CHAPTER IV

NUMERICAL RESULTS AND CONCLUSIONS

The computer program has been developed as listed in the Appendix C for practical application of this study. The computation involves deflection, normal bending moment, twisting moment and shear at any interior point of rectilinear plates under the condition of free edge subjected to concentrated load, linearly distributed load and concentrated moment or combination of these loadings. To check the accuracy of the proposed method, four example problems have been computed and compared with results of the finite element program SAP IV and the results of Bezine (7). In the first example, a square plate with four rigid supports is investigated. Two flat plates which are typically civil engineering plate problems are analysed in the second and the third example. For the last example a plate subjected to the combination of concentrated load and concentrated moment is examined.

Computation has been performed on a PRIME 9750 computer using double precision arithmatics but the program can run also on an IBM PC with little modification on I/O unit specifier.

Example 1 : A square plate with four interior rigid supports loaded by a concentrated force at its center is examined. The geometric and material properties of this plate together with the details of finite element subdivisions are illustrated in Fig.8. This problem has been solved by Bezine (7) with the same formulation. The calculation has been performed by subdividing each side of the plate into 10 intervals. Figure 9 shows that the transverse deflections along the line of symmetry and the diagonal obtained from this study closely agree with those of Bezine (7) and the results given by the finite element method (SAP IV). The normal bending moment and twisting moment which are plotted against the argument of x in Fig.10 and 11 show the good agreement with the finite element method. The stress singularities are normally obtained at the point near the location of concentrated load.

Example 2 : A typical flat plate structure subjected to uniformly distributed load of 1520 kg/m^2 is shown in Fig.12. The modulus of elasticity E and Poisson's ratio ν are taken to be $2.204x10^9$ kg/m^2 and 0.15 , respectively. The size of all columns is of cross-section 0.80x0.80 m and length 3.50 m. The axial and rotational stiffness of all columns are given to be EA/L and 4EI/L, in which A denotes the cross-sectional area and I is the moment of inertia. The boundary of plate is divided into 10 intervals per side. Figure 13 represents the plot of transverse deflection which shows appreciable discrepancies in comparison with that of finite element method. However,the stress solution depicted in Fig.14 through 16 shows close agreement of the two methods. This same problem has been calculated by using an alternative evaluation of the domain integral which devides the domain loading into 40x40 panels and replaces them with equivalent concentrated loads. The computation time consumed in this method is about 5 times of that spent by the method mentioned earlier in chapter 3 which devides the loading area into 40 strips.

Example 3 : An irregular plate has been tested as the third example for checking the capability of the computer program in handling of the plate with arbitrary plan forms. The plate geometry and properties are shown in Fig.17 which included the details of finite element model prepared for the program SAP IV. The axial and rotational stiffness of all columns are considered in the same way as those of second example. Figure 18 shows the plot of transverse deflection and is in good harmony with the result of finite element method. The normal bending moments obtained from two different methods have been plotted in Fig.19 and are in reasonable agreement. The equilibrium condition which has been examined by taking all support reactions and applied loads into account are also preserved.

Example 4 : This last example (Fig.20) which is the same plate as in the first example subjected to the combination of concentrated load and concentrated moment is considered to be the example of isolate footing in civil engineering structure. Figure 21 through 24 show good convergence between two methods.

It is clear that the boundary integral formulation yields the system of simultaneous equations with the influence matrix being non-symmetric and fully populated and requires a large incore memory to store all matrix coefficients. Therefore, the number of boundary subdivisions have to be considered and suitably restricted to keep the computational effort within a reasonable limit. As used in the second example, subdivision into 10 intervals gives so good results for application of the method in such problems. The C.P.U. time consumed in the method described depends on the number of desired points in which we want to know the solution of deflection and stress resultants. Unlike the finite element method, the domain solution obtained from the boundary integral method is normally smooth. The main advantage of the boundary integral technique is due to the need of discretization which involves only the boundary of the problem. Consequently, the data preparation effort is obviously reduced.

Finally, the method presented has the flexibility to investigate further into the analysis of flat plate structures with edge beams.