REINFORCED CONCRETE PLATFORMS FOR CARRIAGE WASHING AT LAHORE STATION.

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General Description—

The work of cleaning the passenger carriages of trains, which start from or terminate at Lahore station, has hitherto been carried on promiscuously all over the yard, wherever the stock happened to be shunted by the traffic staff. This has resulted in a great loss of efficiency, owing to the difficulty of supervision, and when the project for remodelling the yard was got out, it was decided to concentrate this work in one place, and to provide proper facilities for it. This was done by constructing six train examining pits, of lengths varying from 699 feet to 1,067 feet, and aggregating 5,368 feet, equipped with drainage and water supply, both for washing the stock and for filling the carriage tanks with drinking water, as well as with artificial lighting for night work, and with the necessary plant, appliances, and fittings for testing vacuum brake gear, and recharging the electric accumulators or gas cylinders of those vehicles in which this method of lighting is still used. Between the pits, which are spaced twenty feet apart centre to centre, are platforms standing 3'-9" above rail level, to enable the cleaners to reach the upper part of the carriages. It was necessary to leave the space under the platforms as open and unobstructed as possible, in order to allow of other men working simultaneously at the axle-boxes and other running gear of the carriages when necessary, so that the ordinary type of platform with solid walls and earth-filling could not be adopted ; consequently comparisons of costs cannot be allowed to hold unquestioned sway.

Reasons for adopting reinforced concrete—

In the first design proposed a timber platform was carried on a framework of old rails. The timber might have been procured from old sleepers, but as there was considerable doubt whether enough of them in a sufficiently sound condition could be obtained, new deodar planking would probably have had to be used. This, combined with the high prices now obtainable for steel scrap, led to the consideration of a reinforced concrete design. The preliminary estimates showed that this was little more expensive than a new timber and rail platform, while a very decided saving in the maintenance cost was anticipated, as the life of any timber would be very short in such a situation owing to the constant wetting and drying to which it is subjected.

Alternative Designs—

Several trial designs in reinforced concrete were then made by the author on first principles, to ascertain the most economical spacing of the posts supporting the platform. From these it appeared that spans of fifteen feet were most suitable for a platform nine feet wide, taking the live load, as laid down for foot-bridges in the Government of India bridge rules, at 130 lbs. per square foot, including the impact allowance which has to be given to convert a moving load into its equivalent static load, and in this case to provide for the dropping of heavy articles on to the platform. It is of course very improbable that such a load will ever be applied in ordinary use. Tenders and designs were then called for from various firms in India who specialize in reinforced concrete work, but only two designs worthy of consideration were received—(A) a slab four inches thick, reinforced with expanded metal, and supported on $13\frac{1}{2}$ inches brick cross walls at intervals of ten feet, and (B) the design with reinforced concrete beams and slabs on the Kahn system, which was finally adopted. The expanded metal design was considered unsuitable, as the walls would have obstructed the space under the platforms considerably, and its cost would have been higher, owing to the much greater quantity of timber required for forms.

Design adopted—

The design adopted (Fig. 1) consisted of pairs of reinforced concrete columns, spaced fifteen feet centres in the longitudinal direction, with a transverse spacing of six feet between the centres of the posts of each pair when supporting a platform nine feet wide, and three feet for a platform 4'-6" wide. It should here be explained that the portions of the platforms which served a pit on each side are nine feet wide, but where there is a pit on only one side the width of the platform is reduced to 4'-6". The columns are as small in section as can be safely constructed: *viz.*, 8" × 8" outside; reinforced with four rib bars $\frac{1}{2}$" diameter. In one piece with the columns, except at the expansion joints, are cast the longitudinal reinforced concrete beams, 8" × 14" in section, reinforced with two $2\frac{1}{2}$" × $1\frac{1}{2}$" Kahn bars and one $\frac{1}{2}$" rib bar along the central portion of the lower side Across these two beams rests a reinforced concrete slab, $3\frac{1}{2}$" thick at the centre in the nine foot platform, and $2\frac{1}{2}$" thick in the 4'-6" platform, the top of which is finished with a wearing surface of coarse shingle in cement (2 : 1). This slab is reinforced with No. 26 gauge four rib "Hy-rib"; a speciality of the Trussed Concrete Steel Co. of America. It consists of a thin steel sheet, in which narrow corrugations, about one inch deep, have been pressed at intervals of about four inches, the intervening space being perforated to form a sharp-edged mesh, the peculiarity of this metal being its stiffness, and the mechanical nature of the bond between its mesh and the concrete. It will carry the weight of the wet concrete of the slab on spans up to about 3'-6" without intermediate support, and owing to the peculiar shape of the mesh, the concrete can be laid directly on it, without any falsework underneath, provided a rather dry mixture is used to begin with. It will thus be seen that the amount of timbering required for this type of slab is very small, and herein lies the economy of using what seems at first sight such an expensive reinforcement.

Expansion Joints.—

The importance of the question of expansion in these platforms is apparent, when it is realised that in Lahore a reinforced concrete structure a thousand feet long would, if free to expand, vary in length by about six inches between the lowest temperature of the cold weather nights and the highest temperature in the sun during the hot weather. To meet this difficulty the expansion joint shown in Fig. 2 was designed by the Trussed Concrete Steel Co.'s engineer, and five rods, $\frac{7}{32}$ inches in diameter, were added as a longitudinal reinforcement to the slab to take up the temperature stresses. No provision was made for reinforcing the concrete brackets on which the tin-shod sliding ends of the beams rested, or for resisting the pull of the adjoining fixed end on the column. The first platform was constructed, as designed, with these joints at every ninth bay: *i. e.*, 135 feet apart; thus giving an allowance for expansion of one inch in 135 feet, which appeared ample, but shortly after the completion of the platform the appearance of cracks across the slab showed that this was not enough, and the effect became more pronounced later on when other cracks appeared, showing a tendency for the slab to separate from the beams, while the pull of the fixed ends of the latter seemed likely to split the columns. The orientation of the site also appears to have had some effect in increasing the temperature cracks in the surface of the slab, owing to the circumstance that the heavy beams are at all times of the day shaded by the overhanging portions of the slabs, whereas the top surface of the latter are always fully exposed to the sun's rays ; and apparently the unequal heating and cooling of the different parts of this monolithic structure caused cracks to occur in a manner similar to those sometimes produced by uneven heating or cooling in an iron casting. It would therefore seem that in reinforced concrete designs, intended for climates like that of the Punjab, attention should be paid to some of the principles familiar to designers using cast iron, and particularly that abrupt changes of thickness should be avoided.

As a result of these observations, the spacing of the expansion joints in the platforms subsequently built was reduced first to six, and then to four bays, *i. e.*, ninety and sixty feet respectively ; the column reinforcement was strengthened by binding with a few turns of thin wire at the top and bottom, while additional rods were inserted to reinforce the brackets carrying the beams. The amount of these reinforcements was guessed, their position being however accurately fixed by the points of failure in the earlier columns. These changes, which are indicated in Fig. 3, appear to have been successful up to the time of writing (September 1914.)

MATERIALS.

(A) Reinforcement—

The materials used in the reinforcement have already been described, and were supplied ready cut and marked for erection by the contractors. One small point in connection with the "Hy-rib" is worth noting by any one doing similar work in future. It must be cut to dead lengths when a single sheet forms the reinforcement for a slab. Much time was wasted in rectifying sheets which had been cut in the works to the nearest half inch, and could not be got to fit into the forms without further cutting.

(B) Stone and Sand.

During the hot weather of 1913 a series of experiments were carried out by the author and his assistant to determine the best materials for concrete amongst those available from the N.-W. R. ballast sidings at Pathankot. These sidings are laid in the bed of the Chakki river, and material of all sizes, from big boulders to the finest sand, can be dug up there. Hitherto for reinforced concrete work, half inch crushed stone had been used. This was turned out by passing boulders through a stone crusher, the dust from which provided an admirable sharp sand. But the cost of this, and the erratic working of the crusher, led to the trial of concrete made from the fine water-worn shingle of the river-bed, and of water-worn river sand, all of which material is distinguished fundamentally from the crushed stone by the entire absence of sharp edges. The experiments consisted in making up five inch cubes of concrete of various materials and various proportions. These were crushed in the fifty ton testing machine in the N.-W. R. locomotive workshops. Many results were discordant and had to be rejected, principally owing to the difficulty of applying the crushing load quite evenly to the rough surfaces of the concrete blocks, which, through slight warping of the wooden moulds in which they were cast, were often slightly out of square themselves. One fact however remained, running persistently through every set of tests without any exception namely, that other conditions being equal, blocks made of the round-edged shingle and sand were stronger than those made of the same kind of stone, in pieces of the same size, produced by breaking boulders in the stone crusher. A concrete made of clean shingle screened from the Chakki bed to pass a screen of half inch mesh and be retained on $\frac{3}{4}$ inch, and of sand from the same source which passed the $\frac{1}{4}$ inch and was retained on $\frac{1}{30}$ inch mesh, was therefore adopted. Some trouble had to be taken to get these materials clean, as the river brings down silt which must either be washed out, or else avoided by digging the shingle from small rapids in the river bed.

(D) Cement. -

The cement used was that obtained from the India Office for general use on the railway. It is pleasing to note that the tests for tensile strength and soundness, carried out on delivery of each consignment on the works, gave in all cases results above well above the British standard specification.

Construction.

The design of the falsework was supplied by the contractors who supplied the reinforcement, and is shown in Figs. 4—7. As will be seen, it was entirely secured by wedges, which at first gave trouble by shaking loose, but afterwards they were secured by nailing through to the plank, the nail heads being left projecting half an inch or so to allow of easy withdrawal when the forms were removed. The timber used was *chir*, and this proved quite satisfactory for the purpose. Wherever holes were required in the slab for the various lamp posts, hydrants, etc., blocks of the correct size, slightly tapered upwards and well greased with soft soap, were attached to the central supporting battens which carried the " Hy-rib." These formed the hole in the slab, and were withdrawn when the concrete had set. The interiors of the beams and column forms were coated with a mixture of soft soap and whitewash to prevent the concrete adhering to them.

As no suitable mechanical mixer was available, it was decided to use troughs for hand-mixing, of the type devised by Col. H. C. Nanton, R. E., for the construction of the bakery floor at Dalhousie. These have in many ways considerable advantages ; they are compact ; ensure more thorough mixing than on a flat floor ; and allow no waste of the finer portions of the cement grout. A drawing of one of these mixers is given in Fig. 8, and the method of use is as follows : Cement and sand in measured quantities are dropped into the trough near one end, and are then shovelled dry with a circular motion of the shovel along the trough to the other end, and back again, when the stone is added and the process repeated. A measured amount of water is then added from a can without a rose, and the mixture is shovelled backwards and forwards till an even mixture results. The number of turnings required varies with the skill of the shovellers, but coolies soon acquire the knack of doing it. As usual in this country, each shovel is worked by two men, the second pulling a rope attached to the shovel near the blade ; and as the work is hard, it is better to have four shovellers, the two pairs working alternately in each direction and resting in the intervals. When the mixing is complete, the trough is tipped up on its trunnions and the concrete shot into the pans or buckets used for carrying, or direct on to the work in the case of a slab.

For making these platforms two such mixers were mounted on an ordinary open truck running on the pit track, and at either end of it were coupled other trucks containing the stone, sand, and cement. The materials were carried to the mixers along the trucks in the measuring boxes. A rubber pipe, connected to the water supply, delivered water as required in the mixer truck, which was moved on along the pit road after the completion of every two bays of platform. Various methods were tried for carrying the concrete for the beams and columns the short distance required on each side of the mixer ; an operation necessitated by the fact that the forms infringed the loading gauge, and so only hand shunting of the mixer truck

Concreting in Progress.

was possible. A movable tray devised by Lt. H. S. Trevor, R. E., the Assistant Engineer in charge of the work, was finally adopted. It consisted simply of a flat wooden platform, covered with galvanised sheet iron, and supported on four small grooved rollers (as used for supporting point rodding) which ran on the inner edges of the beam forms. This tray was run under the mixer ; a supply of concrete dumped on to it, and the tray moved along to the point of delivery. Here the concrete was scraped off into the beam form by a specially made wooden scraper fitted with a felt edging, to ensure leaving as little as possible of the fine cement grout behind (see photo). As soon as the column and beam forms were filled, the tray was removed, the "Hy-rib" laid on the beams, and the concrete tipped straight on to the "Hy-rib" and shovelled into place. The first batch laid on the "Hy-rib" was mixed drier than usual, and it was surprising how small a quantity was lost through the meshes. To ensure a proper bond over the beams, a layer of cement mortar was laid on them and the "Hy-rib" pressed into it. A wet mixture having been used, very little ramming was required, except in the columns, where a rammer with an enlarged conical end was used point downwards. The sides of the beams were well trowelled to get them smooth.

The work was done in lengths of two bays, *i. e*, thirty feet at a time, and the mixer and the material trucks were shunted forward on completion of each length. The joints between the lengths were made in the middle of the bay where the shear on the concrete in the beams is a minimum. The finished end of a beam section was closed by a temporary vertical partition in the form, which left a clean vertical face on to which the next lot of concrete was grouted when work began again.

The following is a list of gangs employed on the actual concreting ; the bottom portions of the column foundations in lime concrete, and the forms, having been erected well in advance by contract.

(A). Mixing and laying concrete and laying reinforcement, two gangs each consisting of :—

One blacksmith	... Fitting reinforcement.
One hammerman ...	,, ,,
Three masons	... Trowelling sides of beams and floating off surface of slab.
Four coolies	... Shovellers on the mixer.
Six coolies	... Filling and carrying boxes of cement, sand, and shingle.

One coolie	... Filling the water cans with the hose, and adding water to the mixture.
Two coolies	... Mixing and laying cement mortar on the beams under the Hy-rib.
One coolie	... Staunching leaks in the forms with wet clay.

(B). Concreting the base blocks of the columns and setting the reinforcing rods in them ... ...Sixteen coolies.

Each gang worked under the supervision of its own mistry, and all were under a European supervisor.

B. gang was used as a training gang, from which men could be promoted to fill vacancies in A gang. The two concreting gangs were paid on a premium system, the amounts earned being dependant on the time each gang took to finish an identical task. In this way a steady out-turn of six bays, or ninety feet of platform per day, was achieved ; in fact the men got so expert that actual concreting was often over by 2 p.m No attempt was, however, made to increase the daily task beyond this limit, because the mixing was such a severe strain physically on the men ; and the spare time in the afternoons could be well utilized in getting in fresh supplies of material, and making everything ready for a prompt start the next morning. The supply of material and its delivery in the right place needed constant attention from the supervising staff.

The finished work was kept carefully wet for a month after completion ; a matter of the utmost importance in the hot dry weather of the early Punjab summer. Several methods were tried, such as wet grass, wet sand, wet saw dust, and the making of clay bunds on the edges and filling the whole surface of the work with water. The last method is best wherever possible, and elsewhere saw dust, because with either of these methods it is easy to see whether the bhishtie is doing his work properly or not.

The sides of the beam forms were removed after fifteen days, and the rest of the false-work after one month. The under side of the slab was then plastered with 1 : 3 cement plaster, by contract. There was considerable difficulty in getting this plaster to adhere at first, owing to a richer and too wet mixture being used.

Cost—

The cost of the finished work, including all contingencies, worked out to Rs. 9-12-0 per foot run for the nine-foot platform, and Rs. 7 for the 4'-6" platform. The details in the following table are taken from a typical day's work of ninety feet of nine-foot platform. It should be noted that superior supervision charges (*i.e.*, Upper Subordinate and Engineer Establishment) have not been included in the figures given.

The column showing the percentages of the total cost represented by each item is worthy of study, as showing the possible cheapening of reinforced concrete work to be expected from reductions in the price of its components. It also shows that the saving anticipated from the use of this particular reinforcement was not altogether realized, and for similar work in future it would probably be more economical to adopt a simpler form of reinforcement.

The author's thanks are due to Lt. H. S. Trevor, R. E., Assistant Engineer, to whose keen supervision the successful completion of the platforms is largly due.

TABLE OF COSTS.

Based on a typical day's work of ninety feet of platform nine feet wide.

Description.	Quantity.	Rate.	Cost.	Percentage of total.
		Rs. a. p.	Rs.	
(1). Concrete material	..	...	...	...
Shingle (including screening and carriage) ...	254 c. ft. ...	15-8-0 % c. ft ...	39·4	4·5
Sand ditto ...	139 „ ...	15-8-0 „ ...	21·5	2·4
Coarse sand ditto ...	14 „ ...	19-0-0 „ ...	2·2	·3 for surfacing.
Cement (including carriage)...	22 barrels ...	8-12-0 per barrel	193·0	22·0
				29·2 Total for concrete.
(2). Reinforcement (including carriage)	90 l. ft. ...	4·288 per l. foot...	386·0	44·0
(3). Forms ditto	...		130·0	14·8
(4). Plastering under "Hy-rib"	697 s. ft. ...	3-0-0 % sq. ft. ...	21·0	2·4
(5). Labour	...	...	37·0	4·2
Miscellaneous (including petty supervision and contingencies)		...	47·4	5·4
Total	...	...	877·5	100·0

Volume of finished concrete ... ... 404 c. ft.
Cost of finished work per c. ft. ... ... Rs. 2·16.
Cost of finished work per l. ft. of platform ... ... „ 9·75.

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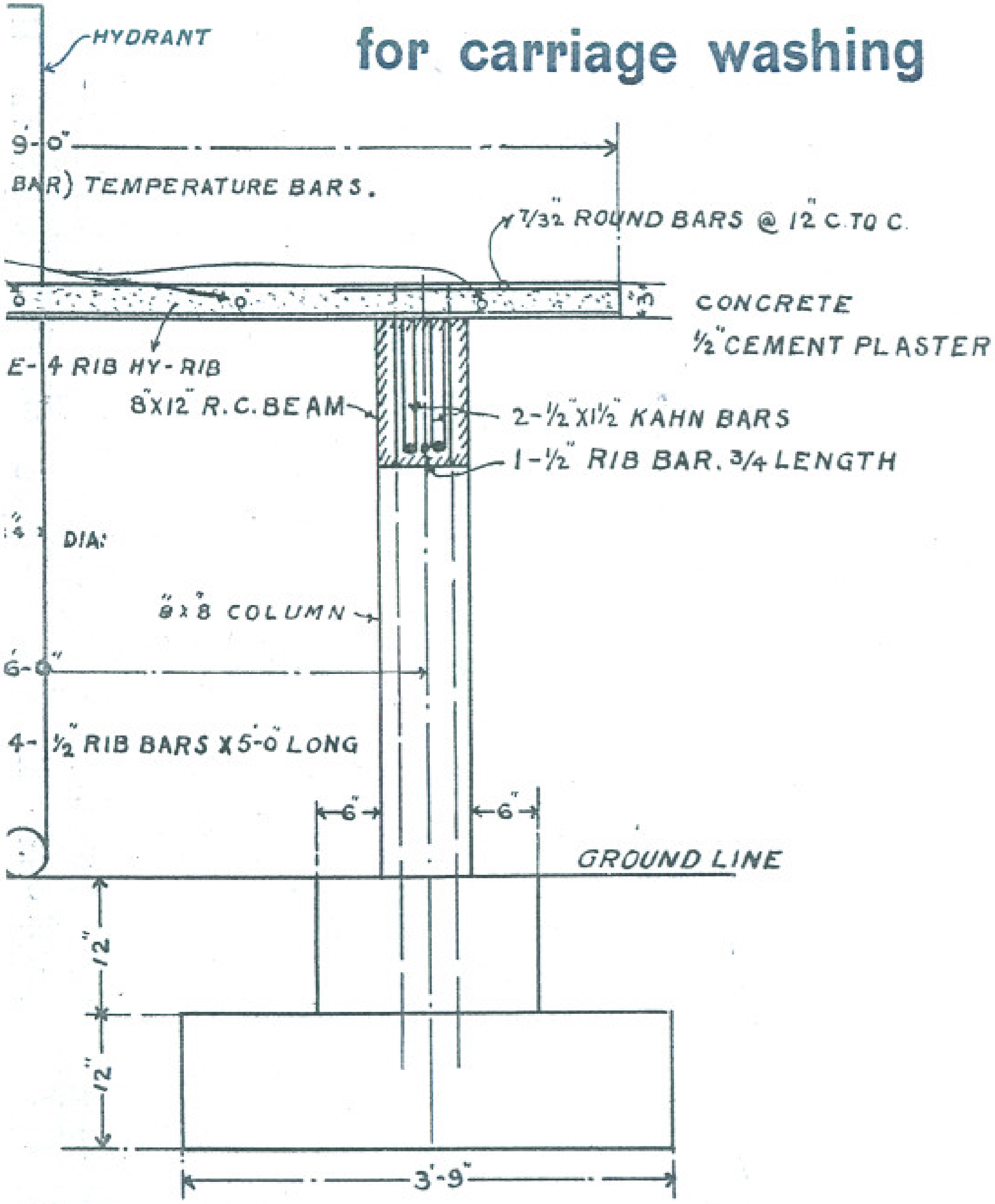
N. W. R. LAHORE
Reinforced Concrete Platforms for carriage washing



V OF PLATFORM

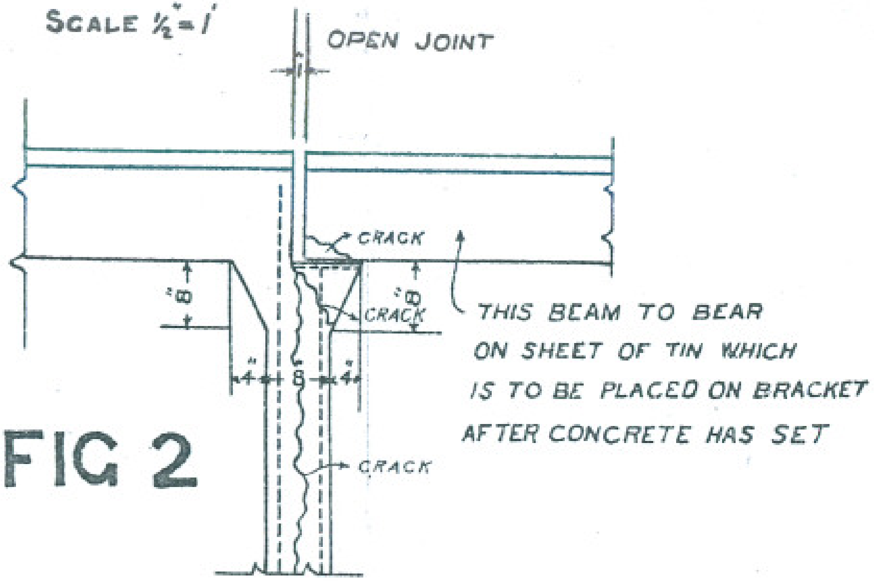


FIG 2

SECTION OF POST AT EXPANSION JOINT SHOWING ORIGINAL REINFORCEMENT AND CRACKS.

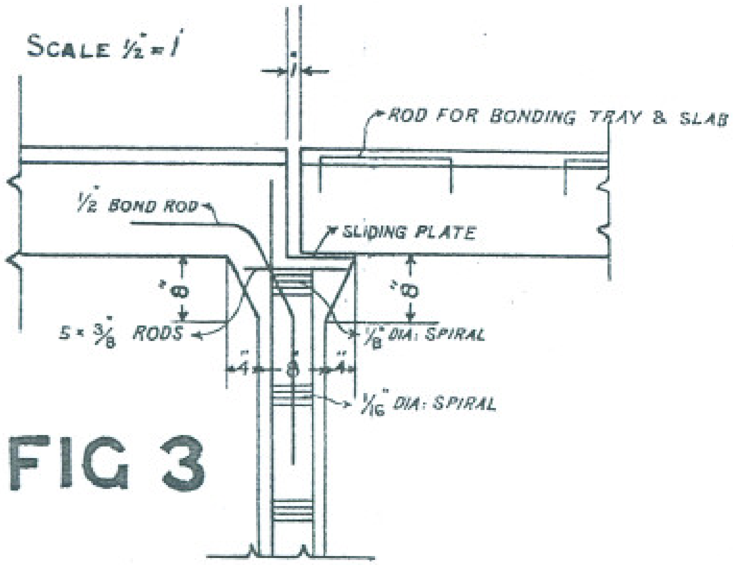
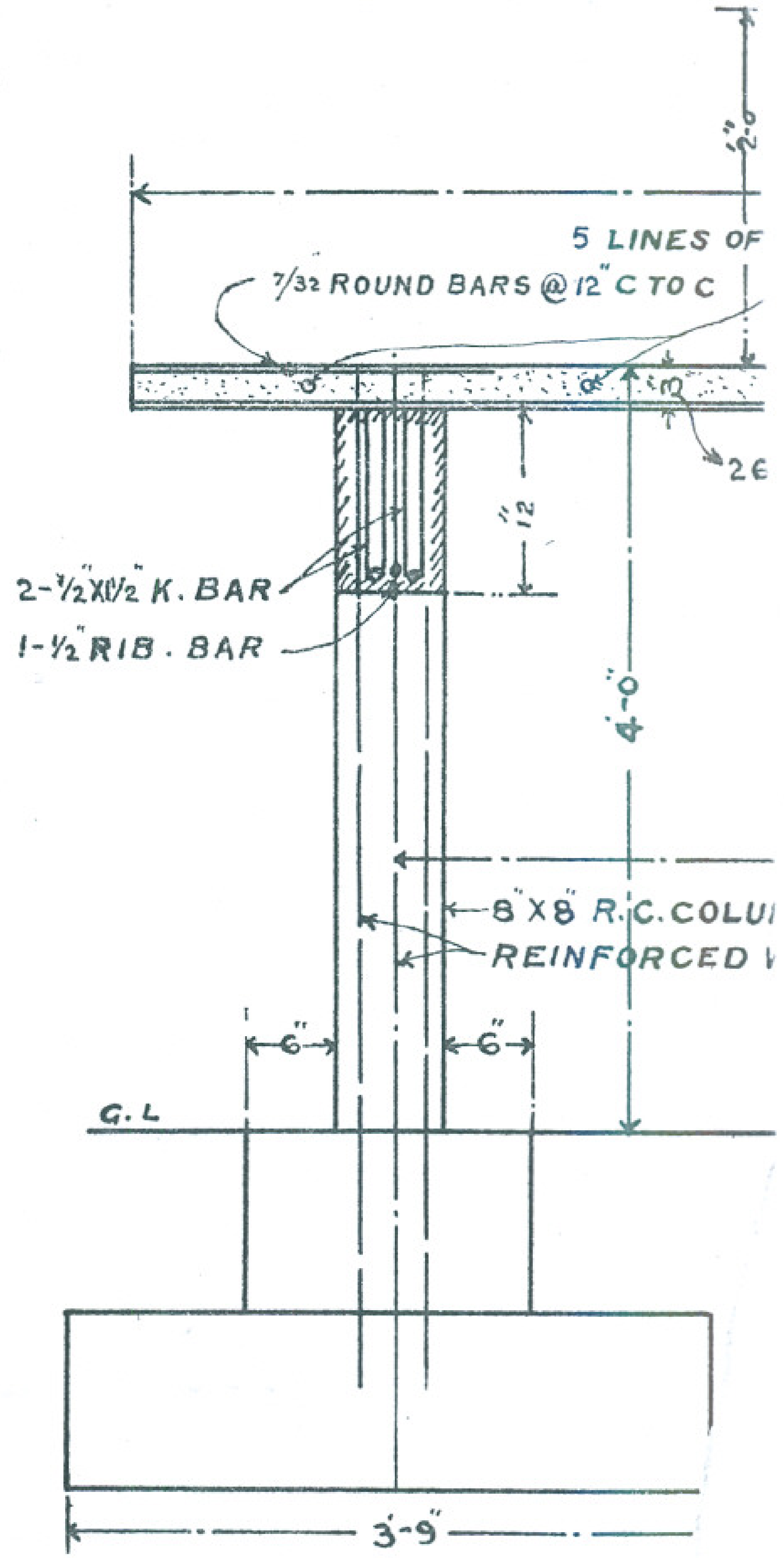


FIG 3

SECTION SHOWING IMPROVED REINFORCEMENT AT EXPANSION JOINT.


2'-0"
5 LINES OF
7/32 ROUND BARS @ 12" C TO C
3"
26
12"
2-1/2"X1 1/2" K. BAR
1-1/2" RIB. BAR
4'-0"
8"X8" R.C.COLU
REINFORCED
6"
6"
G.L
3'-9"

CROSS S

N. W. R. LAHORE
REINFORCED CONCRETE PLATFORMS FOR CARRIAGE WASHING

FIG 4

SIDE ELEVATION OF FORM
SCALE 1"=4' APPROX

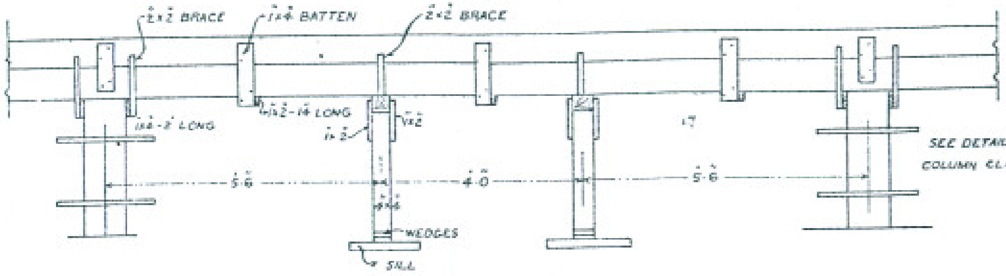
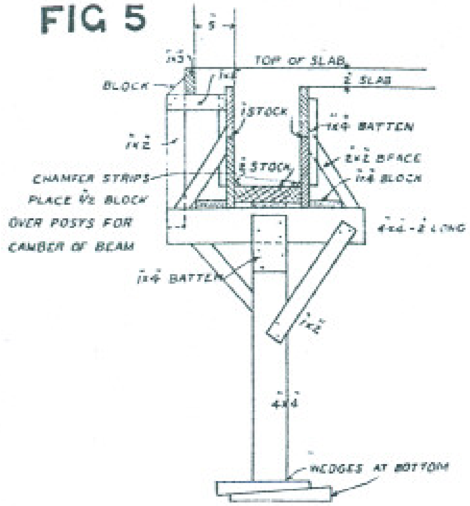
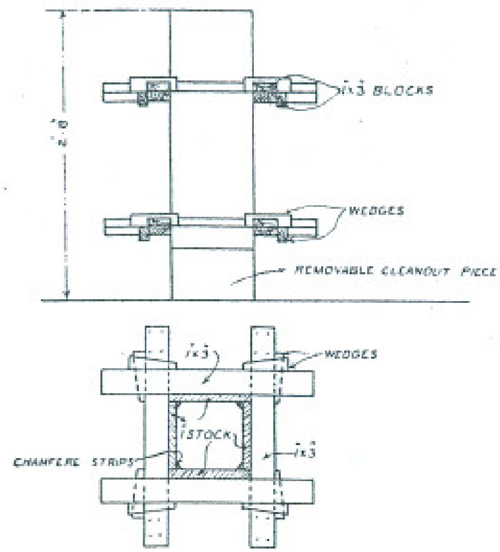


FIG 5



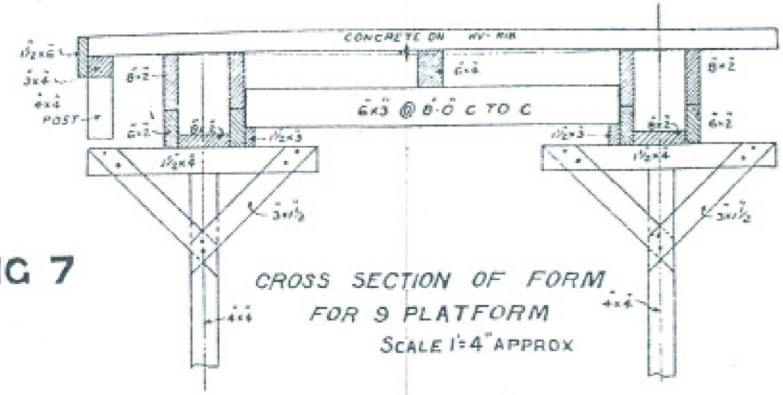
DETAIL OF BEAM FORM FOR 4'-6" SLAB
SCALE 1"=2' APPROX

FIG 6



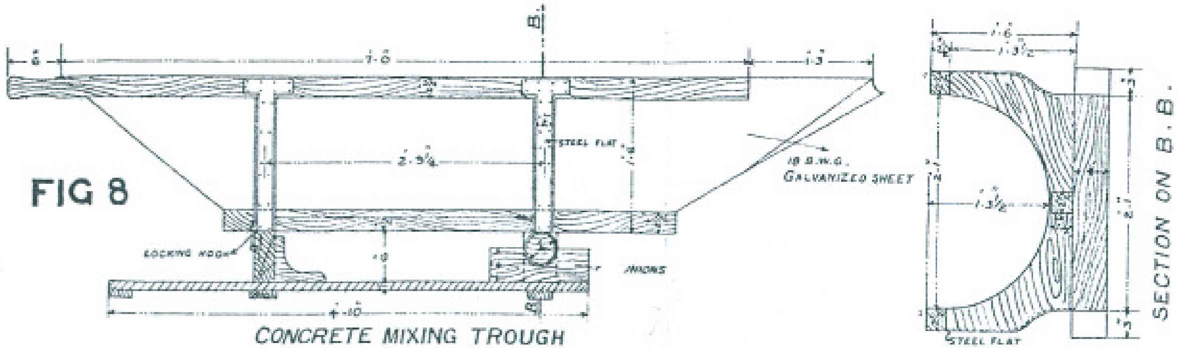
DETAILS OF COLUMN FORM
SCALE 1"=2" APPROX

FIG 7



CROSS SECTION OF FORM FOR 9 PLATFORM
SCALE 1"=4" APPROX

FIG 8



CONCRETE MIXING TROUGH
SCALE 1"=2' APPROX

Discussion.

COLONEL CRASTER, (Chairman) called on Mr. Wilson (Capt. Anderson's successor) to introduce the paper on "Reinforced concrete platforms at Lahore." Mr. Wilson in doing so, said he was very glad to be able to report that the platforms had been entirely successful, and that there had been no further signs of cracking. They were more costly however than ordinary brick work platforms.

As no one had any remarks to offer, Colonel Craster said he had been to a certain extent responsible for initiating the experiment in adopting reinforced concrete platforms for carriage washing purposes in place of the ordinary platforms. Ordinary brick and earth filling would have been cheaper, but would not have served the special purpose for which these platforms were required, as it was essential that men should have plenty of room to work and as much light as possible. The chief difficulty experienced in connection with the platforms was the expansion, which had promised to create considerable difficulty till Capt. Anderson tackled the problem in consultation with the firm who had supplied the materials, and where this difficulty had been overcome all seemed well. Owing to the heavy rains last year, and the consequent softening of the soil in one or two places, in the neighbourhood of the columns, there was a certain amount of subsidence, but these minor troubles had easily been overcome as the load on the platforms was so small. Colonel Craster in conclusion proposed a vote of thanks to Capt Anderson, who, was absent on field service in France.