BRIDGE FOUNDATION ON ROCK

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ABSTRACT

Bridges are constructed in different terrain of the country. Availability of quality rocks at foundation location in particular and in over all cross section of river is advantageous due to various reasons including engineering point of view. Rocks are classified as igneous, sedimentary and metamorphic and important quality of rock is texture, structure and mineralogical composition, for identifying particular type of rocks. Quality of rock need to be examined from engineering point of view including affects of weathering with the passages of time, specially scour. The availability of various X-section and codal provision visa-a-vise pragmatic provision presently in use of laying bridge foundation on rocks has been discussed in this paper.

Key Words: soft rock, hard rock, foundation level, scour, well sinking, geological survey, bearing capacity, crushing strength

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1.0 CROSS SECTION IN ROCKY BED

Various cross section of river available in rocky bed are as under:-

(a) Both banks are in good quality hard rock

(b) One bank is having hard rock and other bank is SMB.

(c) Partly rock and partly SMB.

Criteria for finally approval of foundation level vary from site to site. For taking any decision for bridge foundation after excavation soil strata anticipated as per bore log details to be examined and be compared with the actual soil strata. Decision can be taken based on the quality of rock encountered and accordingly the foundation level can be reviewed wherever required keeping in view the codal provision and practical aspect of construction

2.0 EXPLORATION REQUIREMENT FOR FOUNDATION RESTING ON ROCK

Investigation and interpretation of data for rock is a specialized job. Wherever required the geologist be associated for giving detailed report on Engineering properties of soil. Basic information required from exploration are as under:-

(a) Depth of rocks strata and its variation over site.

(b) Whether the proposed location of the abutment/foundation pier is on rock or isolated boulders.

(c) Extent and character of weathered rock.

(d) The structure of rocks including bedding plans, faults, tissues.

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Fig 1 – Structure of rock face in Pier foundation of Bardal Bridge

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(e) Properties of rock material, strength geological features.

(f) Erodibility of the rock to the extent possible subsequently to affect of water current and weathering.

Fig 2 - Old Piers of bridge constructed in 1949 over Soft Sandstone Rock

(g) Colour of rock

(h) Likely position of rock in case of open foundation on U/S, D/S and on river side. For checking this it is imperative that one bore hole on center of the proposed abutment and on likely position of corner to be taken wherever doubt arises to ascertain the position of rock.

The exploratory bore hole may be drilled into the rock to a depth of about 3 mtrs to distinguish a boulder from a continuous rock formation. A minimum 3 mtr depth in a sound rock is recommended by code. Laboratory test may be done for a specific gravity, porosity, moisture content and shear strength.

3.0 DEPTH OF FOUNDATION

The foundation shall be designed to with stand the worst combination of loads evaluated in accordance with provision of IRC: 78. The foundation shall be taken to a depth they should be safe against scour point of view and be protected accordingly. Apart from this, the depth should be sufficient from consideration of bearing capacity settlement, stability and suitability of soil strata at founding level and sufficient depth below it. The depth of embedment and seating should be decided depending upon the method of construction, the quality and profile of rock and the need for square seating

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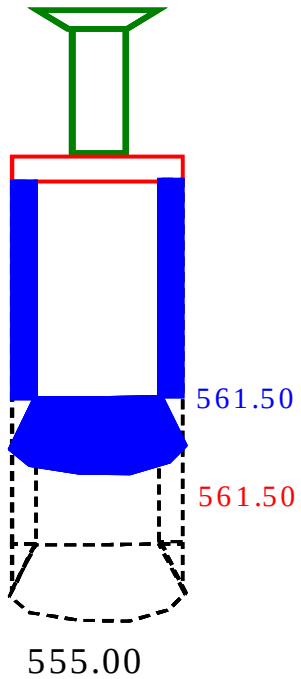
Fig 3 – Creating sump for embedment of well in soft rock of Bhini Bridge



Original founding level = RL 555.000 & Revised founding level – RL 561.500

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Fig 4 – Drawing showing the revision in founding levels of of Bhini Bridge

4.1 OPEN FOUNDATION

For open foundation resting on rock, the depth of rock which in the opinion of geologist weathered fissure shall be excluded in deciding the depth of embedment into the rock existing below. When foundation are to rest on readable rock, caution shall be exercised to establish the foundation level at sufficient depth so as to ensure that they do not get undermined keeping in view the combined erosion of the bed. After allowing for condition stipulated above the minimum embedment of the foundation in to the rock shall be as follows which in case of sloping rock profile can be provided by properly benching the foundation.

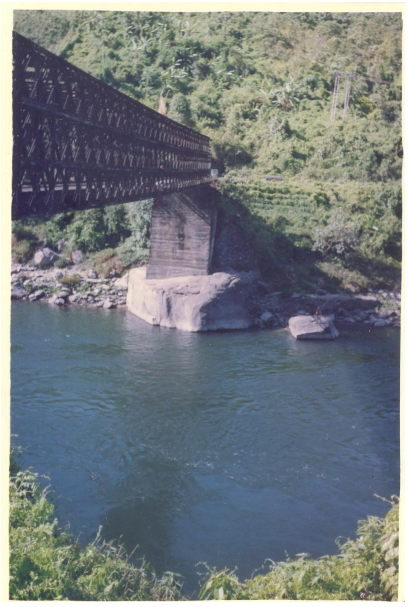

Fig 5 –Open foundation of Bridges on Rock Strata

4.2 WELL FOUNDATION

As for as possible, well shall be taken by all the method of sinking including pneumatic sinking (where considered necessary based on the soil condition underneath) foundation level shall be evenly seated all around the periphery of sound rocks i.e. devoid of fissures cavities weathered zone, likely extent of erosion by providing adequate embedment. The extent of seating be decided based on the soil strata actually encountered and based on the long term safety requirement of the structures. In well foundation also the key effect is given at certain location for better anchoring and addition of safety for stability of foundation.

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Fig 6 –Well foundation of Bhini Bridge Pier in soft rock

5.0 CASE STUDIES

Various bridges have been constructed in different terrain of the country on open foundation and well foundation. In most of the cases judicious judgment based on the site condition becomes imperative with due consideration of codal provisions. Based on the typical site conditions countered the case study of Dimwe bridge has been discussed.

5.1 Dimwe bridge is located on NH 52 and span arrangement of this bridge is two spans of length 65.50 and 22.80 m respectively. Central pier is on well foundation in the main channel of the river and both the abutments are on open foundation. Construction of the channel of the river and both the abutments are on open foundation. Construction of the bridge took more than 8 years which include delay due to logistic reasons and channel problems; working period was also very less and to high rainfall and unprecedented flood. Bridge is located in remote area of Arunachal Pradesh. Salient features are as under: -

(i.) Total length of bridge	:	87.30m (65.50 + 22.50)
(ii.) Velocity	:	5 m / sec
(iii.) Design HFL	:	RL 238.000 m
(iv.) Vertical clearance	:	8.5 m
(v.) Maximum Scour level	:	RL 222.000 m

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(vi.) River Bed Level : RL 232.000 m
(vii.) Foundation Level : RL 207.000 m
(viii.) Silt Factor : 1.4
(ix.) Design Parameters
(a.) Coefficient of lateral friction : 30°
(b.) Angle of wall friction : 20°
(c.) Bulk density of soil : 1.8 t/ cum
(d.) Submerged weight of soil : 0.8 t/ cum
(e.) Buoyancy : 100%

5.2 CONSTRUCTION OF WELL FOUNDATION

(a.) Well foundation work was started with consistent efforts as per notice inviting tender5 scheme. The foundation level was at RL 207.000 m but on reaching RL 222.000 m further sinking got slow due to presence of tough strata. On facing the difficulty for further sinking, data was examined in reference to geology of the area for continuity of the rock if any, this was referred to Geological survey of India. Position of well on date was as under: -

(i.) Cutting edge placed RL : 232.000 m
(ii.) Sump below cutting edge on date : 1.50 m
(iii.) Top RL of steining : RL 237.425 m
(iv.) Tilt along alignment : 1: 300
(v.) Tilt along transverse : 1: 200

(b.) Sinking of well from RL 237.450 to RL 224.000 m was through loose boulders embedded in silty/ sandy matrix. Below RL 224.000 to RL 222.590 m rock was moderately hard closely spaced lightly jointed and represented vt feebly weathered strained banded quartz, granodiorite, genisses. Fresh rock occurred below RL 222.590 to RL 219.000 m. Rock were transverse by falling prominent sets of joints viz (D-1).

(a.) N 30 E S 53 E Dipping vertical
(b.) N 70 E S 57 E Dipping 60 on NE
(c.) Transverse joints N 20 E, S 20 W sub vertical.

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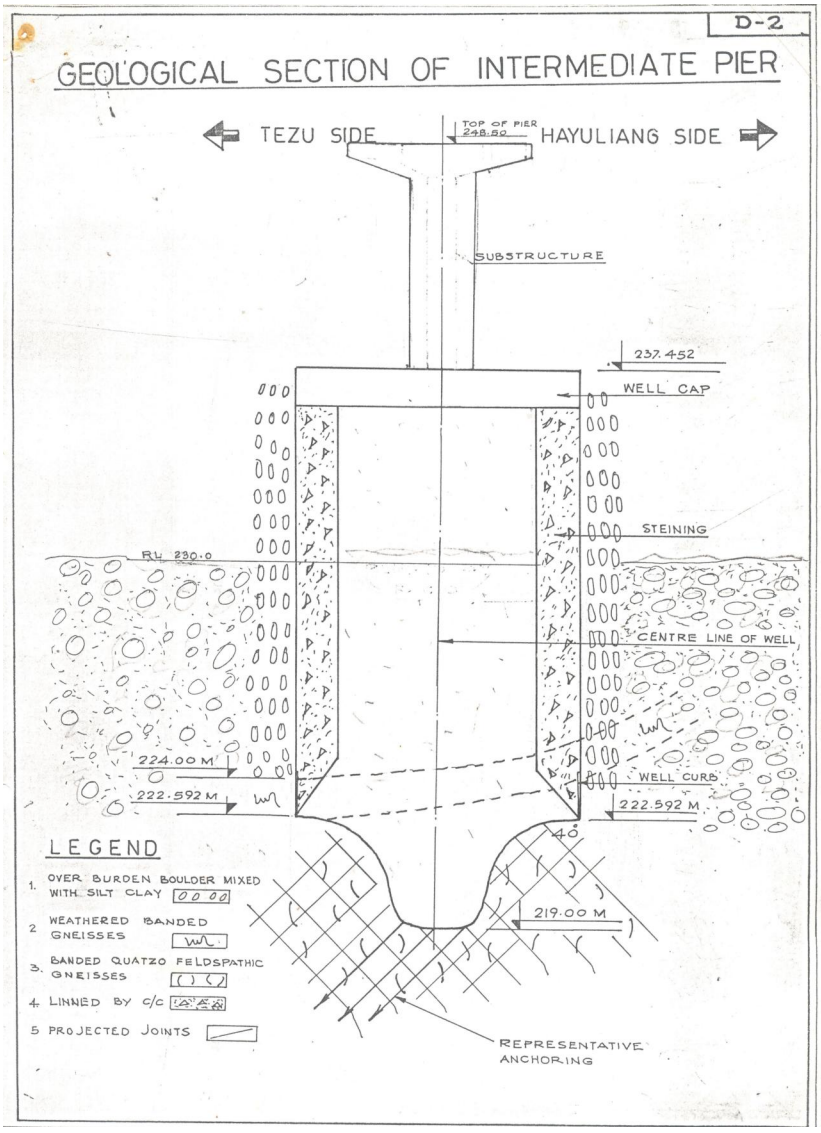

Fig 7 –Anchoring of well foundation in Hard Rock

(c.) Besides the two parallel gougy seam of 8 to 9 cm thick striking NE-SW dipping SE were recorded. The intersection of joints were developing cubical block which were blocked to crushed rock but there were no evidence of crushing. Geologist recommended that anchoring should be provided for the depth of 3 to 5 m in the direction perpendicular to the bedning plane. The foundation RL 219.000 m consisting of fresh hard quartz, granodiorite, genisses lies within the permissible limit (D2).

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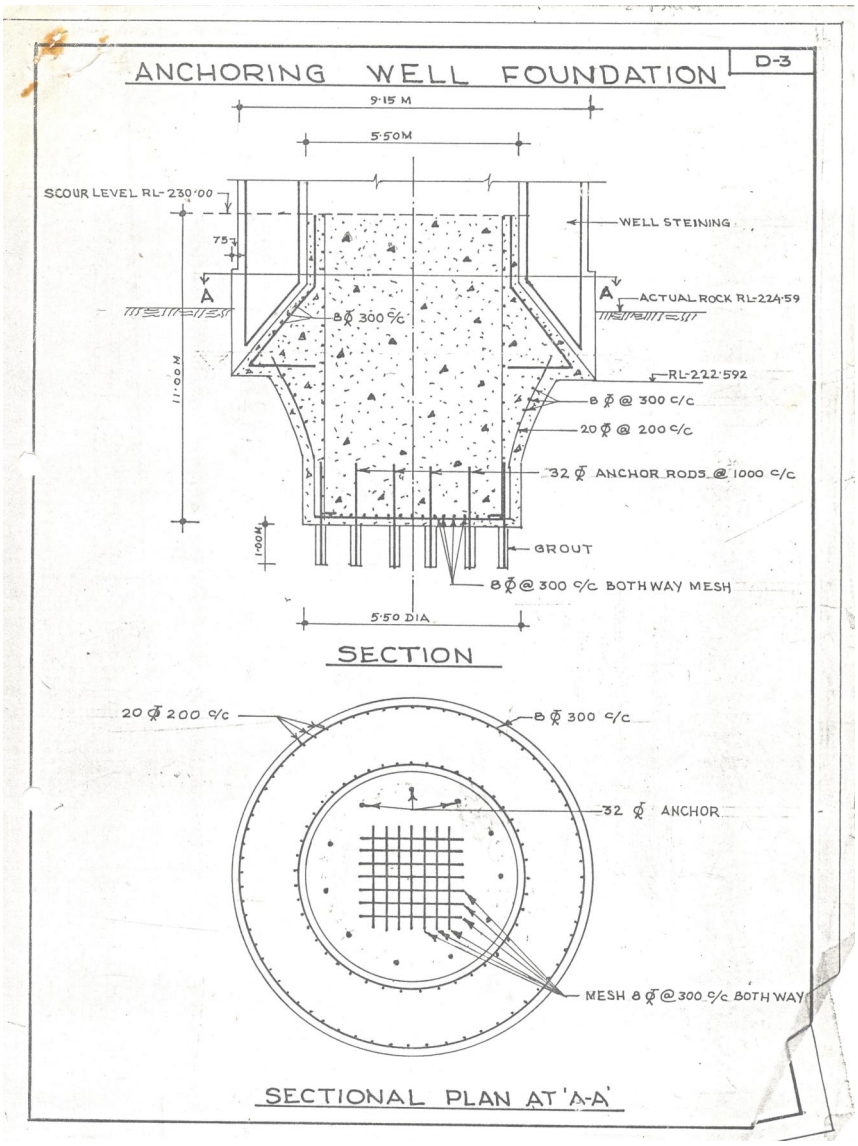

Fig 8 –Anchoring of well foundation in Hard Rock

5.3 CONSTRUCTION PROBLEMS

(a.) Due to tough strata the sinking of well became very difficult due to large size boulders and led to slow down in the overall progress of the bridge.

(b.) Basically there are difficulties of finally deciding the foundation level on such strata and this put the decision making body into dilemma and led to delay in progress.

(c.) Availability of major equipment/ plant is not there in the northeast at all the places and the same is the condition for repairs, these lead to impede the progress considerably.

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(d.) Due to heavy rainfall in the area very small working period is available in the region, which leads to delay in overall completion of activities.

6.0 RECOMMENDATION OF FOUNDATION OF ROCK

Basically foundation level in any location is combination of design and construction practice. In fact the past experience learned at various location can be guiding to lying foundation at particular location, keeping in view the general difficulties faced during finalizing the foundation level in rocks following recommendations are made:-

(a) When there is massive rock visible on both banks, the opinion of geologist be obtained..

(b) (i) Both side sample be taken invariable in case of rocky bank to have the engineering properties of the rock in case of single span bridge.

(ii) When ever there is confusion about isolated boulder and rocks one or two extra bore hole be done to distinguish the same.

(iii) Bore log material be kept ready at site for comparison with actual soil strata encountered to make decision about further review of foundation level either upward or downward.

(c) Codal provision be kept in view while laying the foundation. Generally hoop tension should develop on one face of foundation. In that foundation pressure shall be re-calculated on the reduced area of contact which shall be less than 80% of the base area.

(a) Erodibility of rock also be examined before finalizing the foundation level. While finalizing the foundation, the scour level if any and the SBC assessed level be kept in view.

7.0 Conclusion

Bridge foundations on rocks demand thorough investigation of site in advance. The details of soil strata, quality of rocks is to be judged in advance. Sub soil investigation should be compared with actual soil strata encountered. Whenever possible, pragmatic approach be implemented and foundation be laid based on the experiences gained on various foundation structures completed in past and their behaviour observed so far.

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