

CHAPTER-7

CONCLUSION AND FUTURE DIRECTION

7.1. CONCLUSION

Two different important fields covered in this study are (1) behaviour of pile group under lateral load and (2) resistance of pile cap under the lateral load. Therefore the summary and conclusion from the study is separated in to two different headings.

Behaviour of pile group is quite different to the behaviour of single pile which is obvious from this study. Mathematical models that are available in the literature for laterally loaded single pile and groups of pile are chosen and computer code developed to observe the spacing effects of pile in a group. A fixed head concrete pile embedded in cohesionless soil is considered. From this study it can be concluded that (1) The deflection of a laterally loaded pile is found to increase when non-linearity is considered. (2) The amount of deflection depends on the stiffness of the piles as well as of the soil deposit. (3) Pile-soil interaction is found to influence the behaviour of a laterally loaded pile group. (4) For a particular load, the incremental deflection is decreasing as increasing of spacing of pile group. (5) The group effect in a pile resulting in increased lateral deflection of the group is found to vanish at pile spacing exceeding $9D$, and (6)For particular pile spacing, the group deflection is found to increase with increase in the number of piles in a group (keeping the lateral load per pile intact).

It is obvious that pile caps provide considerable resistance to lateral loads on pile foundation systems from the study of (i) finite element analysis of pile group, and (ii) experimental study of model pile group. Neglecting this resistance in design results in excessive estimates of pile group deflections and bending moments under load and underestimates the foundation stiffness.

The salient conclusion can be drawn from the parametric study of finite element analysis are: (1) It is observed the pile cap has a good contribution against the lateral load. (2) The different factors like the length of pile, position of pile cap, spacing etc. influence the lateral resistance of pile cap. (3) Greater the depth of pile cap from the ground level implies greater lateral resistance of the cap. (4) In case of pile group, the pile cap contributes around 37 % to 44 % for pile group of 2x1, 3x1 and 4x1 pile group for different spacing and different position of pile cap, and (5) Cap contributes around more than 40 % lateral resistance irrespective of position of pile cap at maximum spacing.

The lateral resistance provided by a pile group/pile cap foundation depends on many interacting factors, which were isolated during the experimental study to evaluate their significance. In order of importance, these are (1) Depth of cap embedment- Increasing position of cap below the ground level results in increase of lateral cap resistance. (2) Pile group axial capacity- Lateral behaviour of a pile group is directly related to the vertical or axial capacity of the piles. Pile groups comprised of longer piles (greater axial capacity) have significantly greater lateral resistance than groups with shorter piles. The rotation of the cap and the passive resistance developed in front of the cap are both affected by the axial capacity of the piles. (3) Spacing of piles-

Spacing of piles in the group-pile spacing plays an important role in case of pile cap lateral resistance. As spacing increases, pile cap lateral resistance also increases and (4) Material properties-The material of pile and cap influences the pile cap lateral resistance. The higher the modulus of elasticity of the material, higher is the lateral pile cap resistance.

Finally, from the statistical study it can be concluded that *M5P* algorithm is better than *SVMs* to study this type of problem in civil engineering field.

7.2. RECOMMENDATIONS FOR FUTURE RESEARCH

The response of piles to lateral loading has been the focus of numerous analytical and experimental studies over the past 70 years. However, the response of the pile cap and the interaction between the pile cap and the pile group has received little attention, in these studies. It is recommended that future research be conducted to support and refine the results of this study. The following recommendations for future research include additional experimental studies, as well as advanced analytical and numerical studies.

- (1) Research is needed to investigate the phenomena with more full scale test, although very few full scale tests were performed as reported in the literature.
- (2) Additional experimental studies should include the effect that the pile cap and the pile cap backfill conditions have on rotational restraint of cap. The geotechnical centrifuge may be a good tool for performing these studies, because it provides an effective means of varying test conditions. The

experimental studies would be enhanced by finite element analyses to supplement interpretations based on direct observations.

- (3) Little is known about the performance of pile caps during dynamic or vibratory loading. Research, including full-scale experimental studies is needed in this area to evaluate the effect the pile cap on the stiffness and lateral response of pile groups subjected to dynamic loads.