Rehablitation of Mahatma Gandhi Setu in Patna

Contractor Name:- FPCC Ind. Ltd

1. Introduction

The Mahatma Gandhi Bridge was constructed about 25 years ago over the Ganges River in order to connect patna to the other side of river. Once completed it was supposed to be the part of N.H 19 and comes directly under Central Government of India. It is one of the longest bridge in india.

The bridge has 46 spans each with length 120m. Each span has two cantilever beams on both sides which are free to move at the ends. It has two lanes one upstream and the other downstream each with a width of around 6m. Both the lanes are also free from each other and are not connected anywhere. It was constructed by using 3 meter pre-casted parts being joined at both ends to complete the span. The Spans are connected by using a Protrusion which is free to move longitudinally also along the river flow. In upwards and downwards direction it is such that it allows vibration to transfer smoothly to the next span while vehicular movement without much discreteness. It is shown in fig.

Due to heavy traffic movement and being the only bridge to cross ganges river the bridge is used heavily now. Hence it has started vibrating with a higher amplitude than it was designed to. Also in many spans the cantilever beams were found to have sagged at ends.

2. Rehabilitation

Keeping the structural health prospective in mind it was decided for immediate rehabilitation of the bridge to provide extra strength to the spans so that it bear the existing vehicular load according to the IRC.

2.1. For Rehabilitation the following steps were proposed:-

- External Pre-stressing of the bridge using 9 steel cables in a bunch. It was decided to pre-stress from 6 places starting from the end towards the center portion as shown in fig. It has to be done on both ends along the width rather than in centre making it at 12 places in each cantilever. In each cable a load of 16 tons, or 450Kg/cm3 jack pressure, individually has to be given. All these cables are to be enclosed within pipes and then filled with cement mortar to make it permenant. The anchor are to be made permanent by enclosing it with a cement cube. These cables will further lift the cantilever beams and support the structure.

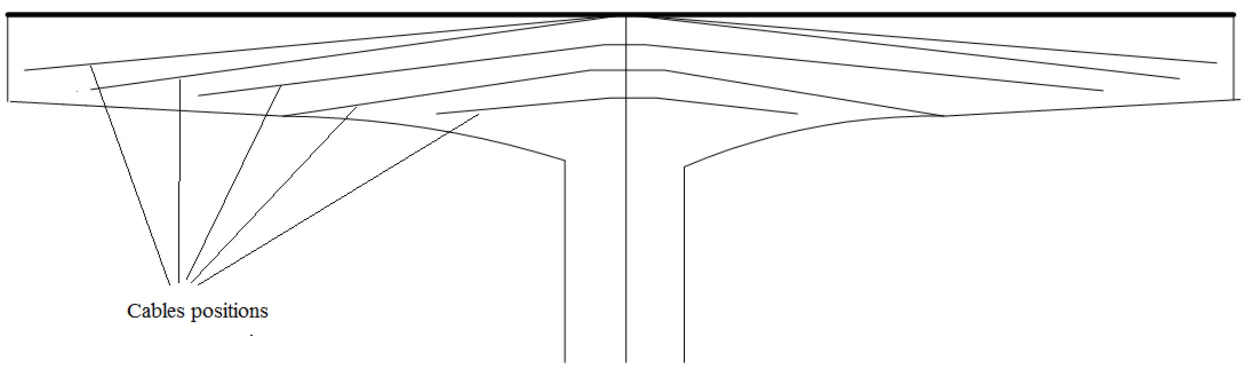


Fig 1. The cables positioning along the span of bridge.

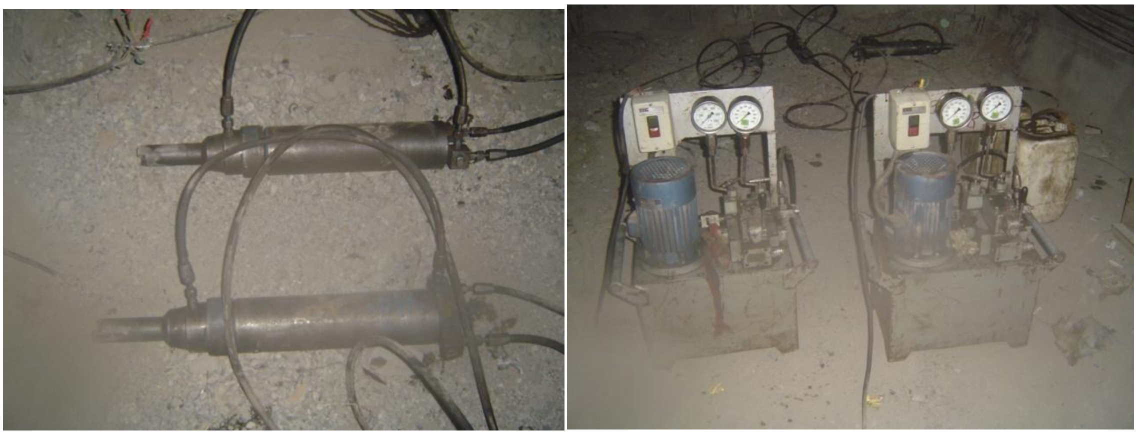
- Grouting of cracks wherever they are visible. It has to be done by putting nozzles at 400mm distance.
- Stitching of spans by using steels jackets in some spans whose condition is not good.

2.2. The Rehabilitation Process

The external pre-stressing is done using steel cables anchored at both ends of the span. 9 of these cables are bunched together at one place and anchored using steel structures bolted to the bridge by means of permenant anchors as shown in Picture Set 1.

Picture set 1. The steel structures and anchors at the site.

These are situated at 6 places through the cantilever beam so that the bridge can be lifted at all places uniformly. Each of these cables is then stressed from both the ends by using clamping jack and hydraulic pump system shown in Picture set 2.



Picture set 2. The cable holding jack and the hydraulic pump system powered by electricity.

This stressing is done to on both sides of the cable and simultaneously to cables at both ends of the width. Hence at a time 2 cables are stressed. This is done to make the load distribution symmetric on the span which is important to avoid any kind of load developed locally in the span. All stressing is done in a very systematic manner.

Each of these cables is given a load of 450Kg/cm3 in steps of 50Kg/cm3.

After stressing all the cables in all the six places over the cantilever the whole system of buched cables is packed with cement mortar and made permanent. After stressing the span looks like in Picture Set 3.

Picture set 3. The span after final external Pre-Stressing by cable bunches.

3. Instrumentation

For Measuring the effectiveness of external Prestressing following testing was also carried out in the bridge spans.

3.1. Strain measurements:-

Strain Gauges were installed at 24 places as follows. As each cantilever span is pre-stressed the strain in the span is relived and to correctly measure all the strain change in the top, bottom, and the two side slabs strain gauges were installed at these parts. There were total six cross-sections were identified, 3 in each arm of the span. At each cross-section one was installed at the bottom of the top slab, one at the top of soffit slab and the other two on the two walls on either side. The gauge placement plan is shown in Fig 2.

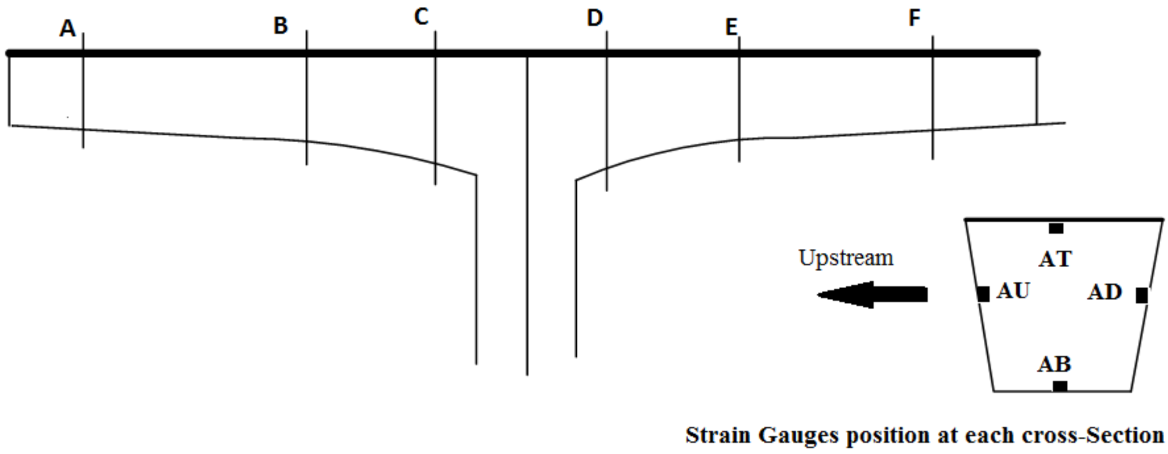
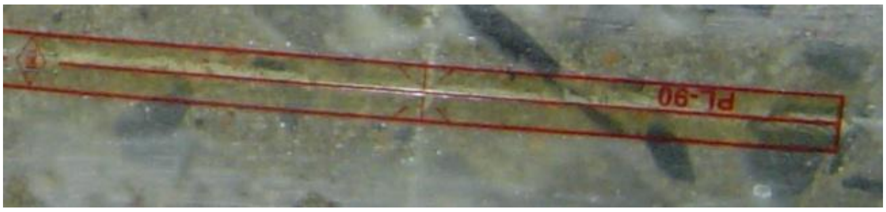


Figure 2. The Strain Gauge placement plan.

The gauges were named according to there positions. Each cross-section was named from A to F starting from patna side. At each cross-section the one at the top is suffixed by a T, the one at the bottom by B, the one in the upstream direction side wall by U and the one in the downstream direction side-wall by D. Hence AT will be the gauge at top and in A cross-section, BB will be gauge at bottom in B cross-section and likewise.

3.1.1. Different elements used for Strain measurement

- The strain gauges used are PL-90-11 TML make.



Picture 4. The PL-90-11 TML made Strain-Gauge.

- The adhesive which is used for sticking it to the concrete surface is CN-E type adhesive of TML make.
- The wires used for strain measurement are three wire cored type.
- The switcher unit is a HBM Germany make which can be used for 10 half-bridge strain gauges and 4 full bridge gauges. Hence for 24 strain gauge measurements we need 3 of these switcher units as we are using it in a half-bridge configuration.(Picture 5)

Picture 5. The HBM Germany made Selector Unit used for selecting the strain gauge.

- The read-out instrument is P3 Strain Indicator and recorder, of Vishay Micro-Measurements make, which has 4 channel inputs. So we can connect four of switcher units to it. It can be set for any bridge configuration. It gives readings directly in micro-strains.(Picture 6)

Picture 6. The Vishay P3 strain indicator used to indicate the strain gauge readings

- A dummy gauge has to be made using a concrete block, made of the same concrete as of the testing surface, and a strain gauge installed over it. This is required for completing the Wheatstone bridge circuit and also to compensate the effect of self heating of the strain gauge on readings.(Picture 7)

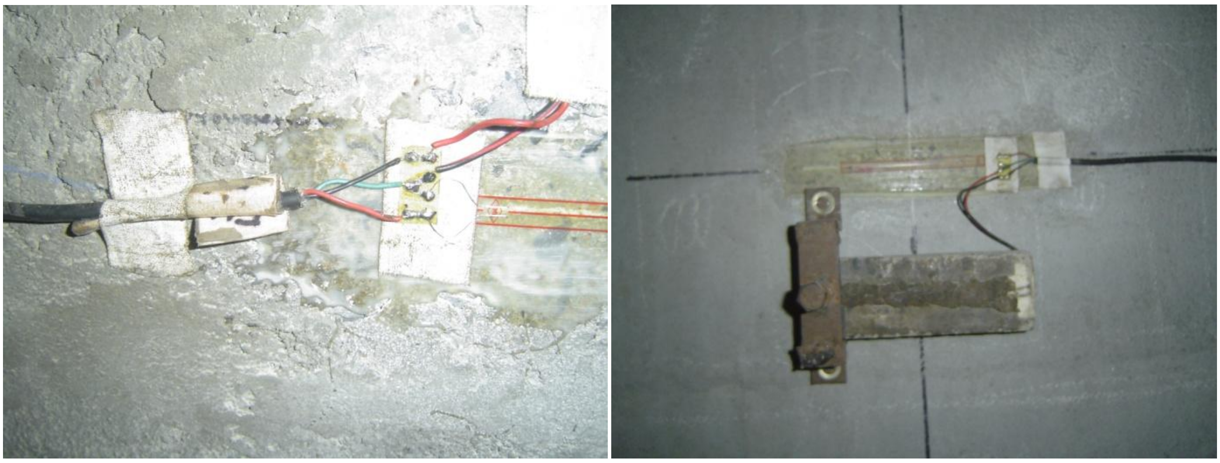
Picture 7. The Dummy Gauge prepared on a different concrete block whose strain is independent of concrete.

- General accessories like acetone, soldering unit, wires, fewikwik, tape, clamps, screw drivers etc are required while installing the strain gauges.

3.1.2. Procedure for Strain-Gauge installation:-

1. The surface is first marked properly as to where exactly the strain gauge is to be placed.
2. This surface is then grinded well to remove all the loose concrete and dust so that the gauge can be fixed on a hard concrete surface.
3. It is then cleaned thoroughly and then the marking is done again which got erased due to grinding using the end lines.
4. In order to make the surface very smooth and fill small unevenness it is applied with Araldite and levelled.
5. After the araldite surface is hardened it is rubbed with sand paper to make it further plain. It is then again cleaned with acetone to remove the sand paper remnants.
6. The Strain-Gauge Adhesive i.e. CN-E is applied over the gauge and it is then glued slowly and carefully so that no kinks are formed it is then applied pressure slowly by keeping a paper, supplied with the gauge, until it is smoothly bonded to the surface.

7. The connections are made using the dummy gauge and the core wire. Dummy gauge block is clamped to the surface near to the strain-gauge. Dummy gauge is required to complete the Half-Wheatstone bridge and compensate for the deviation caused by self heating of the gauge. It can be seen in Picture Set 8



Picture Set 8. The dummy gauge connections and final placement.

8. The other end of the wire is then soldered to the connecting port of the switching unit. Switching unit is basically used to switch between different gauges. In one switching unit 4 full bridges can be connected and switched between and upto 10 half bridges can be connected and switched between. By using this switching unit only one read out instrument is reqired to get the readings. Otherwise it will be too demanding and tedious.
9. The readout instrument has 4 channel inputs and hence 4 switching units can be connected directly. In this case we have only 3 inputs so we will use 3 channel input. It gives readings directly in micro-strains.

Picture 9. The whole setup including 3 Switcher Units and strain indicator used for strain measurements.

10. When all the instruments are in place readings can be taken. The readings are taken before and after external stressing of cables. It should indicate that what relive of strains we are achieving.

3.2. Deflection measurements:-

When the span is externally prestressed by cables it causes the tip of the cantilever arms to move up with respect to the middle of the centre of span. The cables pull the arms upward due to the stressing done. To confirm this it is necessary to note down the initial deflection and the final deflection after prestressing by cables. This is done by putting water tubes at both ends of the span. Three pipes are used two at the ends along the width of arm and one at the middle. The initial and the final readings are taken on a scale with a least count of 1mm on both sides of all 3 pipes. The difference between one side reading and the other side reading gives the deflection and comparing the deflections before and after stressing we can get the effective change caused by Pre-Stressing.

3.3. Temperature measurements

Temperature variations through out the day are quite significant. As they cause the stress to increase or relive and also the deflection in the cantilever arms to vary. It is important to consider the effect of temperature. For this purpose PT type sensors are installed at the surface inside and outside the bridge. The ambient temperature thermometer is also installed outside and inside the bridge span. A temperature cycle is performed and all the readings i.e. the strains, the deflections and temperature is noted down one day before the day stressing is planned to be done. These readings become the basis for the correction required due to temperature variations. The readings of before stressing and after stressing are compared according to the time and temperature at which they are taken. This further refines the readings to find efficacy of Pre-Stressing.