The Effect of HP Pile Orientation, Grade and Soil Profile on Fixity Point of Pile in IABs

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Introduction

Integral Abutment Bridges (IABs) are single or multiple span continuous deck bridges. Instead of movable expansion joints between the spans and bearings at the abutments, IABs have continuous decks integral with abutment walls. In order to minimize the effect of the longitudinal forces in the abutments, the abutment foundation is made flexible by supporting abutment walls on flexible piles.

Objective

To analyze the effect of the orientation of HP piles, grade profile, and the soil conditions surrounding the piles on the fixity point of HP piles in integral abutment bridges (IABs) under thermal loading. Connection between pile head and abutment wall is fixed connection.

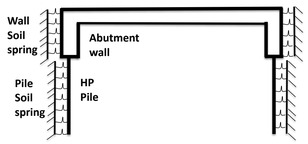

Fig.1 IAB with pile

Fig.2 Three span IAB in Fitchburg

Analyze Cases

Effect of pile orientation (strong axis and weak axis), ground condition (slope 10^o and flat ground), and soil profile on fixity point of a 45 feet long HP pile were studied by using Lpile software. 3 cases were studied (case 1, case 2 , case 3) by varying depth of medium sand (Unit weight (γ)=119 Pcf, Friction angle (Φ)=35^o, Soil subgrade modulus (k) = 129 Pcf), dense sand (γ=119 Pcf, Φ=45^o, k = 329 Pcf), and strong rock (γ=167 Pcf, Uniaxial compressive strength (q)= 33333 psi). In case 1, case 2, case 3 depth of medium sand, dense sand, strong rock were 0'-15'-30'-45', 0'-10'-30'-45', 0'-30'-40'-45' respectively. Pile head were loaded with 0.15 inch displacement due to thermal loading and 30 kips axial force in each cases.

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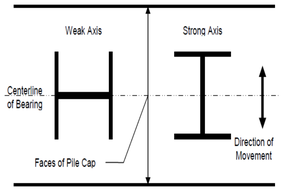

Fig.3 Pile Orientation
Weak vs strong axis

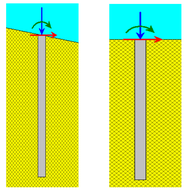

Fig.4 Ground condition
slope vs flat ground

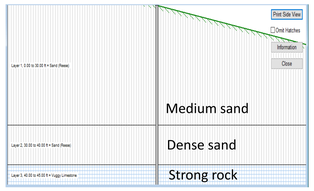

Fig.5 Soil profile

Fixity point Analysis

1. Effect of HP pile Orientation

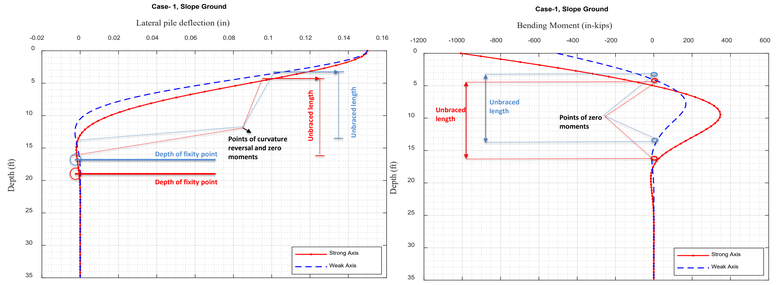

Fig.6 Pile deflection and bending moment between strong vs. weak axis

In IAB, soil behind abutment wall apply more resistance and pile in weak direction bending with the webs of the piles detailed parallel to the centerline of bearing have more flexibility than in strong direction. Thus, In Fig. 6 HP pile orientation analysis with case 1 and ground slope HP pile in weak direction reach fixity point early with less bending moment due less stiffness than strong axis orientation.

2. Effect of Ground Condition

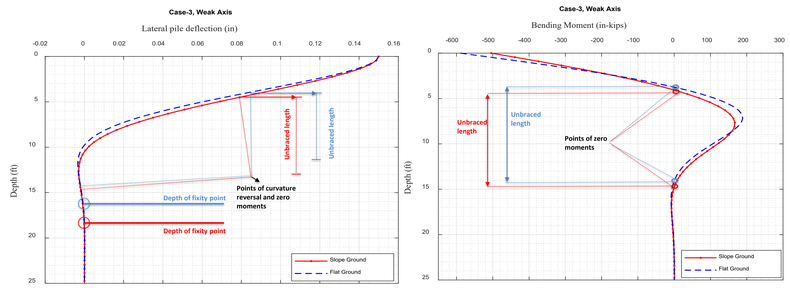

Fig.7 Pile deflection and bending moment between slope vs. flat ground

Ground slope with 10^o angle causes greater pile deflection due to additional soil pressure which increase the depth of fixity of HP pile compared with level ground. In Fig. 7 depth of fixity of slope ground is 2.2 feet more than flat ground. Ground slope will decrease the maximum moments in pile compared to flat ground.

3. Effect of soil profile

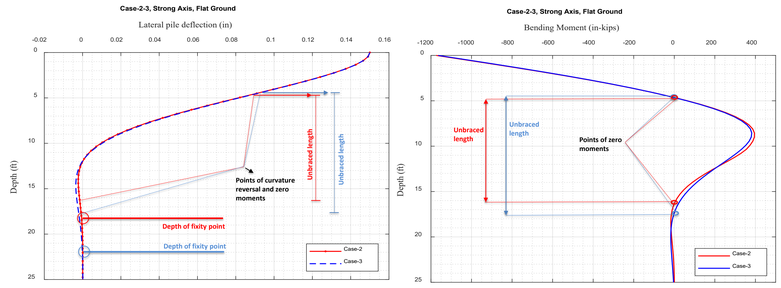

Fig.8 Pile deflection and bending moment between case 2 vs case 3

Medium sand will increase the depth of fixity of HP due to less stiffness of soil around pile compared with dense sand. In Fig. 8, pile with deep layer of medium sand (30 feet) have 3.2 feet of more depth of fixity than pile with shallow layer of medium sand (10 feet). Soil profile has no significant effect on moment of the pile.

Conclusion

- HP pile orientation in weak axis will decrease effective length of fixity point and maximum moments in the pile due to more flexibility of pile with compared to strong axis.
- Ground slope will increase effective length of fixity point due to addition soil pressure and will decrease maximum moments in pile than flat ground.
- Increasing density of soil surrounding pile will decrease effective length of fixity point due to more stiffness of soil around the pile.

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Project 3.7 – Development of general guidelines related to the effect of factors such as the bridge span range, range of pile length, roadway profile grade, and skew angle range on integral abutment bridges (IABs)