Response Analysis of a Rectangular Raft Foundation under Vertical Load using FE-BE Coupling Approach

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1. ABSTRACT

In the present study, a FE – BE (finite element – boundary element) coupling technique is used to calculate the combined stiffness matrix of raft foundations. Boundary element method is employed to find out the soil stiffness matrix and finite element method is employed to find out the plate stiffness matrix. The half-space response is based on the solution given by Mindlin (1936) for a point load in half space, which allows considering the effect of embedment of the plate. Plate-half-space interface is discretised into two-dimensional isoparametric quadrilateral element. The plate is discetised into eight noded isoparametric plate-bending finite elements based on Mindlin's plate bending theory. Each node of the plate bending element has three degrees of freedom, i.e.; vertical displacement and two orthogonal rotations. Same discretisation scheme is used for the half-space to maintain a node-to-node correspondence between the plate and the half-space. The stiffness matrix of the soil is obtained by boundary element method (by inverting the flexibility matrix). Suitable transformation is carried out for compatibility at the interface obtained from two different approaches. Once the deformations of the plate are obtained, the stresses can be estimated by back substitution. Combined stiffness of the pile raft system will be obtained by summing up the stiffness of the soil medium and raft system. A computer programme in Fortran language is developed in which discretisation is automatic and requires very nominal data input.

Modulus of compressibility method has been adopted while using ELPLA program. In this case, the raft is considered as elastic plate supporting on Isotropic elastic half-space soil medium, i.e.; continuum model and this approach is based on the settlement will occur not only under the loaded area but also outside. Otherwise, the settlement at any nodal point is affected by the forces at all the other nodal points. The interaction between the raft and soil is considered in Modulus of compressibility method for elastic raft on half-space soil medium. Compatibility between the raft and the soil medium in vertical direction is considered for each calculation methods.

2. OBJECTIVES OF THE RESEARCH

The primary objective of the study is to develop an approach for optimization of raft foundation system. Effect of raft and soil parameter for analysing the responses of a raft system subjected to vertical load is studied. The results obtained using the present formulation is compared with the results available in the published literature and the results obtained by the program ELPLA. The elastic settlement of raft foundation and contact stress developed beneath the raft plate and shear forces developed within the raft plate, are studied using the Present formulation and the approach used in ELPLA. The behaviour of the raft plates is compared with the different approaches. Analysis of a thick raft foundation subjected to vertical load is carried out in this study.

3. RESULTS & CONCLUDING REMARKS

It has been observed that the vertical displacement of a square raft at edge and the centre point along the centre line is little bit higher than the vertical displacement determined in the published literature. But it has also been noticed that the bending moments developed at the centre point about X and Y – axis are almost nearer to the results obtained in the published literature. The ranges of bending moment predicted as per the present formulation are in close proximity with the published result. The predicted bending moments for the present study are on the lower side. This may be attributed to the modeling of the raft as a thick plate which considered shear deformation into account and formation of the meshing of the soil medium and raft system.

While comparing the vertical displacement at edge and the centre point along the centre line, obtained using the present formulation and the approach by ELPLA, are almost same. In both cases the modeling of the raft as a thick plate which considered shear deformation into account. But the formulation of stiffness matrix of the soil medium using ELPLA approach is different with the present study.

This work presented an efficient and FEM–BEM coupling approach applied to the interface of the raft–soil system. Based on the theoretical study, the developed computer programme in Fortran language is used to analyse the response of rectangular raft foundation and shows good convergence with lesser number of elements. In future work, this formulation can be extended for the applications of containing layered soils and more complex geometry. It is devoid of the formidable computational problems encountered in finite element analysis due to the infinite lateral extent of the soil continua. In the examples, the results of the present formulation were compared with the published related work and had shown good agreement in all cases. And the results of the present formulation were also compared with the approach using ELPLA and had been noticed that the results of settlement along the centre line is almost same in both the cases. For future scope of work, the extension of the present formulation can be included nonlinear effects of the raft-soil system.

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