Paper No. 332

Regirdering Ravi Bridge at Abdul Hakim

By

*MIR GHULAM SARWAR

The Scheme.

This Bridge was opened to traffic in its original form on the 14th of April, 1900, with the opening of the Toba Tek Singh-Khanewal Section of the Wazirabad-Multan line. It consisted of 1×100′ and 4×90′ Warren type Pony trusses fabricated in Wrought iron. In 1914 they were strengthened by the addition of a secondary system of triangulation fabricated in steel and by extra sections in the top and bottom chords and end rakers. Extra cross girders were provided at the panel points of the secondary system of triangulation-thus also strenghening the floor system. Fig. 1 shows the spans as strengthened. This strengthening brought the bridge upto SB plus 25% standard of loading, which is equivalent to the present day M.L. loading.

In 1950 a test of metal specimens cut from the wrought iron members of the main girders revealed a considerable deterioration in the metal with laminations and loss of ductility. The breaking point of the majority of the specimens was between 17 and 22·5 tons/sq. in., and the yield point was between 15 and 21 tons/sq. in., showing that not much margin existed between the yield and the breaking points. From these results a tensile working stress of 3·67 tons/sq. in." was obtained in accordance with the rules laid down in the Railway Steel Bridge Code. The analysis of stresses showed serious overstressing of many members of the structure, and the case was met by restricting the speed over the bridge to 10 miles per hour for all groups of engines upto and including Group II (17½ ton axles); Group I (22½ ton axles) engines were not allowed to run over the bridge. With this restricted speed the stresses under all effects of loading were within safe limits.

This was a temporary remedial measure untill the bridge could be renewed. The progressive deterioration in the metal and the loss of effiiency due to the speed and engine restrictions over an important section of the railway could not be permitted to continue for long. The replacement of the spans was decided upon, and the work was programmed for the years 1952-53, and 1953-54. In the meantime as a

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result of the 1950 floods, the Flood Commission recommended an increase in the waterway of the bridge, so that it could deal with a discharge of 1 lac cusecs. Various schemes of lengthening the bridge and rebuilding it entirely at a new site were investigated. During the course of these investigations it was found that the existing bridge was capable of safely passing 1 lac cusecs and that there was no justification for extending the water-way. It was, therefore, decided to replace the old spans with new ones, retaining the existing piers which were found to be in sound condition. As a further safeguard against high floods, however, the free board under the new girders was increased by $1' - 9''$, resulting in the permanent raising of the rail level by $1' - 1\frac{1}{2}''$. In view of these peculiar circumstances the reconstruction work was somewhat delayed and the actual construction was commenced in September, 1956.

New Girders.

The new spans have been designed for M.L. Standard of loading. This consists of 2 locomotives and tenders of the type shown in Fig. 1 (a) followed by a train of 2·3 tons per ft. run. In addition to the vertical loads represented by the above loading and the dead load of the structure, the sections were proportioned to resist stresses from wind loads longitudinal loads, deformation stresses and secondary stresses. The last named were taken into account only in the case of end posts where they arise from lateral wind loads.

The code provides that the deformation stresses shall be reduced to a minimum under full design load. This was to be accomplished by the so-called prestressing of the girders. Prestressing may be defined as the mechanical imposition of deformation stresses in the structure during erection, equal and opposite in sign to those which would be induced by the loading. No calculations of the deformation stresses as such were made, but negative deformation stresses were imposed on the members by increasing or decreasing their lengths by an amount equivalent to their calculated strains under the design load. It should be noted that by so fabricating the structure the necessary camber is automatically introduced into it. This necessitated extreme refinements in the fabrication of girders which were not possible to attain with our limited experience in this field. The degree of accuracy and the stringent tolerances under which these results could be achieved need not only a highly skilled staff versed in this sort of work, but also plenty of experience in making jigs and their application during all stages of the work. The possibility of damaging the rivet holes during positioning and fairing up in the field, and thus neutralizing the entire prestressing was also not over-looked. The idea of prestressing was, therefore, given up.

The main details of the 100 ft. span truss are shown in Fig. 2. The details of the 90 ft. span trusses are identical, except for lengths and need not be produced. Contrary to the usual practice for spans of this order, the effective depth is 21 ft. i.e., 1/5th of the spans. It is the economic depth for a 100 ft. span parallel chord truss. With parallel chords, the cross section and therefore the weight of the chords decreases as the depth of the girder increases, and conversely the weight of the web increases as the depth increases. Therefore in such a frame the economic weight approaches a minimum when the weight of the chords equals the weight of the web. The 100 ft. span approximately meets this requirement; the weight of the complete span is only 76 tons. There are six panels, each of 17′ — 6″. Both the top and the bottom chords are are made up of 15″ × 4″ double channel sections. All web diagonals are made up of 10″ × 3½″ double channel section and all hangers are 10″ × 3″ double channel sections. The top chord is provided with single channel lacings on both flanges, whilst the end rakers have 3/8″ thick cover plates on the top flanges and single channel lacings on the bottom flanges. Bothflanges of the bottom chords are stiffened with batten plates at intervals. The web members have single channel lacings on both flanges.

Floor System

The track is carried on stringers of the usual plate girder type. The cross girders have been provided with deep knee brackets at their ends giving rigid connections capable of transferring part of the bending moment from the cross girders to the hangers. The bottom lateral bracings have been connected to the stingers at their inter-sections forming braking or traction trusses in each panel in the plane of the bottom laterals, relieving the cross girders of the bending moment from the longitudinal forces and from the deformation of the bottom chords. This relief of bending moment in the cross girders affected a substantial savings in the weight of the structure.

To ensure the use of same thickness of bridge sleepers throughout, the stingers have been so connected to the cross girder that they do not have the same camber as the main truss, but become level under the dead load. This detail is shown in Figure 3.

Piers

The original piers were 20 ft. wide. The new spans which were made wider than the old ones to cater for the present day structural clearances, necessitated widening of the existing piers to 24 feet. This was accomplished by corbelling out the masonry at both ends. The top was then covered with a 2′ — 6″ deep reinforced concrete cap which was designed to act both as a combined bed stone and a beam to support the girders, assuming that the corbelling were ineffective. Figure 4 shows these modifications.

The total estimated cost of the scheme was Rs. 7,99,600/- made up of the followiag main heads :—

1. Steel work in girders.		Rs. 5,64,000
2. Piers including R.C. Caps.		Rs. 46,000
3. Tools and Plant.		Rs. 20,000
4. General charges.		Rs. 69,000
5. Miscellaneous.		Rs. 59,200
6. Contingencies.		Rs. 41,400
	Grand Total	Rs. 7,99,600

Preparatory Work and Plant.

Several months were taken up in preparatory work. A new railway siding with a system of erection yards was constructed on the left bank. It included, boiler house, compressor house, water supply arrangements, stores, offices, a smithy and a carpenters yard. Construction material began to arrive at the site of work in August and by the middle of October, 1956, much of the preparatory work had been completed. The heavy plant included a large boiler, a portable boiler, a 1200 cft. per minute capacity air compressor, two twenty five ton steam cranes, one seven ton steam crane, an auxilary portable compressor, one portable welding plant, one portable concrete mixer and two No. 7 Mc Kiernen Terry steam hammers. Much of the lighter plant employed was of a type commonly used by the bridge branch and warrants no description. About 500 tons of plate girders and R.S. joists etc., were drawn from various stock yards at Sukkur, Jhelum and Khanewal. About four hundred 12" dia wooden piles and 200 tons of old rails were also collected before the construction work was started. A number of pontoons made locally from 45 gal. drums were employed for a variety of purposes, particularly for carrying construction materials to various places in the river. Two one inch dia: steel ropes were stretched across the river and anchored into the banks, one about 100 ft. upstream and one downstream of the bridge. These ropes were used for anchoring the guys from the pile driving derricks and for guiding the pontoons across the river.

RECONSTRUCTION WORK.

Erection Scheme.

Fig. 5 explains the erection scheme, which involved raising the existing rail level by $1' - 1\frac{1}{2}''$. Pile clusters driven into the river bed and supporting four tiers of rail giders and two tiers of old plate girders formed the erection staging. The staging was designed to meet the dual requirement of the reconstruction scheme. First to relieve the piers of load for their dismantling and rebuilding. Secondly to support all steel-work during erection and slewing of the new spans, and slewing and rolling out to the shore of the old spans.

The whole work was to be so arranged that the operations were carried out during the interval between trains. Due to the traffic conditions it was not permissible to block the line for more than four hours daily in two intervals of 3 hours and one hour. As most of the work described in this poper could only be done while the line was blocked careful preparations had to be made to complete the various operations in time. No detentions were experienced througout the period of reconstruction.

The bridge is situated over a pond caused by the afflux from the Sidhnai headworks about four miles downstream. The depth of water around piers, varies from 15′ — 20′ on the upstream, and from 30′ — 40′ on the downstream. The water level remained constant from October to May, except during winter freshets, when it rose upto a couple of feet above the pond level. The clear headway (water level to bottom of existing girders) was only nine feet. The depth of service girders necessary to take the train loads during rebuilding of piers was such that they could not be used for slewing the spans, as about 2 ft. additional depth was needed to accommodate the tracks and rollers which were employed for this pupose.

Service girders of smaller depth were therefore substituted for the ones used during rebuilding piers. This was permissible as they were not now required to carry live loads. The arrangement, however, still fell short of the necessary clearance required to accommodate the tracks and rollers and the whole bridge and its approaches had to be temporarily raised by about one foot.

Piled Staging.

The reconstruction work was begun with the raising of the rail level. Permanent bench marks were fixed at both ends of the bridge and all levelling was referred to them. Pile driving was started around pier No. 1 on 21st October, 1956. Four clusters of 12 piles each were driven around each pier. They were tied up with rail waling at the cap level, but no other bracings could be provided as the top of the piles had to be kept at the water level to enable erection of staging girders of the required depth within the limited headway. The 12 inch dia timber piles were sufficiently long to reach above water level after being driven from 12′ — 15′ into the river bed. All piles were driven to refusal and the completed structure was similar to a table with its many legs unbraced from 20′ — 35′ below water level standing on hard clay bottom, through 12′ — 15′ of soil. When the cap level waling was completed quarry stone was tipped round the legs to a depth of 10ft above the bed level.

In addition to these 48 piles around each pier, groups of 6 piles each were driven to support ends of 80ft long cross giders of the staging. These piles were also used for jacking up the spans whenever it become necessary to do so. On the downstream side four additional piles were driven midway between the piers to support service gear used for rolling out the old bridge girders after they had been slewed out. Fig. 5 shows this arrangement.

The piles were lowered into the river by means of the 25 ton crane and were guyed to floats made up of 45 gal: drums and manned by experienced bridge Khalasies whose duty it was to keep the pile true and plumb under all circumstances. For driving, a Mc Kiernen Terry No. 7 hammer was used, which gives a large number of blows at high valocity and keeps the pile in constant motion. No pile frame was employed, the hammer being suspended either from the jib of the 25 tons crane or was attached to a derrick which was placed on a contilevered platform suspended from the bottom boom of the existing girders. No trouble was experienced from obstructions such as boulders and trees. Whenever a pile suddenly checked it was taken for granted that the obstruction was due to quarry stones which are dumped around the piers during flood season. The driving was continued, with care not to over drive, untill the obstruction was displaced.

Pile driving work around pier No. 1 was completed on 5th November, 1956, about a fortnight after it began on 21st October, 1956. Fixing of caps and water level waling took another week and by 13th November, 1956, all staging girders had been erected. During a block on 14th November, 1956, the ends of the two existing spans were raised from the pier with 100 ton jacks untill their bearings were clear of the bed stones. Wooden packings over the staging cross girders, under the panel points to be supported, were adjusted and the jacks were slackened off. The staging was tested under a group II engine available at the job for working the material train. Reference marks were fixed on the permanent pier from where readings were taken with levelling instrument, but no perceptible sinking was observed.

Rebulding Piers.

The old masory was in an excellent state of preservation. The holding power of the old mortar was so good that the concrete bed stones (with their steel bed plates) had to be removed as a whole. Niches were cut in the brick-work at the four corners of the bed stones and hundred ton jacks were applied which pulled away the concrete blocks. Even so the mortar did not give way, and some brick-work was also torn away with them. They were then bodily lifted by crane through openings in the staging, over which the ends of 2 adjacent spans were now supported. The rest of the masory had also to be chipped off in bits by means of pneumatic paving breakers upto a few inches above water level. The pier was rebuilt in brick work in 1:3 cement mortar and was completed on 25th November, 1956.

Piling work on pier No. 2 was started on 6th. November, 1956, and the masonry work was completed on 8th December, 1956. Reinforcement cages for pier caps, which were fabricated and assembled on the shore were then carried to the piers by crane. They were swung into position over the piers and steel lined wooden shuttering erected around them. The cap on pier No. 1 was poured on 11th December, and that on pier No. 2 was poured on 14th December, 1956. A portable concrete mixer was employed, which was mounted successively on stagings opposite each pier to discharge directly into the shutterings. All materials for concrete were collected at the staging beforehand where a water tight platform had been erected for the purpose. Arrangements for concreting were gradually perfected, until the time taken to cast a pier cap was reduced from 7 hours to 4 hours. Rapid hardening cement was used to enable the load to be taken on the new piers within 3 days after concereting. In order to alter the staging to suit span erection and slewing, the old spans were reseated over remodelled piers. Since the bearings had been removed, the girders were supported on wooden bed blocks made up of 12″×12″ salwood cuttings from the piles, with through bolts. The service girders on piers No. 1 and 2 had already been changed to suit erection of spans by 4th January, 1957 and 17th January, 1957 respectively, and all was now set for the next operation. The scheme provided for the erection of girders on shore and then transporting them to the staging and placing them alongside the existing spans by means of 25 ton cranes. The floor and the latral bracing system were then to be fitted and rivetted up. The completed spans were then to be slewed in and the existing spans slewed out simultaneously.

Erection of New Girders on Shore.

The fabricated steel-work had started coming in from Jhelum Workshops by the beginning of November, 1956, and assembly had commenced by the middle of November, 1956. For this purpose centre lines of the trusses had been laid out in the erection yard, and position of panel points were exactly located. At each panel point, timber packings were laid out and levelled, over which camber jacks were placed in pairs under inside and outside webs of the bottom chords. In this position the trusses were about 2 ft. clear of the ground giving freedom of access to work at all points of the bottom booms. The bottom chords were assembled perfectly straight with drifts and were bolted up. They were cambered by lowering the camber jacks to calculated dimensions. All the web members were then erected on drifts, and lastly the top chords were erected by working symetrically from the center outwards, each panel point being cambered in turn. Finally, the end rakers were inserted closing the girders at the end joints over bearings. All holes in the joints were now filled with drifts and 40% erection bolts. Care was taken that the metal was not injured by the drifts and any holes that did not match were reamed. Before rivetting the girders were checked once again for alignment and camber. The centre holes in a joint were rivetted first and drifts and bolts in outer holes were retained as long as possible.

The girders for each span were erected side by side at about 8 ft centres and were secured by means of temporary lateral and cross bracings made up of old angles and channels. The girders assembled away from the lifting track were provided with back stays also made up of old angles, so that when inner girder were carried to the staging (after undoing the temporary lateral and cross bracings and leaving only the back stays) the outer girders stood fast. Suitable scaffolding was in the meantime erected around both girders to give the workmen easy access to all points.

The girders for span No. 2 had been assembled and completely rivetted up by the 30th November, 1956. Wooden bed blocks were then inserted under the bearing ends of the girders, and the camber jacks were removed, and the girders swung clear. The camber at the centre of the 90ft., supported girders was 7/8 inch, an average of about 1/16 inch was lost when the camber jacks were lowered.

All erection work was done by means of 25 ton bridge cranes. The capacity of these cranes is 25 tons at 28 ft. radious propped, 20 tons at 25ft radious unpropped, and 12 tons at 47′ — 3″ radius travelling with jibs parallel to the track. Fortunately, the rotating mechanism of the cranes cleared the top booms of the existing semi-through spans of the bridge, making it possible to use them for all operations until the new spans were slewed in.

Transporting New Girders.

During a line block on the 6th January, 1957, the girders for span No. 2 were carried to the temporary pile staging in the river, one by one, suspended from the jibs of two 25 tons cranes. Lifting trackles with detachable links made locally from angles and flats were attached to the top booms of the girders at both ends. The tackles were fitted with shackles removed from 20 ton blocks and were put directly into the crane hooks (Fig. 5). The booms were packed with timber at the points where the lifting tackles would engage to avoid damage to steel-work. The operation was perhaps the most specatacular part of the whole reconstruction work, and was carried out without a flaw, credit for which goes to Bridge Inspector Mir Hameed Ullah.

The whole operation is shown in photographs 1—5. Photograph 1 shows one of the girders being lifted from the side of its twin in the erection yard. Photograph 2, shows the girder being carried over the bridge. In photograph 3 the girder is being placed on the staging; in the back-ground can be seen another new span which had already been placed on the staging. Photograph 4 shows the second girder being placed along-side the one which was already there and photograph 5 shows a piece of the lateral bracing being assembled.

Erection of Lateral and Floor Systems.

At the staging the outer girder i.e., the one which was carried ou first was secured to raking trestles through hangers U_1 L_1 (Fig 5). These trestles were specially made for the purpose and were mounted successively on stagings for each span. At the points L_1, permanent cross girders were botled to the outer girders to enable the inner girders to be unloaded at the correct position both longitudinally and laterally. The permanent floor system, and the lateral and sway bracings, which were carried to the stagings loaded in trucks between two 2 cranes, were then assembled and bolted up.

After the assembly of the floor system, suitable scaffolding was rigged up for rivetting up the span. The raking trestles were now removed and the span was jacked up to a predetermined height from where it would roll into its permanent position on the piers. In this position the span was checked for alignment, levels, and verticality. During rivetting every care was taken to keep the members bolted tightly together, and this was constantly checked. It is creditable that the number of bad rivets was very small, hardly 1%. The number of field rivets in a span was 6710.

Slewing the Spans.

While the revitting up of the span was in progress, arrangements for slewing were also being completed. A track consisting of 2 rails about 12″ apart, and 3 ft. cut timbers had been laid over both the staging girders. A single rail inverted track had been fitted under the cross girders of both the new and the old spans. Both the spans were tied up rigidly so that they would move together and also remain a constant distance apart. At the downstream end of the staging hand winches were mounted over prepared frames and tackles were attached to the old spans. At the upstream end of the staging preventor tackles were attached to the spans to control their movement during slewing. During a line block on 24th January, 1957, the track over the old span No. 2 was disconnected. Both the new and the old spans were jacked up and 4″ dia movable rollers were inserted between the rolling tracks over the staging, and those fitted under the cross girders of the spans. During movement, whenever the girders worked skew, the rollers provided a means of adjustment. It took exactly 23½ minutes to complete this operation. The new span was then lowered over temporary timber bed blocks by means of jacks. and the track over the approaches was connected up. The span was tested under a material train at the restricted speed of 5 miles per hour and the first regular train, the 11 up Express, was passed over the new span at 14—20 hours on 24th January, 1957.

Proceeding progressively on the lines identical with those followed previously, staging work on all piers had been completed by the end of December, 1956. In all over 300 piles were driven into the river bed, The maximum vertical load on a pile came to abont 10 tons. By the 22nd of January, 1957, all piers and abutments had been rebuilt, and the old spans reseated over the new piers. The progress of the work is clearly seem from Fig. 6 of the remaining four spans 2 were changed in February and 2 in March, 1957. The last span was slewed in on 30th March, about 10 days before the target date. The time taken for slewing in the last span was only 5 minutes.

Dismantling Old Girders and Stagings.

The dismantling of old girders had commenced immediately after the first span had been slewed in. The floor system was dismantled first. Joints were cut and during line blocks each section was removed and loaded into trucks by cranes working on the old spans adjacent to the new ones. After the removal of floor system the old girders were skidded inwards and were braced up with angles at close centres. Under the closed girders suitable service girder work was erected on staging piles and on the four additional piles, (Fig. 5.) Rolling tracks similar to those used for slewing the spans were provided and in this position the old girders were lifted by jacks and were placed on the new service girder work, releasing the staging girders which were removed to shore.

Standing on this new intermittant staging, the old girders were cut at the joints A, B etc, (Fig. 5), and the cut parts were removed to shore by 25 ton cranes. The remaining portions of the girders which now stood cantilevered into the gap between the two stagings were hauled forward on rollers into such position that they could also be cut into pieces and removed to shore.

All old spans and heavy staging material were similarly removed to shore by 25 ton cranes which worked on old spans, just ahead of the slewing in of the next span. The light service material including rail clusters, pile caps and etc., were lifted and loaded into trucks by 7 ton crane working from the new spans. Part of the service material was man-handled and removed to shore loaded on pontoons.

Extraction of Piles.

The piles could not be withdrawn by direct pull. A derrick mounted on pontoons made from second hand steel tanks was tried without auccess. Two 100 ton jacks resting on alternate piles and pulling the pile in between by means of a bridge beam were tried next, and proved successful. It was only necessary to lift each pile 3 to 5 ft. and the 7 ton cranes or the improvised floating crane pulled them out. They were then loaded on pontoons which were manhandled to shore. The four corner piles in each group were lifted by resting the jacks on the pontoons. Sometimes the pontoons began to sink under the load, and had to be tied with chains to the adjacent piles which had been lifted up but were not completely pulled out. A number of extracting gangs were employed and the river was cleared by the middle of May 1957.

Positioning of Spans.

In the meantime the new spans which were resting on wooden bed blocks were placed on bearings. During line blocks the spans were held on jacks to enable erection of the bearings. Provision for expansion is made at one end of each span and there is one set of expansion and one set of fixed bearings at each pier.

Painting

After erection on site the steel work was well cleaned by scraping and brushing, before two coats of red oxide paint were applied. The scraping and brushing was carried out satisfactorily and although the steel work had been freed from rust scale and dirt, as far as could reasonably be done, it could not be said to be perfectly free from mill scale. It could be said however, that its condition was such as satisfied general practice. It is submitted that sand blasting the steel work either during fabrication or in the field will amply repay itself in a work of this magnitude.

The paint was not firmly adherant and had a tendency to turn into ash coloured powder, which could be easily rubbed off after drying. For this reason part of the steel work had to be given 3 coats and yet the finished work was not satisfactory. It appears that the pigments contain too much of clay and other earthy material, and the Stores Branch will do well to check the deliveries of paints more carefully.

Testing of Spans.

Very comprehensive tests were carried out before the bridge was opened at the maximum speed of the section. The test train consisted of coupled group II engines, as Group I engines (for which the bridge has been designed) are not permitted to run over the section at present. The bridge will however be tested again under group I engines when they are permitted. The test results are shown in Fig. 7 and the stresses are found to be well below the calculated values every where. The stress readings were taken with Fereday-Palmer stress recorder which is universally employed for experimental varification of stresses.

Deflection and oscillation tests were also carried out and are tabulated in Fig. 7. The maximum deflection recorded under group II engines was 0·45 inches, and the maximum oscillation of the top boom was 0·14 inches.

Organization

The design, fabrication and construction of the bridge was carried out under the general direction of Mr. M. M. Zubair, Chief Engineer, N. W. Railway and the supervision of Mr. A. M. Akhoond, Deputy Chief Engineer Bridges. Raja Mohammad Nawaz was Executive Engineer incharge of construction. Fabrication of steel work was carried out by Mr. Abdul Rahim, Assistant Works Manager, N. W. R., Bridge Workshops, Jhelum. The author was Assistant Bridge Engineer incharge of both, the design and the construction of the bridge throughout.

Acknowledgements.

The author wishes to express his thanks to Mr. M. M. Zubair, Chief Engineer, N. W. Railway for permission to present this paper. The auther acknowledges the assistance he recieved from Messrs Nasir Khan, Superintendent Drawing Office, Kausar Abbas, Head Computor, Mohammad Sharif and Ahmad Din, Draftsman in the design office, and from Mr. Hamidullah, Bridge Inspector incharge, and his assistants in the field.

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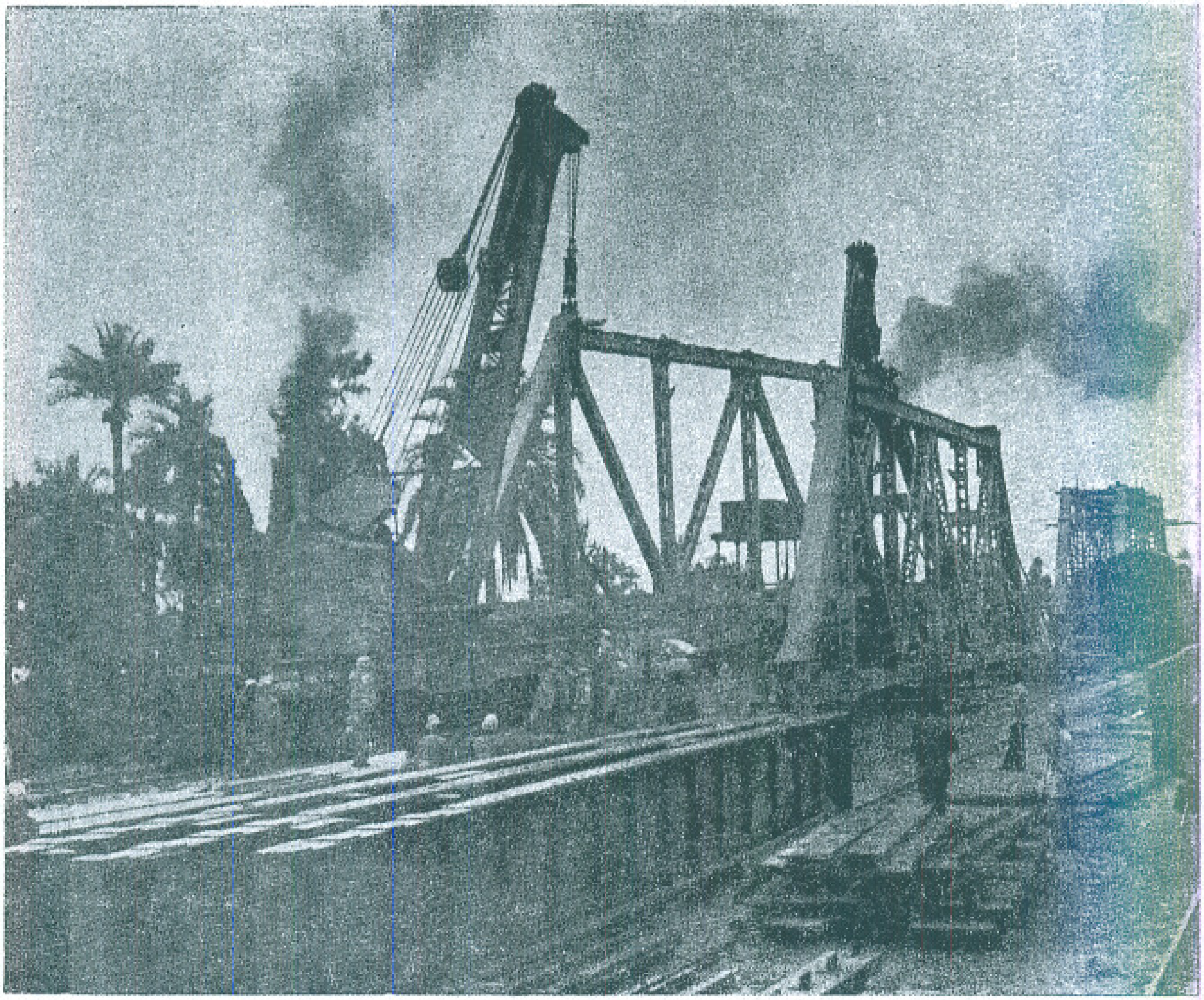

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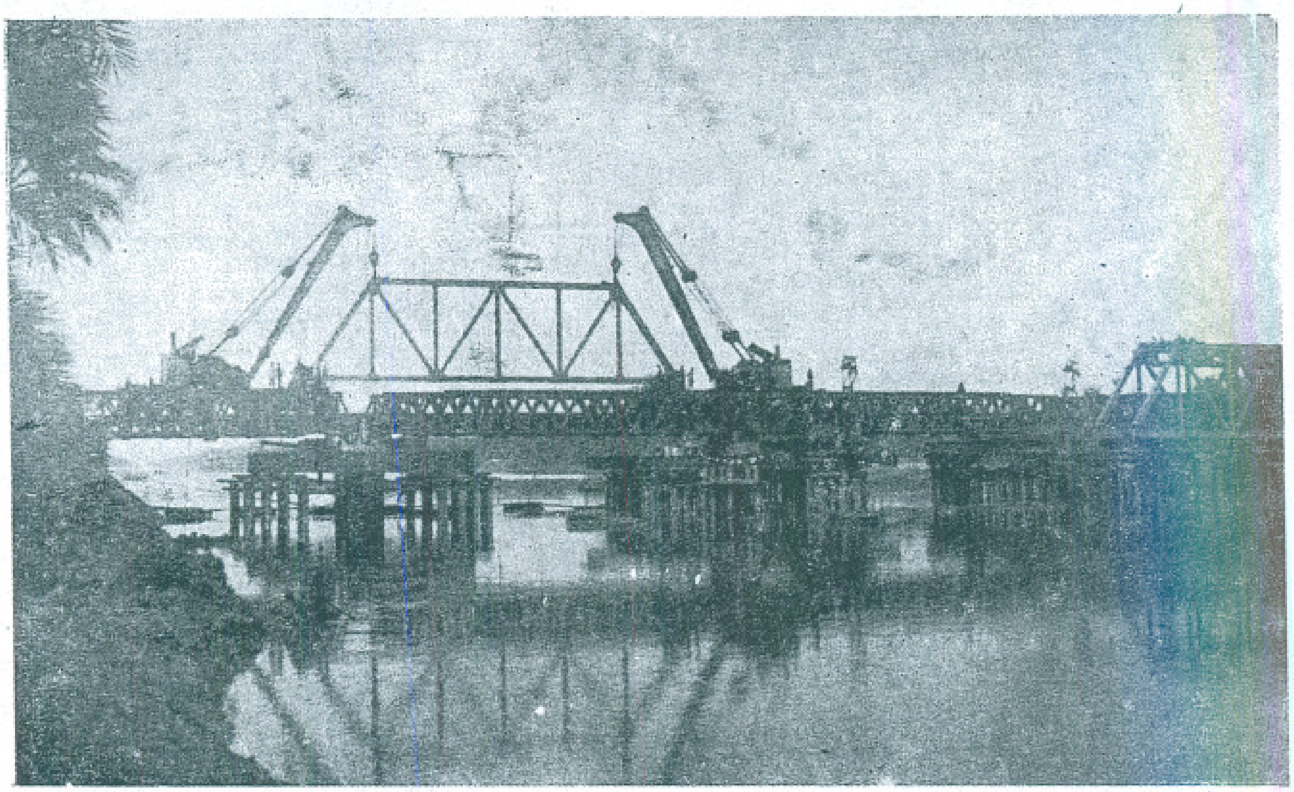

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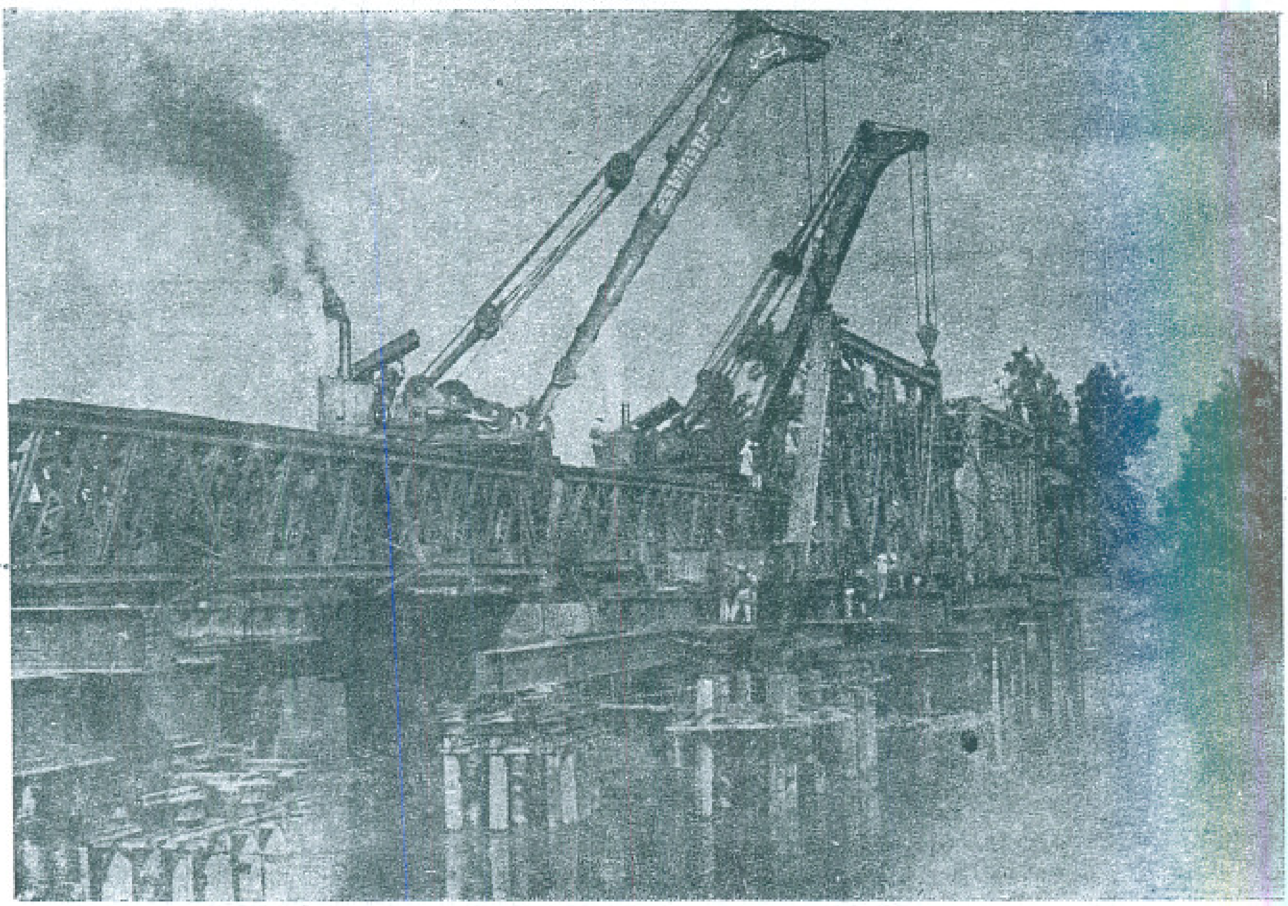

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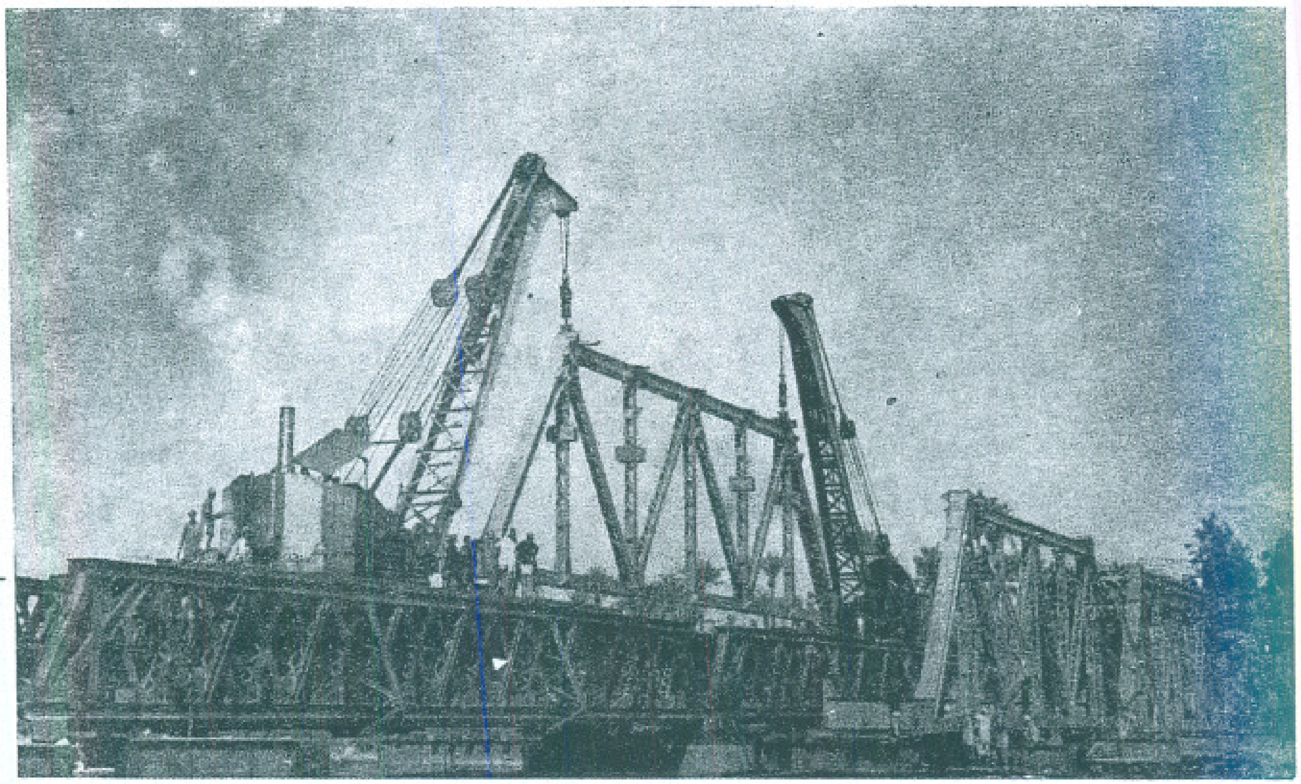
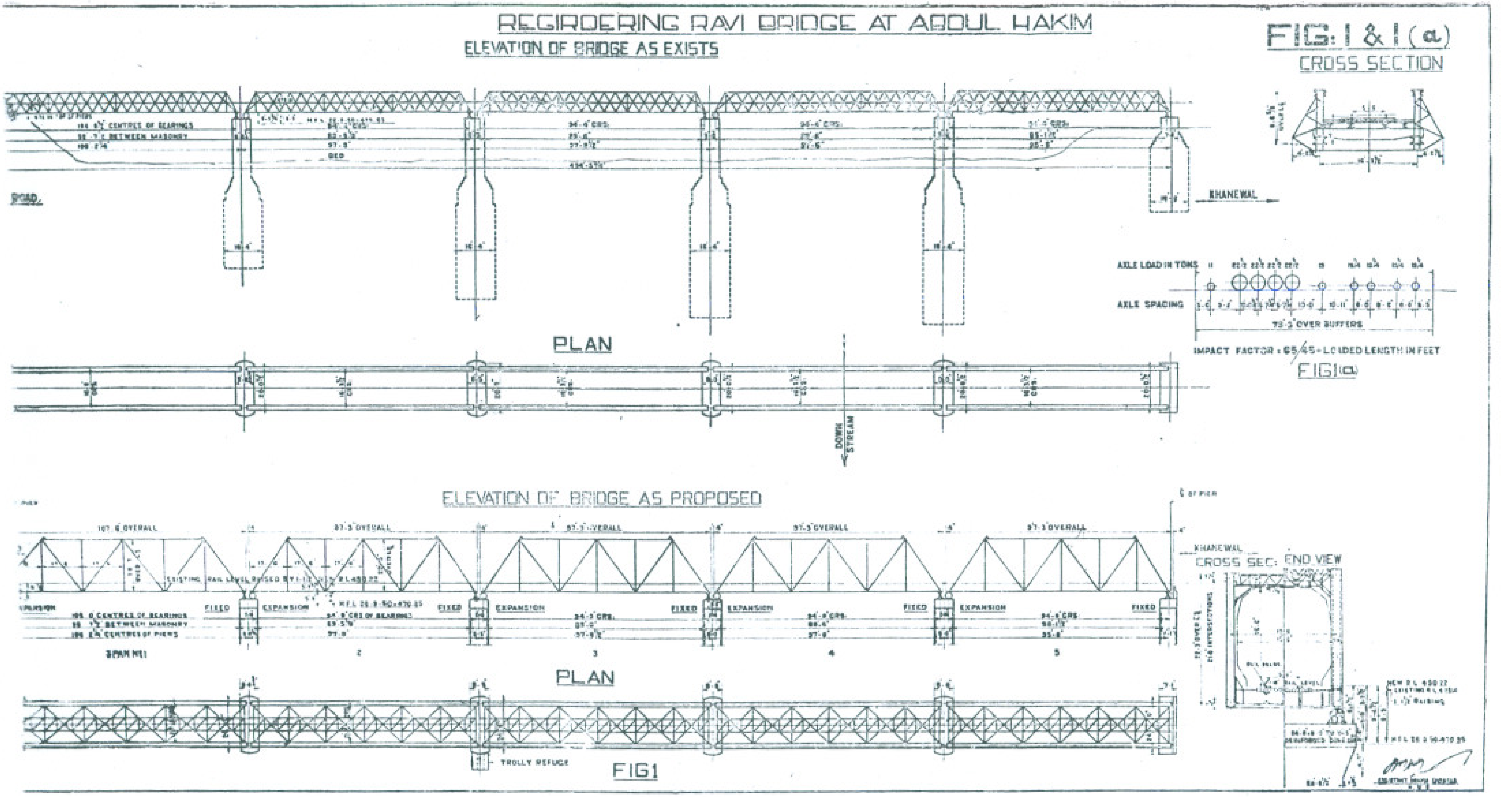
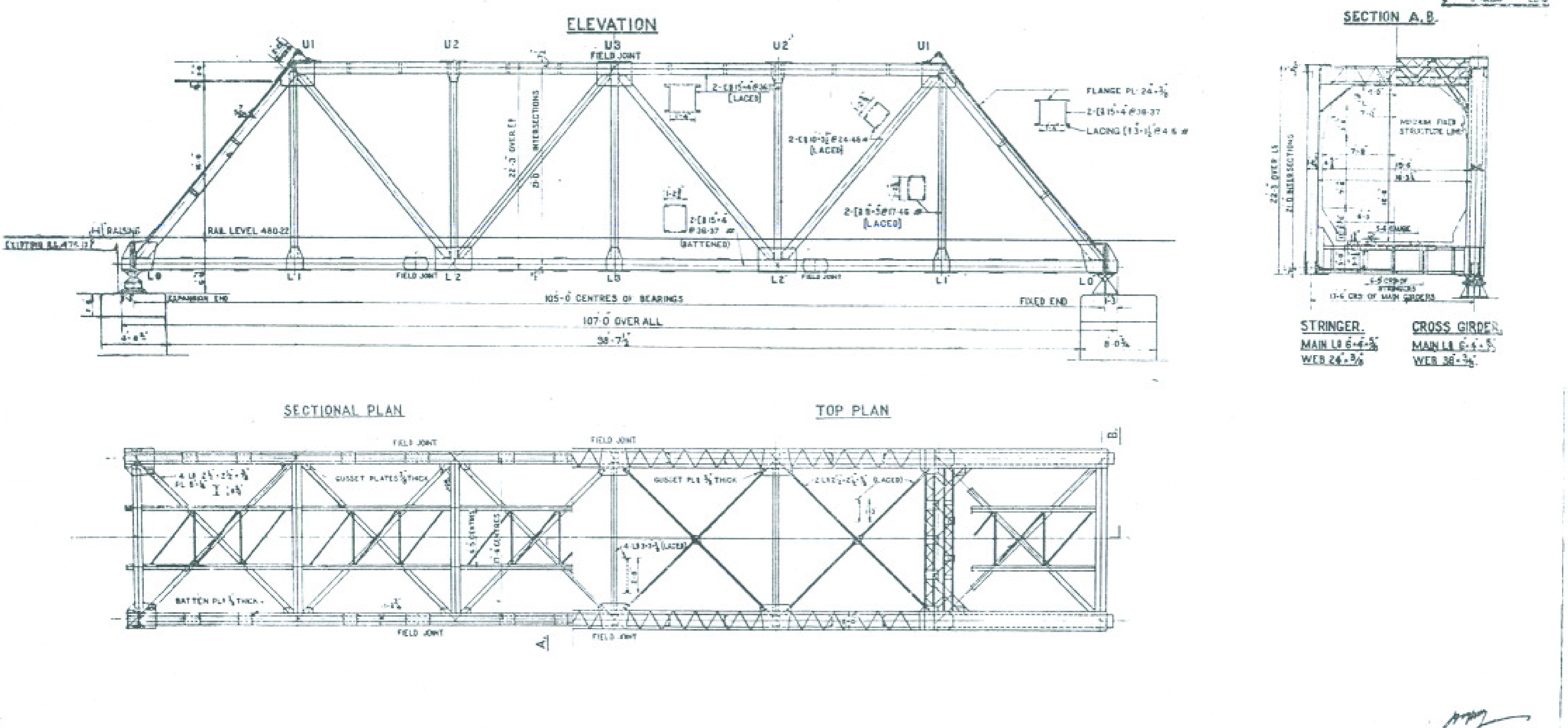




REGIRDERING RAVI BRIDGE AT ABDUL HAKIM
ELEVATION OF BRIDGE AS EXISTS
FIG: 1 & 1 (a)
CROSS SECTION
ROAD
KHANEWAL
AXLE LOAD IN TONS
AXLE SPACING
73'-5" OVER BUFFERS
IMPACT FACTOR = 65/45+LOADED LENGTH IN FEET
FIG1(a)
PLAN
DOWN STREAM
ELEVATION OF BRIDGE AS PROPOSED
107'-6" OVERALL
97'-3" OVERALL
EXISTING RAIL LEVEL RAISED BY 1'-1 1/2"
KHANEWAL
CROSS SEC: END VIEW
EXPANSION
FIXED
SPAN NO 1
TROLLY REFUGE
FIG1

REGIRDERING RAVI BRIDGE AT ABDUL HAKIM

FIG: 2



ASSISTANT BRIDGE ENGINEER
N. W. R.

FIG: 3

REGIRDERING RAVI BRIDGE AT ABDUL HAKIM

ERECTION CAMBER

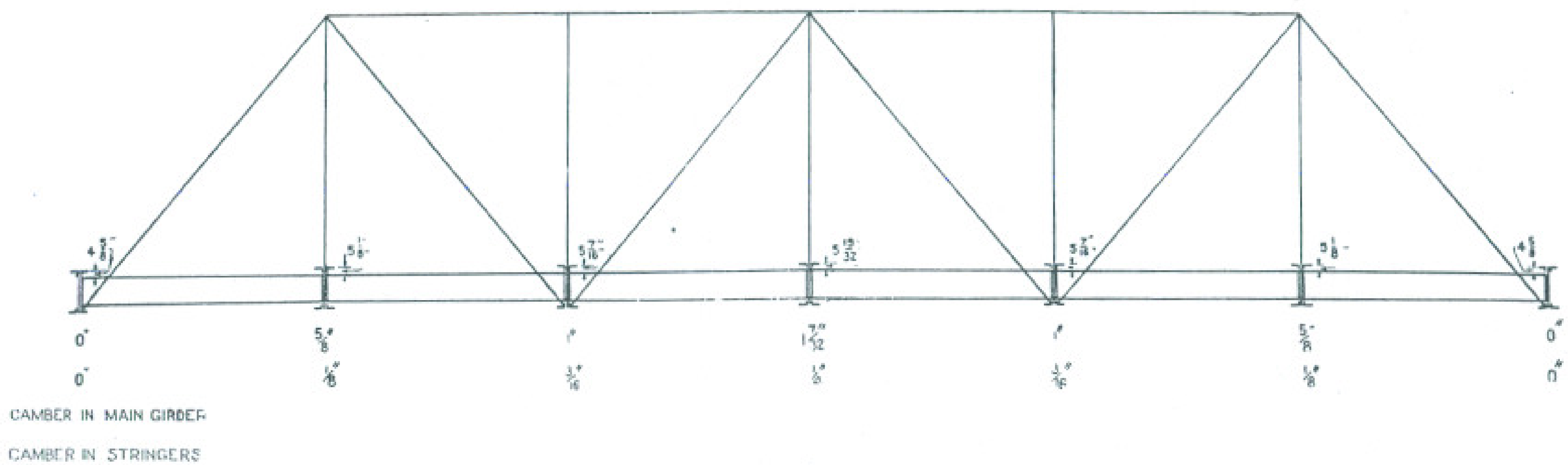
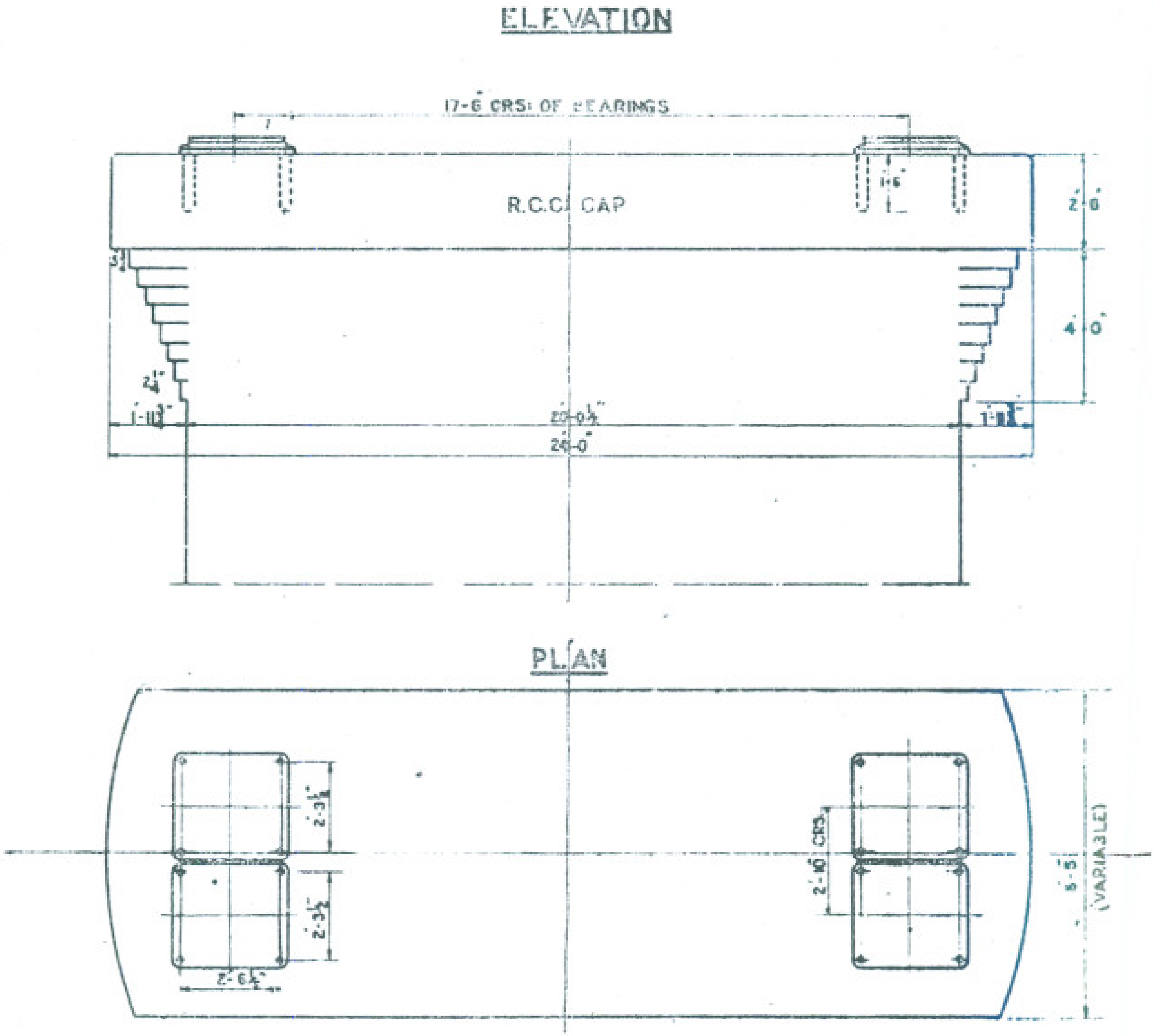


FIG: 4

REGIRDERING RAVI BRIDGE AT ABDUL HAKIM

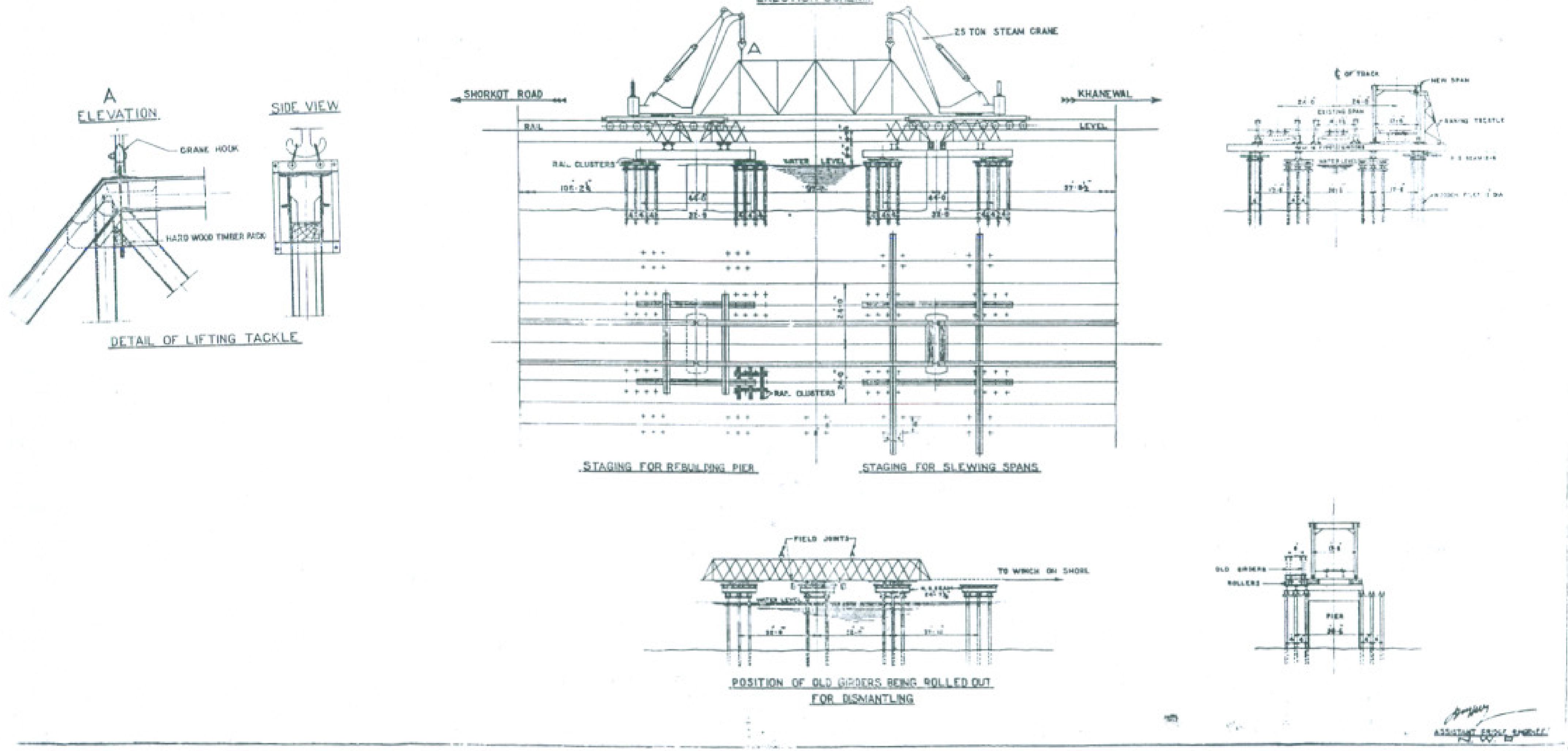


ASSISTANT BRIDGE ENGINEER,
N.W.R.

FIG: 5

REGIRDERING RAVI BRIDGE AT ABDUL HAKIM

ERECTION SCHEME



REGIRDERING R

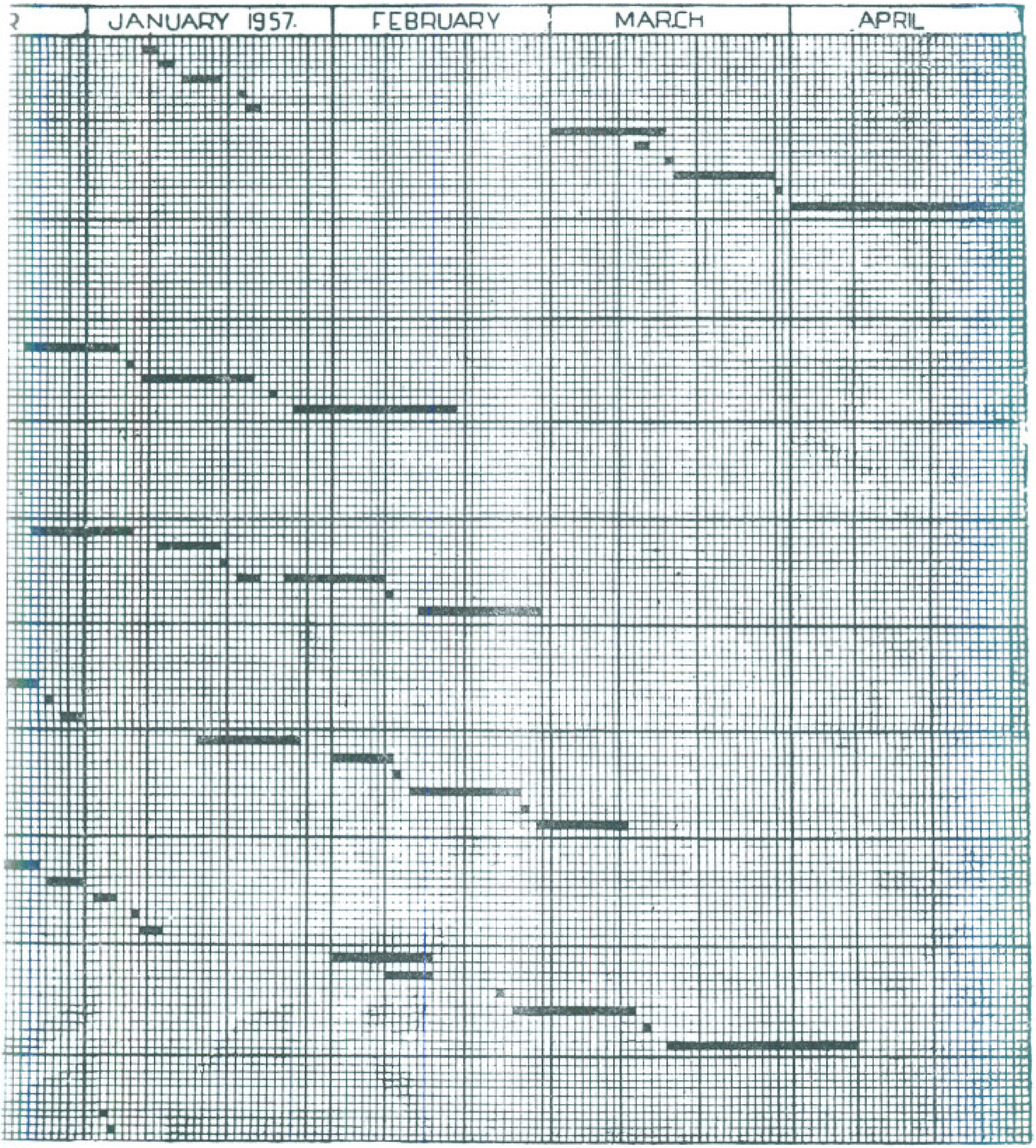
PROG

	DESCRIPTION OF WORK	OCTOBER 1956	NOVEMBER	DECE
ABUTMENT SHORKOT END	1. ERECTION OF SLEEPER CRIBS & STAGING.			
	2. FIXING SERVICE GIRDERS & TAKING UP LOAD.			
	3. DISMANTLING OLD MASONRY & REBUILDING			
	4. SETTING STEEL REINFORCEMENT FOR PIER CAP			
	5. SHUTTERING & POURING CONCRETE.			
SPAN Nº 1	1. ASSEMBLY OF NEW GIRDERS ON SHORE.			
	2. CHANGING POSITION OF SERVICE GIRDERS TO SUIT ROLLING.			
	3. CARRYING NEW GIRDERS TO STAGING			
	4. RIVETTING CROSS GIRDERS & LATERAL SYSTEM.			
	5. ROLLING IN NEW GIRDERS & ROLLING OUT OLD.			
	6. DISMANTLING OLD GIRDERS & TAKING OUT ON SHORE.			
PIER Nº 1	1. PILE DRIVING.			
	2. CAPING & TYING UP PILES.			
	3. FIXING SERVICE GIRDERS & TAKING UP LOAD.			
	4. DISMANTLING OLD MASONRY & REBUILDING.			
	5. SETTING STEEL REINFORCEMENT FOR PIER CAP			
	6. SHUTTERING & POURING CONCRETE.			
SPAN Nº 2	1. ASSEMBLY OF NEW GIRDERS ON SHORE.			
	2. CHANGING POSITION OF SERVICE GIRDERS TO SUIT ROLLING.			
	3. CARRYING NEW GIRDERS TO STAGING.			
	4. RIVETTING CROSS GIRDERS & LATERAL SYSTEM.			
	5. ROLLING IN NEW GIRDERS & ROLLING OUT OLD.			
	6. DISMANTLING OLD GIRDERS & TAKING OUT ON SHORE.			
PIER Nº 2	1. PILE DRIVING.			
	2. CAPING & TYING UP PILES.			
	3. FIXING SERVICE GIRDERS & TAKING UP LOAD.			
	4. DISMANTLING OLD MASONRY & REBUILDING			
	5. SETTING STEEL REINFORCEMENT FOR PIER CAP.			
	6. SHUTTERING & POURING CONCRETE.			
SPAN Nº 3	1. ASSEMBLY OF NEW GIRDERS ON SHORE.			
	2. CHANGING POSITION OF SERVICE GIRDERS TO SUIT ROLLING.			
	3. CARRYING NEW GIRDERS TO STAGING.			
	4. RIVETTING CROSS GIRDERS & LATERAL SYSTEM.			
	5. ROLLING IN NEW GIRDERS & ROLLING OUT OLD.			
	6. DISMANTLING OLD GIRDERS & TAKING OUT ON SHORE.			
PIER Nº 3	1. PILE DRIVING.			
	2. CAPING & TYING UP PILES.			
	3. FIXING SERVICE GIRDERS & TAKING UP LOAD.			
	4. DISMANTLING OLD MASONRY & REBUILDING.			
	5. SETTING STEEL REINFORCEMENT FOR PIER CAP.			
	6. SHUTTERING & POURING CONCRETE.			
SPAN Nº 4	1. ASSEMBLY OF NEW GIRDERS ON SHORE.			
	2. CHANGING POSITION OF SERVICE GIRDERS TO SUIT ROLLING.			
	3. CARRYING NEW GIRDERS TO STAGING.			
	4. RIVETTING CROSS GIRDERS & LATERAL SYSTEM.			
	5. ROLLING IN NEW GIRDERS & ROLLING OUT OLD.			
	6. DISMANTLING OLD GIRDERS & TAKING OUT ON SHORE.			
PIER Nº 4	1. PILE DRIVING.			
	2. CAPING & TYING UP PILES.			
	3. FIXING SERVICE GIRDERS & TAKING UP LOAD.			
	4. DISMANTLING OLD MASONRY & REBUILDING.			
	5. SETTING STEEL REINFORCEMENT FOR PIER CAP.			
	6. SHUTTERING & POURING CONCRETE.			
SPAN Nº 5	1. ASSEMBLY OF NEW GIRDERS ON SHORE.			
	2. CHANGING POSITION OF SERVICE GIRDERS TO SUIT ROLLING.			
	3. CARRYING NEW GIRDERS TO STAGING.			
	4. RIVETTING CROSS GIRDERS & LATERAL SYSTEM.			
	5. ROLLING NEW GIRDER & ROLLING OUT OLD.			
	6. DISMANTLING OLD GIRDER & TAKING OUT ON SHORE.			
ABUTMENT KHANEWAL END	1. ERECTION OF SLEEPER CRIBS & STAGING.			
	2. FIXING SERVICE GIRDERS & TAKING UP LOAD.			
	3. DISMANTLING OLD MASONRY & REBUILDING.			
	4. SETTING STEEL REINFORCEMENT FOR PIER CAP.			
	5. SHUTTERING & POURING CONCRETE.			

BRIDGE AT ABDUL HAKIM

SS CHART

FIG: [illegible]



REGIRDERING RAVI BRIDGE AT ABDUL HAKIM

FIG: 7

STRESSES FOR 100 FT. SPAN

STRESSES TONS PER SQUARE INCH

Recorded: Stress Recorder No. 43 (3)	Recorded: Stress Recorder No. 11 (4)	Calculated: Dead Load (5)	Calculated: Test Train Live Loads Without Impact (6)	Calculated: Test Train Live Loads With Impact (7)	Calculated: Total Stress Columns 5+7 (8)	Recorded: Dead Plus Live Load With Impact (9)	Permissible Stresses: Tension (10)	Permissible Stresses: Compression (11)	Description of Member (12)
+3.0	+2.5	+1.11	+2.52	+3.04	+4.15	+4.11		8.7	TOP BOOM (DOWN STREAM GIRDER)
+3.2	+3.0	+1.11	+2.52	+3.88	+4.99	+4.31		8.7	
+3.4	+2.9	+1.11	+2.52	+4.62	+5.73	+4.51		8.7	
+2.8	+2.4	+1.11	+2.52	+3.06	+4.17	+3.91		8.7	TOP BOOM (UP STREAM GIRDER)
+3.4	+2.5	+1.11	+2.52	+3.86	+4.97	+4.51		8.7	
+3.5	+2.6	+1.11	+2.52	+4.85	+5.96	+4.61		8.7	
-2.0	-2.2	-1.40	-3.18	-3.96	+5.36	-3.60	9.0		BOTTOM BOOM (DOWN STREAM GIRDER)
-2.5	-2.5	-1.40	-3.18	-5.01	-6.41	-3.90	9.0		
-2.7	-3.0	-1.40	-3.18	-5.61	-7.01	-4.40	9.0		
-1.7	-2.4	-1.40	-3.18	-3.80	-5.20	-3.86	9.0		BOTTOM BOOM (UP STREAM GIRDER)
-2.2	-2.5	-1.40	-3.18	-5.01	-6.41	-3.90	9.0		
-2.5	-2.7	-1.40	-3.18	-5.61	-7.01	-4.10	9.0		
+2.0	+2.0	+ .762	+2.06	+2.27	+3.032	+2.762		8.4	END RAKER (DOWN STREAM GIRDER)
+2.4	+2.4	+ .762	+2.06	+2.82	+3.582	+3.162		8.4	
+2.5	+2.2	+ .762	+2.06	+3.64	+4.402	+3.262		8.4	
+2.0	+2.0	+ .762	+2.06	+2.42	+3.182	+2.762		8.4	END RAKER (UP STREAM GIRDER)
+2.4	+2.4	+ .762	+2.06	+2.90	+3.662	+3.162		8.4	
+2.5	+2.7	+ .762	+2.06	+3.60	+4.402	+3.462		8.4	
+3.0	-2.4	-1.13	-3.36	-4.04	-5.17	-4.130	9.0		DIAGONAL (DOWN STREAM GIRDER)
-2.7	-2.5	-1.13	-3.36	-5.6	-6.73	-3.83	9.0		
-3.0	-2.6	-1.13	-3.38	-6.35	-7.48	-4.13	9.0		
-2.5	-2.8	-1.13	-3.36	-4.18	-5.31	-3.73	9.0		DIAGONAL (UP STREAM GIRDER)
-2.6	-3.0	-1.13	-3.36	-5.46	-6.59	-4.13	9.0		
-3.8	-3.2	-1.13	-3.36	-6.62	-7.75	-4.33	9.0		
-1.0	-2.4	- .304	-1.625	-2.25	-2.654	-2.704	9.0		VERTICAL (DOWN STREAM GIRDER)
-1.5	-2.7	- .304	-1.625	-3.24	-3.504	-3.004	9.0		
-1.5	-3.0	- .304	-1.625	-3.24	-3.604	-3.304	9.0		
-1.3	-2.5	- .304	-1.625	-2.27	-2.634	-2.854	9.0		VERTICAL (UP STREAM GIRDER)
-2.0	-2.7	- .304	-1.625	-3.24	-3.604	-3.004	9.0		
-1.7	-2.8	- .304	-1.625	-3.24	-3.284	-3.104	9.0		
+5.8	-2.5	- .455 + .455	[illegible]	[illegible] +3.53	[illegible] +3.975	[illegible] +3.455	9.0	8.6	CROSS GIRDER
+3.7	-3.8	- .455 + .455	[illegible]	-4.86 +4.34	[illegible]	-5.485 +4.155	9.0	8.6	
+3.5	-3.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9.0	8.6	
-2.1	-2.4	- .24	-2.77	-3.5	-3.74	-3.244	9.0		END STRINGERS
-2.8	-2.5	- .24	-2.77	-4.07	-4.31	-3.04	9.0		
-2.2	-2.6	- .24	-2.77	-4.99	-5.23	-2.84	9.0		
- .8	- .8	- .418	-2.02	-2.22	-2.638	-1.218	9.0		BOTTOM LATERAL BRACING ENDS
-1.3	-1.2	- .418	-2.02	-2.46	-2.878	-1.718	9.0		
-1.0	-1.0	- .418	-2.02	-2.62	-3.038	-1.418	9.0		

RECORDED DEFLECTIONS & OSCILLATIONS

100 FT. SPAN

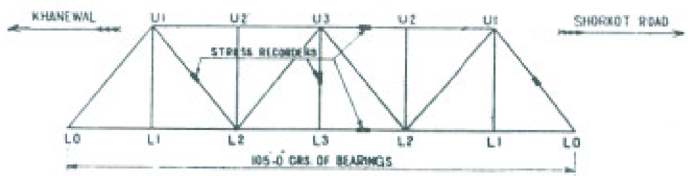
Girder	Speed M.P.H.	Top Boom: Deflection	Top Boom: Oscillation	Bottom Boom: Deflection	Bottom Boom: Oscillation
UP STREAM	12.36	0.38	0.04	0.35	-
	28.09	0.4	0.1	0.38	-
	47.55	0.44	0.14	0.42	0.07
DOWN STREAM	12.36	0.4	0.06	0.4	-
	28.09	0.42	0.1	0.42	0.06
	47.55	0.43	0.13	0.45	0.01

MAX. CALCULATED DEFLECTION AT CENTRE OF BOTTOM BOOM FOR 100 FT. SPAN = 1.19"

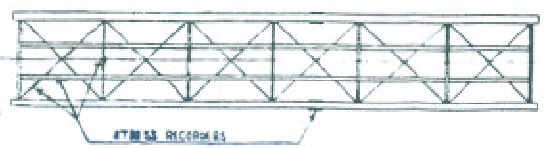
NOTES

1. BRIDGE TESTED UNDER COUPLED HP/S No. 2871 & HP/C No. 61 ENGINES
2. DIRECTION OF TRAVEL DURING ALL TESTS FROM SHORKOT TO KHANEWAL
3. DATES OF TESTS 9-6-57 TO 19-6-57
4. + INDICATES COMPRESSION
   — " TENSION

ELEVATION



PLAN



ASSISTANT BRIDGE ENGINEER