PAPER No. 199.

THE RAISING OF JHELUM BRIDGE.

By T. McIntyre.

During the last thirty years the general water level of the Jhelum River at Jhelum Bridge has risen by four feet, due to silting up of the river bed. This silting up process though still in progress is almost finished.

The bridge crosses the river between Jhelum and Sarai Alamgir and is one of the longest in India. The railway bridge consists of fifty spans of 96 ft. 6 inches and a short approach span of 23 ft. 9 inches at the Jhelum end. The spans of the road bridge rest on the same piers as the railway spans; they are similar in number and length, and are on the downstream side of the railway spans. The weight of the railway spans is 130 tons each and the weight of the roadway spans 96 tons each.

The attention of the authorities was called very forcibly to the rise in levels in 1929, when a heavy flood broke all previous records and at one time the floating logs in the river touched the bottoms of the girders of the bridge. Had any further rise in water level taken place, the consequent jam of logs on the upstream side of the girders would undoubtedly have injured some of the spans seriously, if not actually destroyed them.

After consultations between the Railway, P.W.D., and Irrigation authorities, it was decided to raise all the spans of the Railway bridge and the road bridge by four feet. This has been done by raising the girders and inserting steel grillages under the bearings on top of the piers.

The railway bridge spans consist of three main girders; the central one being deeper than the outer girders. To adjust this difference in depth and keep the tops of the grillages level, new cast steel bottom bearings were fitted under the outer girders.

The actual raising of the bridge and the approaches presented no point of exceptional difficulty, but as the whole work was carried out without any interruption to either rail or road traffic, a carefully thought-out scheme of working had to be prepared and adhered to.

It was decided to complete the raising of the railway bridge first and then carry on with raising the road bridge. The raising was started at the Sarai Alamgir end of the bridge.

The method of raising the spans is shown in Plate II. Temporary jacking-girders were bolted on to the ends of the spans, and projected well to either side of the span, so that heavy jacks resting on the top of the pier could be placed under the extremities of the jacking girders, and lift the span clear above the pier. The jacking up of the spans was done in small lifts of ten inches.

The sequence of jacking operations is shown in Plate I.

Hard wood packings, ten inches thick by two feet square, were placed under the ends of the girders as each lift was completed. These hard wood blocks were made of selected timber carefully planned to size, and strongly bolted, and, although each span was finally supported on columns of packing blocks four feet high, no instability could be seen, and heavy railway traffic continued to cross the bridge without interruption. Each railway span has three main girders, and this contributed to stability.

All railway traffic on arrival at the bridge was required to stop dead and then proceed across the bridge at five miles per hour.

The jacking operations were carried out during the day in the intervals between trains. The intervals varied from seventy-five minutes to thirty minutes. When the khalassi gangs had had some experience and each man knew his work, twenty five minutes were long enough to perform a ten inch lift, insert hardwood blocks under the ends of the girders, and lower off the jacks.

In the beginning jacking operations were tried on two adjacent piers simultaneously, so that the span between the piers was lifted completely off its bearings; but this was discontinued, because the span was liable to move sideways.

The method then adopted was to restrict the jacking operation to one pier at a time. The ends of two adjacent spans resting on the pier would be jacked up simultaneously a height of ten inches, hard wood blocks inserted under the ends of the girders, and then the jacks would be lowered off. The same operation would then be performed at another pier. This method was very successful, and there was no sideways movement of the spans.

The slope in the bridge, from the spans which had been raised four feet, down to those which had not been raised at all, was taken out in a length of five spans as will be seen from Plate I. This gave a maximum gradient of about 1 in 120.

It was expected that the sequence of jacking operations and the constant flexure of the track might throw the track out of alignment, but no curving of the track or creep of the rails was observable.

When a span had been raised its full four feet, the hardwood packings were taken out from under the ends of the girders, and the steel grillages inserted. These grillages, which are shown in Plate III, were made up in the N. W. Railway Bridge Workshops in Jhelum. Each grillage arrived at the bridge loosely bolted together. It was then unbolted, and the component pieces lifted on to the pier separately, fitted in position under the ends of the girders, and, when completely assembled, the grillage was rivetted up "in situ".

The raising of the approaches had to be carried out at the same time as the raising of the spans. When the work was begun at the Sarai Alamgir end of the bridge, the end span of the road bridge was raised at the same time as the end span of the railway bridge, and the raising of both railway and road approaches carried on at the same time.

On reaching the Jhelum end of the bridge the same procedure was adopted, the end spans of the railway bridge and of the road bridge, and the approaches were raised at the same time.

At the Sarai Alamgir end of the bridge, a new reinforced concrete retaining wall was built. This can be seen on Plate IV. Plate IV also shows the temporary approach spans inserted to allow of dismantling the old masonry retaining wall, and making of the new reinforced concrete retaining wall.

At the Jhelum end of the bridge, where there is a small permanent approach span, a similar arrangement was used. This is shown on Plate V. The permanent approach spans were taken out, and long temporary approach spans which reached back well behind the abutment were inserted. Here, the existing retaining wall was not dismantled, but was reinforced by a heavy concrete buttress, keyed on to the existing retaining wall and surmounted by a combined reinforced concrete bedstone and ballast wall. The temporary arrangements at this end of the bridge, and the concrete buttress and other work can best be seen on Plate V.

After all spans of the railway bridge had been raised and their grillage inserted, the raising of the road bridge was taken in hand.

The road bridge being of lighter construction than the railway bridge, a light type of lifting bracket was used. The lifting process and the sequence of operations, were exactly the same as that used for the railway spans. The lifting brackets and the temporary bracing fitted to the ends of the girders may be seen on Plate II. The ends of the road-bridge spans were strengthened by fitting additional cross frames between the girders.

The steel grillages on the tops of the piers were finally encased with concrete. The upstream nose of the concrete was rounded and protected by a steel plate, as protection against floating timber in future floods.

Work was begun in February 1936. By the end of May, forty-two spans of the railway bridge had been raised, the reinforced concrete abutment at Sarai Alamgir end of bridge cast, and road and railway approaches at this end completed. By the end of July, all spans of the railway bridge had been raised, both abutments and approaches completed, and work of raising road bridge spans commenced. When work was in full swing in May, a rate of progress of one span per day of the railway bridge was achieved and maintained.

The tools and plant used on the work consisted of 100-ton Duff jacks, hand operated; a steam driven air compressor, delivering 350 cubic feet of air per minute at a pressure of 100 lb. per square inch to operate the rivet buster guns, drilling machines, rivetting hammers, and paving breakers. The concrete retaining walls and buttresses were poured by two $\frac{1}{4}$ cubic yard mixers and the pier caps by one $\frac{1}{4}$ cubic yard portable mixer. A portable single operator electric arc welding set was also used.

The concrete was all 1 : 2 : 4 mix, using Portland cement, Haro River sand, and crushed limestone graded from three quarters to one eighth inch.

The Chief Engineer, N. W. Railway in consultation with the P.W.D. authorities, made a very full investigation to see if anything could be done to widen the road bridge and relieve congestion of traffic. Each scheme had to be abandoned after investigation because of the excessive cost, or because of the already overstressed condition of the road bridge girders.

As the spans of the road bridge were raised they were all moved three inches downstream in order to give more clearance to traffic on the railway bridge.

Total estimate amounted to Rs. 5,23,000.

This was divided up into the following main items :

Raising spans of railway bridge, including steel grillages, concrete abutments, concrete casing to grillages etc., Rs. 2,56,000.

Raising spans of road bridge, including steel grillages, concrete abutments, concrete casing to grillages, etc., Rs. 2,30,000.

Raising railway approaches Rs. 19,000.

Raising roadway approaches Rs. 18,000.

Permanent steel grillages under railway spans amounted to 300 tons, and new cast steel bearings amounted to 188 tons.

Permanent steel grillages under the road bridge spans amounted to 265 tons, and new cross frames 20 tons.

The raising of the approaches to the bridge was carried out by Sub-Divisional Officer, N.-W. Railway, Jhelum, working under Divisional Superintendent, N.-W. Railway, Rawalpindi.

The raising of the bridge spans and the rebuilding of the abutments and retaining walls was carried out by Executive Engineer, Bridges, N.-W. Railway, Jhelum, using Bridge Department labour.

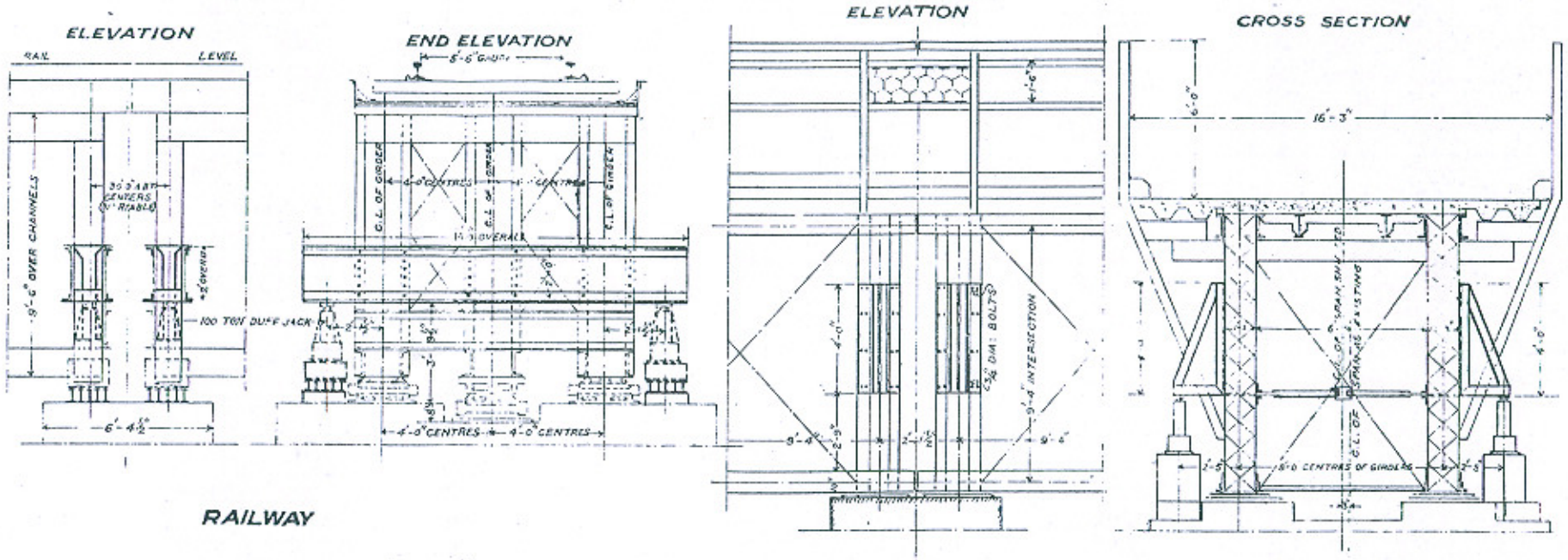
At the time of writing this paper, which is the end of August, 1936, work has been slowed down considerably. The delivery of steel grillages from bridge workshop at Jhelum for the road bridge spans is continuing at the rate of eight piers per month only, due to other urgent works on the railway for which steel work has to be manufactured. This, however, does not matter very much, because the rainy season is finished and no big flood can now be expected. The only work which remains is raising and placing grillages under thirty-eight spans of the road bridge, and this work goes on without traffic being aware of it. The encasing of grillages of both railway and road bridges with concrete also remains, and this will be started about the end of September, and proceed at the rate of fifteen to twenty piers per month.

It is hoped to complete the work entirely by the end of January, 1937.

PLATE I (Paper 199)

PLATE II
(Paper 199)

TEMPORARY GIRDERS AND BRACKETS FOR JACKING UP SPANS



PERMANENT STEEL GRILLAGES PLACED UNDER SPANS

PLATE III
(Paper 199)

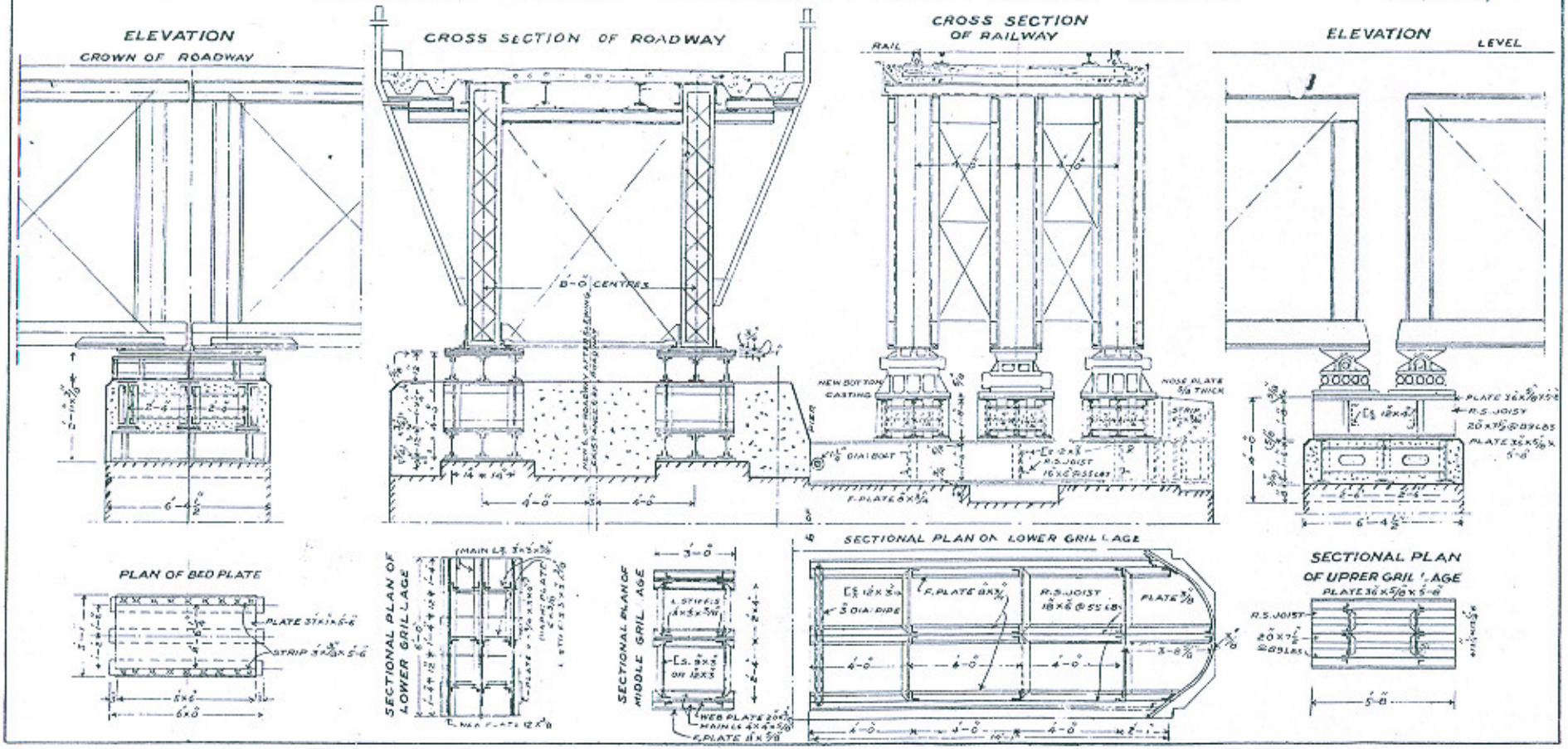
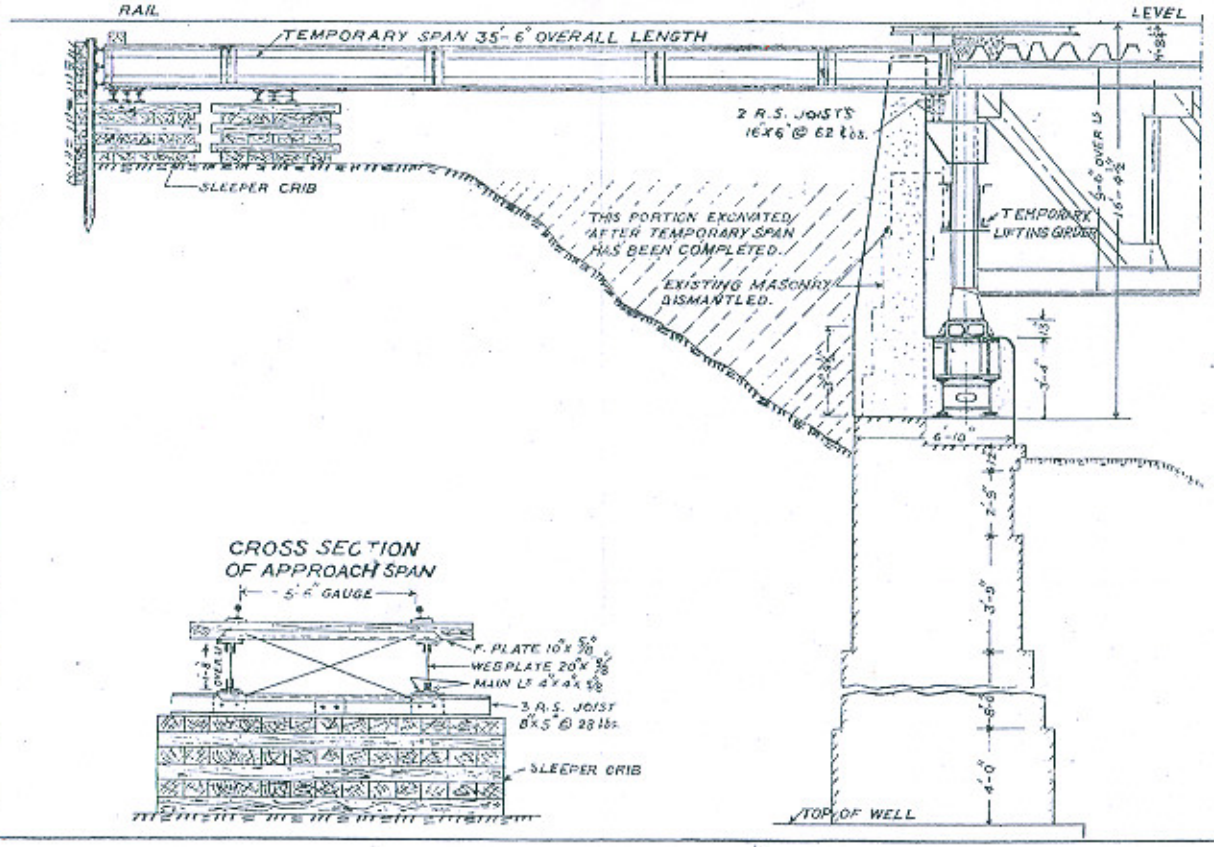


PLATE IV
(Paper 199)

NEW REINFORCED CONCRETE RETAINING WALL AT SARAI-ALAMGIR END OF BRIDGE AND TEMPORARY ARRANGEMENTS

SIDE ELEVATION



CROSS SECTION OF APPROACH SPAN

SECTIONAL ELEVATION OF RAILWAY BALLAST WALL SHOWING REINFORCEMENT

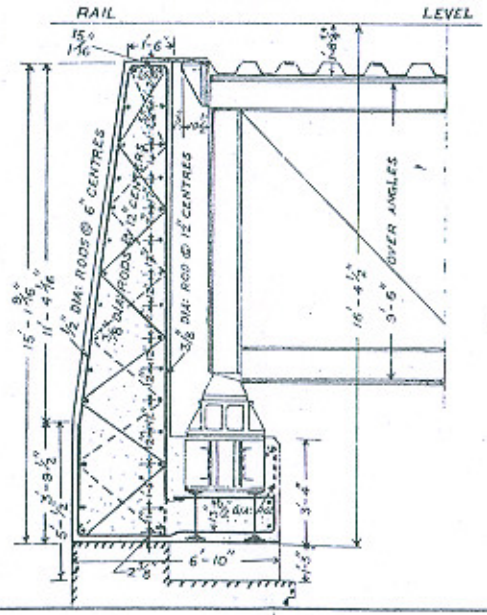
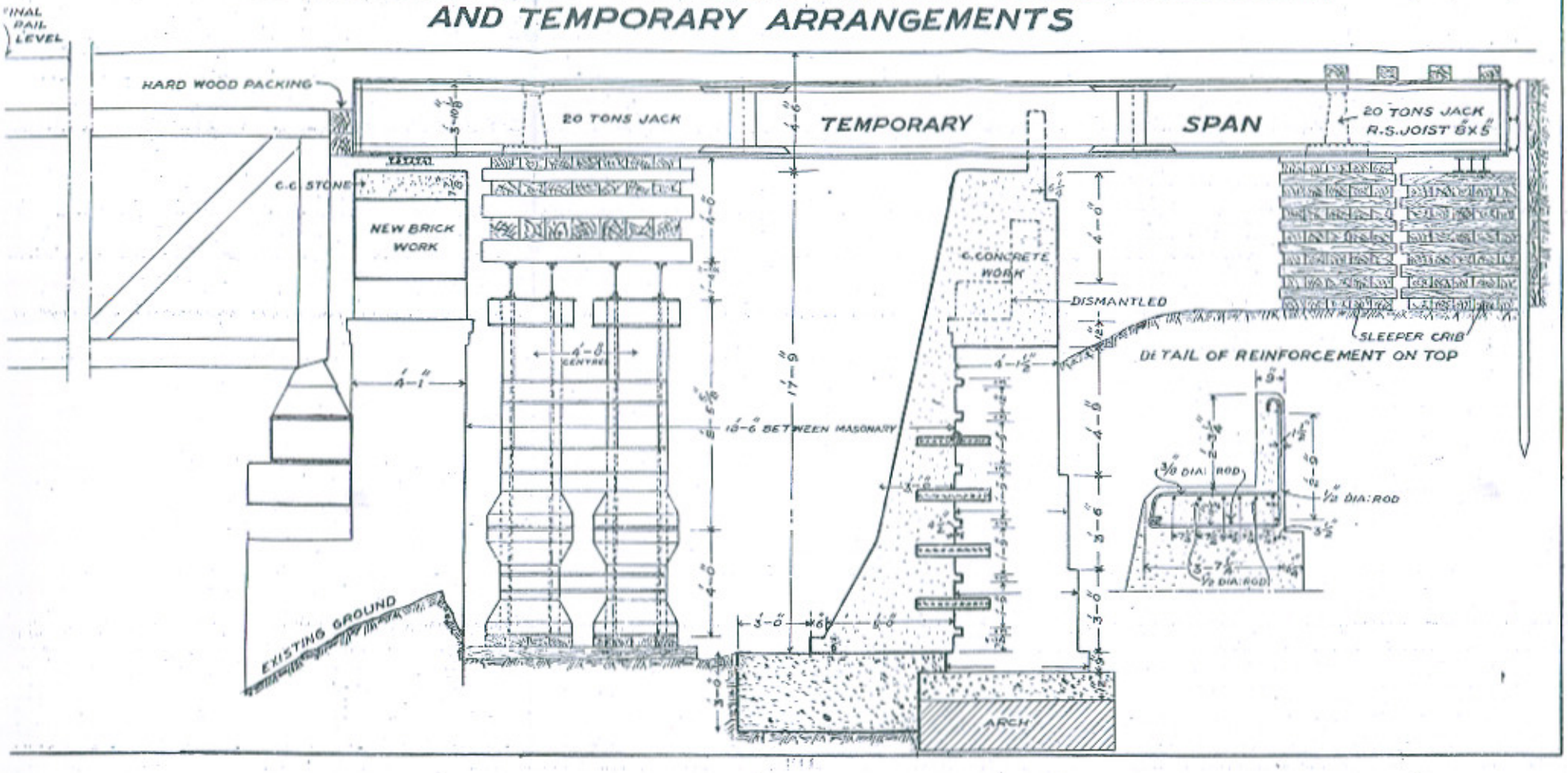


PLATE V
(Paper 199)

NEW MASONRY AND CONCRETE WORK AT JHELUM ABUTMENT AND TEMPORARY ARRANGEMENTS



DISCUSSION.

The **Author**, in introducing his Paper, said he had very little to add to what was in the published copy of his Paper and that he had compressed the Paper purposely, because he thought that Members of the Congress who were accustomed to dealing with this type of work, would not be interested in details, and he assumed that the other Members of the Congress who were only interested in the general scheme and general description of the work would find a mass of details uninteresting. He, therefore, described in his Paper the scheme used for raising the bridge, and what he thought to be points of interest to all Members of the Congress.

He was glad to say that since his Paper was written, the raising of both the Railway Bridge and the Roadway Bridge had been successfully completed. There still remained the remodelling of the handrailing on the downstream side of the roadbridge, and the replacing of the existing wooden wheel-guards on the roadway with concrete and steel wheelguards.

This work has been deferred for several reasons, the main reasons being :—the concrete mixer and electric welding plant working on the road bridge had caused some slight obstruction to traffic, and he did not wish to cause any further obstruction until these machines were finally taken off the bridge ; the posts carrying telegraph and telephone wires had to be moved when the handrailing was remodelled, and for several months his Department had been forbidden to interfere with them, because of danger of interrupting communication with the Frontier.

The handrailing and wheel guards would be started about the middle of March and would take two months to complete.

Mr. **R. R. Handa** asked the Author to describe how the spans of the road bridge were moved 3" downstream laterally.

Referring to the opening sentence of para. 3, page 43, he asked the Author how the raising of the approaches was done, considering that the traffic was uninterrupted and suitable gradients had to be allowed for the trains, at all times.

He also enquired of the Author whether any cracks appeared in the R. C. Slabs of the road bridge, after they were shifted from the old position.

The author, in replying to the points raised by Mr. R. R. Handa, said that the spans of the road bridge were moved three inches downstream by jacking up the girders clear of the piers, and placing rollers under the bearings. Jacks were then applied horizontally at the bearings, and the spans were pushed downstream three inches.

The sequence of operations was similar to that used in raising the spans, as shown on Plate I of the Paper. The horizontal jacking operation was performed on a length of spans at a time, that is a length of 200 feet. A horizontal movement of 3 inches at the end of a 200 foot length of roadway, meant that a crack would occur in the road surface, and be $\frac{1}{4}$ inch wide at its worst point. The road material was ballast with a tarred surface and in actual practice it was found that several cracks developed across the width of the road; the $\frac{1}{4}$ inch rupture being distributed amongst them, the effect was negligible.

2. As to the raising of the railway approaches, the Author said that before the first ten-inch lift was performed, the ballast was raked out from the track, and extra earth was brought by material train and stacked on either side of the track. When the lift was being performed, a large gang of permanent-way men raised the track on the approach and packed earth under it. The same operation took place when subsequent lifts of ten inches were performed at the end span.

The raising of the roadway approaches was done in a slightly different way. At either end of the bridge, the approach was raised to its full height, remetalled, rolled and consolidated, up to within about a hundred feet of the end span. During this process road traffic had to divert to the berm on one side or other of the roadway, according to where the earth was being dumped.

At the abutments of the bridge, temporary approach spans had been inserted to facilitate the rebuilding of the retaining walls.

During the process of raising the end span of the road bridge, the end of the temporary span adjoining it was raised also ; the other end of the approach span remaining stationary. This produced a switchback contour in the road at the abutments, but this did not last for more than a day or two ; the road work at the abutment was pushed through with great speed, and although the wheeled traffic may have experienced some irregularity in the road surface it was never seriously inconvenienced and never held up.

When the temporary approach spans were finally taken out, the approach at the abutment was consolidated, metalled and rolled as quickly as possible. The Author thought that traffic was only interrupted for a period of three hours. This was absolutely necessary, because the road narrows to a bottle neck where it passes through the guard gates and a short interruption to traffic was essential in order to place the road metal and roll it. Care was taken to perform this operation during that period of the day when traffic was a minimum.