CHAPTER 7

CONCLUSIONS

The present study aimed at understanding the influence of various factors on lateral response of single piles and pile groups. Lateral load tests have been conducted on model single piles and pile groups embedded in three types of soil: sand, gravelly sand and clay. The effects of various parameters such as spacing, number of piles, embedded length, slope of ground surface, surcharge load, presence of vertical load and magnitude of applied lateral load on the lateral behavior of piles are investigated. The experimental setup, materials used, and test programme are presented. The experimental results are presented and discussed in detail in the previous chapters. Based on the results of the present investigations on model single piles and pile groups, the following conclusions are drawn.

Lateral Response of Piles in Sand

1. Efficiency of closely spaced pile groups in sand is less due to group interaction caused by the shadowing effect. The efficiency of group increases with spacing as overlap of stress zones getting reduced at larger spacing.

2. The percentage reduction in lateral capacity of the pile groups in comparison to single pile increase with number of piles in the group. The maximum reduction of lateral load capacity of about 32% occurs for 2×3 pile group with S/D ratio of 3.

3. The group efficiency for a pile group with 3D spacing reduces to about 25% when the number of piles in the group increase from 2(1×2 group) to 6 (2×3 group).

Lateral Response of Piles in Gravelly Sand

4. Lateral load carrying capacity of pile decreases as the eccentricity of applied load increases. Ultimate lateral load for single pile (aluminium) with eccentricity of 6D and 8D are 10% and 17% less than that of pile with eccentricity of 4D.

5. Piles embedded in sloping profile have reduced lateral resistance of pile when compared to that of the pile in level ground surface. Location of pile in the slope has significant influence on lateral capacity of pile. The reduction in lateral capacity for
the 2 × 2 pile group located at -10D infront of the crest and at the crest are 37% and 26% respectively.

6. Surcharge loads of magnitudes of 12.8kN/m$^2$ and 16kN/m$^2$ lead to 25% and 39% increase in ultimate lateral load of the single pile.

7. Ultimate lateral load capacity of pile group with vertical load is increased for all magnitudes of vertical load when compared with that of pile group with no vertical load. Substantial increase in lateral capacity is observed for pile group subjected to vertical load greater than 30% of ultimate vertical load. Lateral capacity of 2 × 2 pile group with 45% and 60% of ultimate vertical load is increased by 30% and 44% respectively.

8. Lateral capacity of closely spaced (S/D=3) 2 × 2 pile group is reduced by 32% when compared to that of the single pile due to group interaction effect.

**Lateral Response of Piles in Clay**

9. Flexible piles subjected to lateral load greater than about 60% of ultimate lateral load cannot be considered as flexible (length independent). This observation is significant in structural design of piles particularly in deciding upon the curtailment of flexural reinforcement.

10. The load distribution in pile groups is not uniform among the piles but depends on the position of row with respect to the direction of applied lateral load. The front row piles carry more load than that of the trailing row piles due to group interaction effect. For a given deflection, front row (R1) pile of 2 × 2 group carries about 18% more load than that of rear row (R2) pile. In 3 × 3 group, the rear row pile (R3) carries about 15% less load than the leading row (R1) pile.

11. Though the single pile exhibit flexible bending behaviour, the piles in 3 × 3 group do not exhibit flexible behaviour due to strong group interaction effects.

12. The lateral capacity of the 3 × 3 pile group with vertical load (60% of ultimate vertical load) is about 18% less than that of the pile group with no vertical load. The maximum bending moment of the pile group with vertical load is about 50% higher
and occurs at a depth of about 25% deeper when compared to that of the pile group with no vertical load.

**Comparison of lateral behaviour of piles in different soil types**

13. Pile-soil-pile interaction has very significant effect in clay than in gravelly sand. The lateral capacity of $2 \times 2$ pile group in gravelly sand is 32% less than that of the single pile whereas the lateral capacity of $2 \times 2$ pile group in clay is 45% less than that of the single pile.

14. Presence of vertical load produces different effects on lateral capacity of piles in gravelly sand and clay. In gravelly sand, the lateral capacity of pile group increases for all magnitudes of the vertical load. Where as in clay, lateral capacity of pile group increases for low vertical load levels (less than 30% ultimate load), but decreases at higher vertical load levels (greater than 50% of ultimate load).