Examining the Applicability of Micro-pile for Bridge Foundation in Difficult Terrain using Pile Load Test

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Introduction

In remote areas and difficult hilly terrains there are several problems faced during construction of bridges. The hilly atmosphere has oxygen deficiency, negative temperatures, chilling cold, snowfall, frozen water bodies, lack of adequate transportation facilities and roads are some of the innumerable problems faced during construction. A number of environmental conditions allow only a limited period for construction which is hardly four-five hours a day. Considering the terrain and hydraulic factors at such sites there is limited option of foundation for the bridges. Usually such terrain has cobbles/gravels in the river bed. The seepage rate is likely to be very high. The high seepage rate requires heavy de-watering works while undertaking construction of substructure. Also such heavy concreting will be time consuming. Since, the time slot for construction is limited, regular procedures do not work.

Based on scour criteria, for such heavy loads as on bridges deep foundations are suitable but boulders, cobbles in such area do not allow sinking of well foundation, leaving us with only one option – piles. However, due to limited transportation facilities, roadways, it is not possible to transport such heavy rigs to such remote and inaccessible areas. Therefore, micro-piles are the most suitable option for bridge foundation considering all the above factors and limitations. A micro-pile is a small-diameter drilled and grouted non-displacement pile that is typically reinforced. It is constructed by drilling a borehole, placing steel reinforcement, and grouting the hole and can bear axial loads as well as lateral loads. They are suitable and can be installed in restrictive areas and in all soil types and ground conditions. In India, the use of micro-piles has been restricted only to slope stabilization in hydro projects and earth retaining structures and not in bridge foundation and therefore, it will be a new area for future endeavors.

SUB-SURFACE INVESTIGATION

A case study for Leh - Ladakh region was taken up. The sub-surface investigation (SSI) was carried out by bore holes of 40m depth each at the planned abutments and intermediate pier locations for the SSI. It was planned for two test piles at each location to be driven up to a depth of 20m and tested for vertical static load which will be twice the design load or up-to the pre-mature failure limit. Results obtained from SSI and micro pile testing shall be utilized for the design and subsequent construction of micro pile foundation for design of appropriate substructure and superstructure.

The specifications of micro pile consist of 273 mm outer diameter steel casing with M-35 grade cement grout filled inside at a pressure of 4 to 5 bar, re-drilled to place four nos. 32 mm diameter longitudinal bars with a centralizer to maintain spacing. This micro pile shall be tested for static load as per IS 2219 Part IV. The bore holes were to be drilled. Standard penetration test (SPT) to be conducted in bore hole at the depth of every three meters or refusal. The collection of disturbed and un-disturbed soil sample for lab test was to be undertaken. And results were to be analyzed for type of soil strata, water table & safe allowable bearing capacity.

Tests Conducted:

Field tests

(a) Boring at the proposed site to ascertain the type of soil strata at the requisite depth and collection of soil samples, both disturbed and undisturbed by boring tools.

(b) SPT conducted for measuring the penetration resistance of the soil, which is measure of its bearing capacity.

(c) Depth of Water Table was to be determined.

Laboratory test

(a) Bulk Density, Moisture content was determined for samples collected in field.

(b) Particle size analysis was carried out as per IS 2720 (Part-4).

(c) Atterberg's Limits were determined as per IS 2720 Part- 5 1985.

Results and Conclusion

The results of pre-production pile load test have been listed below. However, the micro-pile with length 21m, outer diameter = 273mm, casing thickness 8mm, given stiffness factor T = 1.3 is flexible and slender.

- Safe lateral load capacity of micro-pile is found to be 1.8 Ton and 11 Ton acting alone and in a group respectively
- The vertical load carrying capacity of pile is 32 Ton in normal conditions and 40 Ton in seismic condition.
- The worst vertical load expected on a pile is 23.4 Ton which is smaller than 32 Ton, hence safe.
- The micro-piles have been planned as flexible compression member and to take large lateral load and bending moment, the outer peripheral piles have been battered at 10^0 with vertical.

The problems owing to high altitude, remoteness, weather constraints and other difficulties as explained earlier can be overcome by micro-piles. Application of micro-pile for bridge foundation in submergence in river is debatable issue, as IRC78-2014 Section 9 Pile foundation in its clause 709.1.7 enumerates that minimum allowable diameter of bored pile should be 1000 mm for river water zone and 750 mm for bridge on land such as viaducts and ROBs etc. However, IRC: SP109-2015 permits use of small diameter pile in special circumstances. Based upon the success results, the design of micro-pile foundation and sub structure would be carried out. It is expected that this work would be considered as a distinguishing milestone in the era of bridge construction in similar difficult situations, repair and rehabilitation of endangered structures.

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