published by N. Sen, Hony. Secretary, Indian Roads Congress, Jamnagar House, Mansingh Road, New Delhi-2—1,000