**Zeitschrift:** IABSE reports = Rapports AIPC = IVBH Berichte
**Band:** 80 (1999)

**Artikel:** Construction and maintenance problems of Kallabhomara bridge across river Brahamputra near Tezpur on NH-37a
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**DOI:** https://doi.org/10.5169/seals-60788

# CONSTRUCTION AND MAINTENANCE PROBLEMS OF KALIABHOMARA BRIDGE ACROSS RIVER BRAHAMPUTRA NEAR TEZPUR ON NH-37A

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## SUMMARY

The Kaliabhomara Road Bridge across Brahmaputra near Tezpur, Assam (India) has 24 main spans 120.00m and two shore spans 67.50m each. The span arrangement consists of Pre stressed Concrete balanced cantilever arms of 52.50m long on either side of piers with a central Reinforced Cement Concrete suspended span of 15.00m.

During the construction of the bridge certain problems were faced and the remedial measures taken were as under: -

1) Compulsion of plugging of one well much above the design founding level solved by providing 5 No. bored 1.50 m R.C.C. piles under the well cap and a wire crated boulder garland 60 m dia, 3m thick to check scour.
2) Encountering part rock and part soil at open foundation level of other pier solved by providing anchor rods in the rocky portion and anchoring the portion on the soil by providing piles.

The problems faced during maintenance and remedial measures taken are as under: -

1) Shift of main channel at the location of well which was plugged much above the designed founding level, washing away the wire crated boulders garland provided at the time of original construction, tackled by replenishing the same upto RL 45.00m as per maintenance manual guidelines.
2) Tilt of another well due to a series of earthquake causing damage to the slab seals of the elastomeric slab seal type of expansion joints, being replaced as and when required as a temporary measure. The permanent measure being replacing the expansion joints by strip seal/modular type of expansion joints now available.

## BRIEF PARTICULARS OF THE BRIDGE

The Kaliabhomara Bridge near Tezpur has 24 main spans 120.00m and two shore spans 67.50m each. It was completed in the year 1987. The span arrangement consists of balanced cantilever arms of 52.50m long on either side of piers with a central suspended span of 15.00m long. The total length of the bridge is 3015m. The cantilever arms are of Prestressed Concrete Box girders over the pier and the suspended span consists of two R.C.C.girders jointed by three cross diaphragms and the deck slab. One abutment of the bridge is located on the Bhomorgauri hill on right bank (North side) and the other abutment is located near the village Burbandha Chapori on the left bank (south side). A guide bund is provided on the south bank. A schematic view of the bridge is shown in Figure 1. The bridge is located in seismic zone V of the country is seen to be subjected to shaking often due to small earthquakes.

During the construction of the bridge certain problems were encountered for the foundation work. Also after completion of the bridge some problems of maintenance were faced mainly due to subsequent floods and a series of earthquakes which took place in the year 1988,1990. Particulars of problems and the remedial measures are detailed below:

## PROBLEM NO.1

Sinking of well under Pier P2 was the first activity with which the work of Kaliabhomara Bridge commenced. It also so happened that it was the last foundation to be completed. As per preliminary sub-soil investigation report the strata for founding this well appeared to have dense sand. However after sinking for 25m deep upto RL 35.60m against the design founding level of RL 5.00m, the work slowed down as it encountered bouldery strata. For two seasons the work of removal of boulders continued and after removing 100 boulders the well reached a level of RL 32.08m. At this point the stability of the well was checked for scour considerations and it was established by the calculations that if the scour could be controlled at RL 45.00m the well will be safe. Secondly though the calculations proved that the well would be safe under normal conditions, under seismic effect there was tendency to develop tension.

## REMEDIAL MEASURES

To arrest scour at RL 45.00m it was decided to provide a boulder apron around the pier. This was feasible since the well was near the bank. The well was protected by providing 60.00m dia, 3.00m thick crated boulder garland packed under dry conditions prevailing at the time of construction of the bridge at the location of well under pier P2 (Figure 3). The top level of this garland was kept as RL 64.12 and it was decided that the performance of this garland should be closely monitored so that under no circumstances the scour be allowed to reach below the RL 45.00, the calculated maximum scour level for which the well was found to be safe. Regular probing is being done now to see if the level has gone below RL 45.00 in which case crated boulders are dumped to make up the level difference.

To solve the second difficulty of development of tension under seismic conditions, it was decided to provide 4 No.R.C.C.bored piles of 1.50m dia on the outer periphery outside the well and 1 No. similar pile in the middle though the dredge hole (Figure 2). Apart from this a combined well-pile cap, square in size was provided so as to act as a

composite unit. This was based on the analogy of stays for a tower. The piles however had to be terminated at different levels due to the rock sloping steeply towards the riverside. The central pile has been taken to RL 24.00m and other piles to levels varying from RL 29.00 TO RL 32.00m. Thus the piles take care of the tensile (uplift) forces under seismic condition and ensure stability of the foundation as a whole. The above solution was preferred since the other alternative of anchoring well by inserting anchor rods through well steining or driving piles through the bottom plug was not considered satisfactory due to bouldery strata.

## PROBLEM NO.2

The bridge work was taken up in December 1981 and completed in all respects by March 1987. When the bridge was under construction the river bed near pier P2 was dry. Later on during the floods of year 1991, the river started attacking the north bank and active channel developed near P2. The wire crated boulder garland was washed away and scour around this well extended up to RL 37.47.

## REMEDIAL MEASURES

Protection measures and replenishment of washed away boulders were carried out by dumping wire crated boulders and the top level of the garland was brought back to RL 45.00. A close monitoring of the top level of the garland up to RL 45.00 is being maintained by taking levels at regular intervals. This level has appeared to stabilize at RL 45.00.

## PROBLEM NO.3

During the year 1988 in the month of April and August a series of earthquakes in the region took place. A routine inspection of the bridge was carried out after the first earthquake on April 16-17/ 1988 when it was noticed that pier P3 showed a tendency of tilting towards south. Further routine inspections were continued and the following inferences were drawn: -

1) During the period from April 1988 to September 1988 deck at the location of pier P3 towards south has increased from 55mm to 83mm i.e. 28mm.

2) The expansion gap in P3-P4 span on u/s side was more than that on the d/s side at the fixed end, indicating that the Pier P3 has a tendency to tilt towards south west direction.
3) The elastomer pad slab seal type expansion joints for the suspended spans for P2-P3 and P3-P4 were under sustained shear stress and there had been same related movement between top and bottom plates of the knuckle-cum-elastomeric/knuckle-cum-sliding type of bearings with seismic arresters.

4) The railings on the u/s side at fixed end had touched each other, which also indicated tendency for tilt.

## POSSIBLE CAUSES OF TILT OF PIER P3

1) Although the movement of P3 was first noticed in April 1988, it is to be stated that the slow movement occurring much before that date can not be ruled out. The effect of movement was noticeable by the visible distress in expansion joint pads &

reduction or increase of expansion gaps. The expansion joint pads were placed in March 1987 and the damage was noticed in April 1988 just about a year after placing the pads. Therefore if any movement which could have occurred prior to placing of pads this cannot be determined as there are no records of visible movement.

2) From the bore log for foundation of pier P3 it could be noted that the well was not seated on rock. The well is resting on 2-3m thick layer of pebbles/cobbles mixed with sand and therefore movement due to unevenness of bearing capacity could be possible.
3) It was possible that the repeated shaking due to the earthquakes could have triggered of the movement.
4) In Jan 1990 another earthquake took place when the number of shocks were seven. However this didn't cause any further movement. This showed that pier P3 appeared to have stabilized because of large passive resistance built up due to earlier movement in foundation.

## REMEDIAL MEASURES

1) The slab seals of the expansion joints are being replaced.

2) The pier P3 is kept under constant observation and as already mentioned in (d) in prepara no further tilt is noticed.

3) A garland of wire crated apron for a thickness of 2.50m has been provided with the top at RL 44.50m and for a diameter of 66m.

## SECONDARY EFFECT DUE TO THE PROBLEM NO.3

The clear gaps provided between faces of cantilever end and suspended spans are 40mm and 110mm at fixed end and free ends respectively. On the advice of Prof. Leonhardt elastomeric slab seal type of expansion joints were provided. However the expansion joints provided at free end are capable of catering for a movement of +/-62.50mm. The technological development at that time in this respect suggested that wider expansion joints would have been far more costlier and it was thought the utility of these joints would have been called into play only in most sever combination of movements. However these extreme combinations of movements have probably come into play because of the severity of earthquakes and it is observed that the seals of expansion joints are getting damaged frequently.

## REMEDIAL MEASURES

There is no other quick alternative to the above problem than that replacing the damaged slab seals at regular intervals. The only other solution is the replacement of the expansion joints for the entire bridge by providing the latest single strip/modular type of expansion joints at fixed/free ends, which however can probably wait for the time being.

## PROBLEM NO.4

During initial sub-soil investigations conducted in 1980 it was observed that the founding strata for pier well P1 would be on a dipping surface of rock. To overcome this the bridge was shifted by about 60m towards northwards. However when detailed boring was conducted at the shifted location of P1, it indicated the presence of a combination of hard

strata in northern half at a higher location and soft strata in southern half. On practical considerations, it was clear that it was not possible to provide a well foundation for shallow depth due to risk of tilting. Thus there was a design problem.

## REMEDIAL MEASURES

A separate design for pier P1 was carried out by providing a raft foundation for supporting the pier. The raft was designed in the following way: -

1) On the south side where the strata was soft, the raft was supported on 6 No. of bored piles of 1.50m dia.
2) On the north side where hard strata was found, the raft was anchored into the rock by means of 98 Nos.36 mm dia HYSD rock anchors.

Further in the design it was assumed that the piles would not share any longitudinal force. However the rock anchors would share part of the longitudinal force. They were designed for 9 t of uplift force. Balance force was proposed to be taken care of by providing shear keys underneath the raft in the form of beams embedded in the strata below. For this purpose large size R.C.C. shear keys were provided in both directions under the pile cap (raft) by cutting trenches below soil in a grid pattern and casting beams which formed an integral part of the raft.

## REFERENCE

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2. Manual for maintenance of Kalibhomara bridge over river Brahmaputra, Calcutta, 1987, by Stup Consultants (India) Ltd
3. Earthquake engineering studies, eq: 90-06, investigation of probable cause of tilt of pier no.3 of Tezpur bridge, by Department of Earthquake Engineering, University of Roorkee, Roorkee-247667, India

SKETCH SHOWING FOUNDATION LEVEL SCOUR LEVELS AND TENTATIVE PROTECTIVE MEASURES TO PIER WELLS P-2 AND P-3 OF KALIA BHOMORA BRIDGE ON NH-37-A

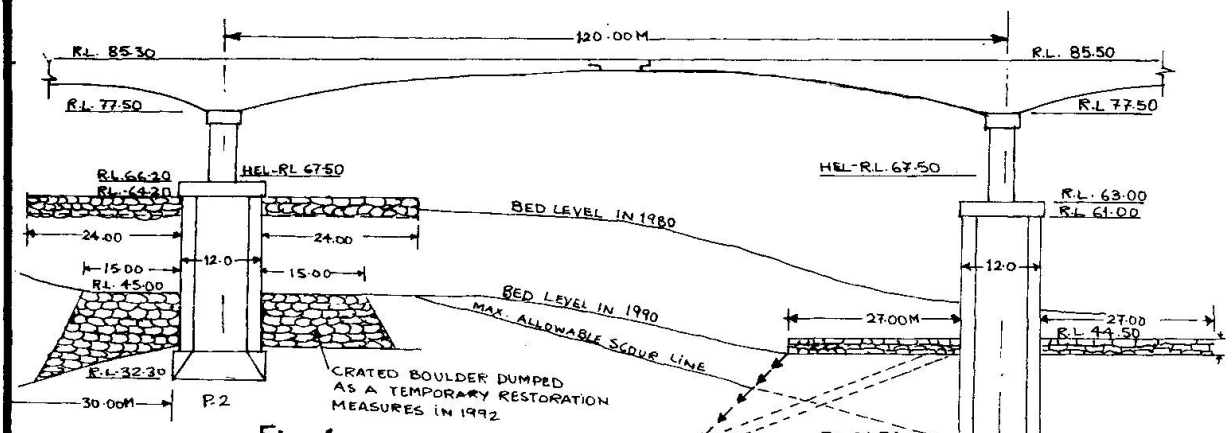
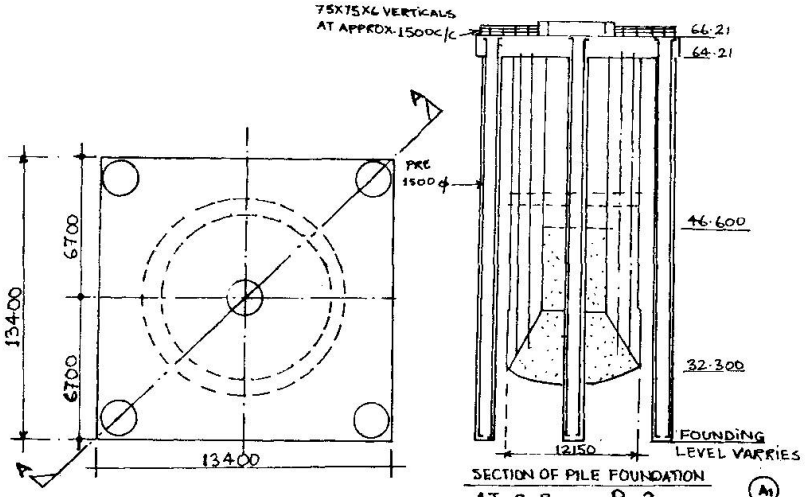



Fig. 1




SECTION OF PILE FOUNDATION AT B-B P-2

Fig. 2

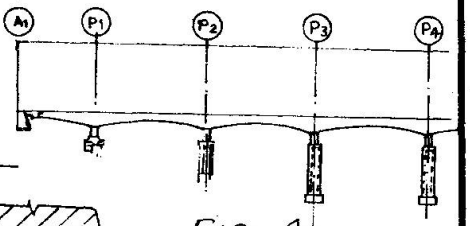
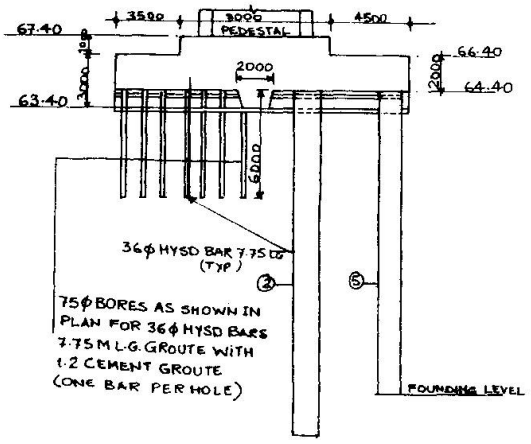
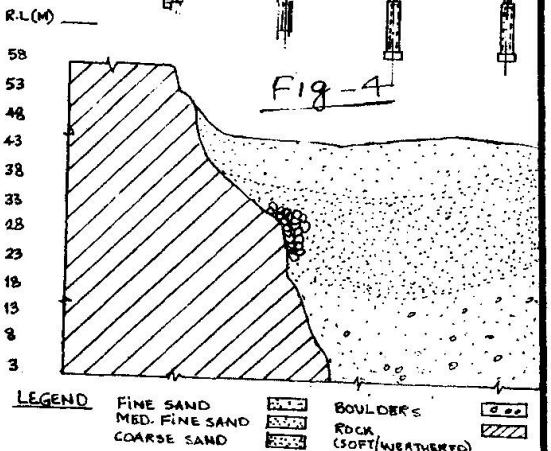



Fig-4




SECTIONAL ELEVATION AT A-A P-1

Fig. 3




GENERAL ARRANGEMENT DRAWING