VARIATION OF THICKNESS ON FINITE GRID SOLUTION OF RECTANGULAR PLATE DEFORMATIONS FOR BENDING

[1]ABDULHALIM KARASIN, [2]IBRAHIM BARAN KARASIN

[1,2] Civil Engineering Department, Dicle university, Turkey

Abstract - The finite grid method was developed to determine deformation of rectangular thin plates subjected to external load, perpendicular direction to the plane, provides a great advantage considering the flexible boundary conditions and external loading. Elastic thin plates are used in many engineering structures. In this study, the maximum deflection values of thin rectangular plates were calculated by finite grid method and other solution methods were compared with the analytical solutions as case study. The analyzes are determined by Sap2000 and Ansys Workbench with difficulties in case of complicate plate problems for mathematical modeling. It is noted that the method is a powerful preferable method for complex plate bending problems with thickness variations that provides small error rates.

Keywords - Plate Bending, Thickness Effect, Finite Grid Method.

I. INTRODUCTION

The two dimensional plates can be modeled as a particular case of three-dimensional continuum by eliminating the thickness direction. The two-dimensional plate structures can be analyzed Such integration can be made by following two different methods: the method of asymptotic expansions[1]. Two well known examples of classical thin plate thseories that have been derived on the basis of intuitions are the 'Thin Plate Theory' (TPT) by Cauchy [2] and Kirchhoff [3] type assumptions; discard transverse shear and trough-the-thickness deformation. After all, within limitations of simplified formulation as Wilson [4] indicated, plate bending is an extension of one dimensional beam theory. In present study the rectangular plates through the lattice analogy at which the discrete elements are connected at finite nodal points is represented by one dimensional beam elements.The individual element matrices are used to form the system load and stiffness matrices for plates[5]. The matrix displacement method based on stiffness-matrix approach is suitable to solve gridworks with arbitrary load and boundary conditions. A combination of finite element method, lattice analogy and matrix displacement analysis of grid works was used to obtain a finite grid solution [6-7]. The system cannot truly be equal to the continuous structure but solutions adequate for engineering purposes can be found with greater ease. In this form, plates are idealized as a grillage of beams of a given geometry satisfying given boundary conditions as shown in Figure 1.

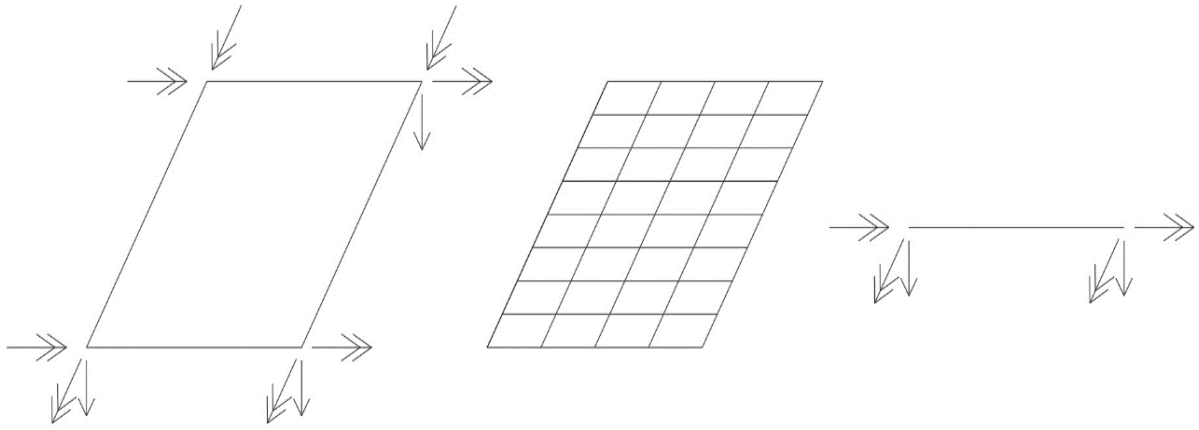


Fig. 1. The idealized discrete system

In the figure the elements are connected at finite nodal points of a rectangular thin plate in flexure with parallel sets of one-dimensional elements replaced by the continuous surface. Typical node displacements and forces in a grid plane as a beam in local coordinates is simplified with 3 degree of freedom at each node.

II. CASE STUDY

The finite grid method and the other solution methods for maximum deflection values of thin rectangular plates with variation of thickness were compared as case study. The results were compared with the analytical solutions.

The error percentage for maximum deflection values of 8 different types of samples in the literature were calculated with various loading and boundary conditions taking into account. An algorithm developed in Matlab using the stiffness and load matrices to determine Finite grid method solution [8]. The finite element method was calculated using Sap2000 and Ansys Workbench package programs [9-10], and the exact solutions were calculated using the data presented by Timoshenko [11]. In this study, since excact values of Navier solution is well known in the literature, uniformly distributed load condition of rectangular plates with all edges simple supported cases were considered. The number of plate subdivisions and plate thickness cause variation of the error percentage for maximum deflection values. The variations of the error percentage for simple supported rectangular plates are illustrated in Figs.2-3. On the other hand the error rates for the two different thickness cases are given in Figs.4-5.

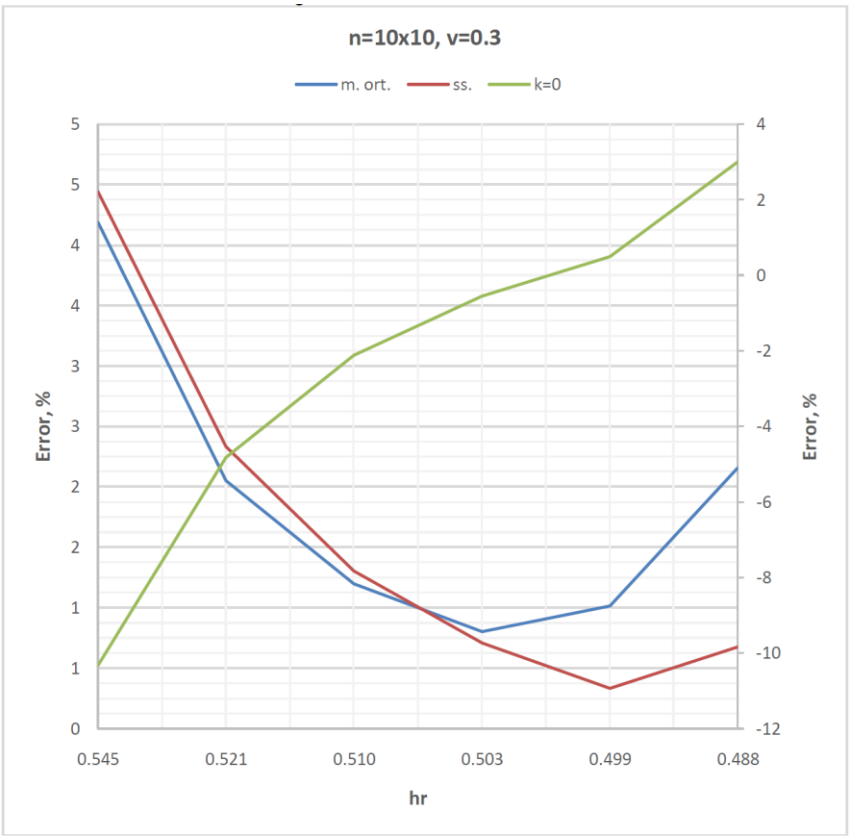


Fig. 2. Variation of Error percentage for v=0.3 and the plate divided by 10x10 division in each direction

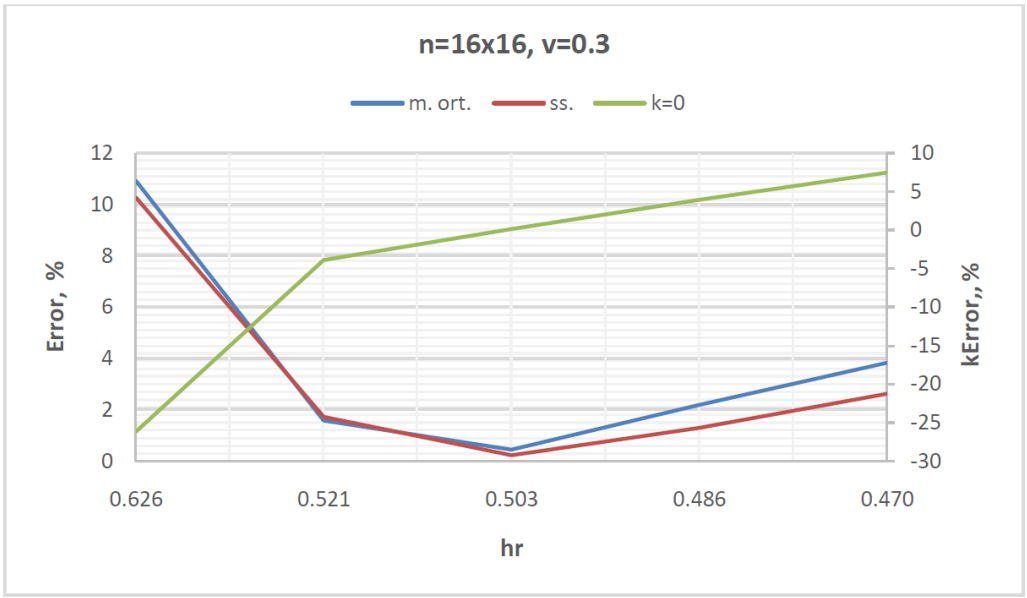


Fig. 3. Variation of Error percentage for v=0.3 and the plate divided by 16x16 division in each direction

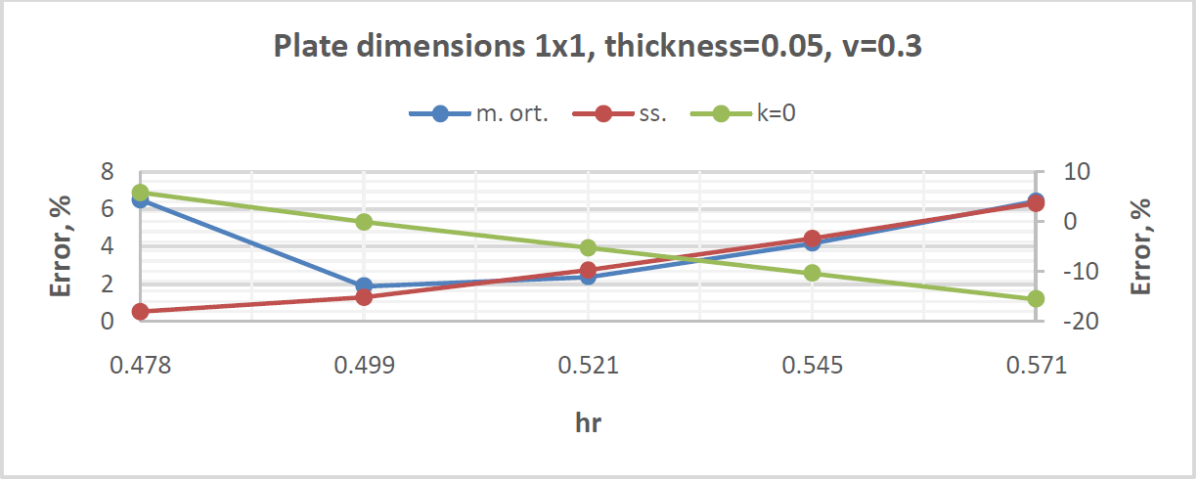


Fig. 4. Variation of Error percentage for v=0.3 and and the plate thickness of 0,05 unit.

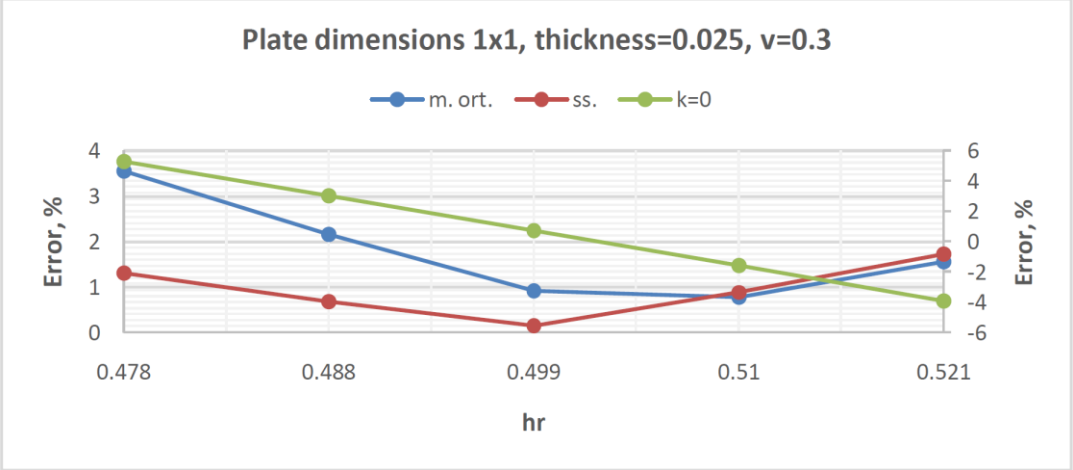


Fig. 5. Variation of Error percentage for v=0.3 and the plate thickness of 0,025 unit.

III. RESULTS AND DISCUSSION

In the analysis performed according for the flexural rigidity of the plate, D is 1 and plate poisson ratio n= 0.3, plate thickness of h= 0.025 m and h=005 with the plate sizes 1x1 m for b / a = 1 were considered illustrated in Figs. 2-5. From the figures it can be noted that the variation of error percentages for normalized maximum deformation values shown sensitivity with respect to plate thickness and plate subdivisions. The normalized maximum deflection values with the reference results solved by analytical method shown the average error rates calculated. According to the analysis made, as the number of mesh size increases the error rate in finite grid method also partially increases. On the other hand as plate thickness increases the error percentage obviously decreases. As error rate taken into consideration the solution method provides practical and modeling facilities for thin plate solutions.

IV. CONCLUSION

This method leads one dimensional element generation using any convenient numbering scheme to collect all displacements for each nodal point in a convenient sequence the stiffness and geometric stiffness matrices of the system for any type of grids. Then finite element based matrix methods is used to determine stiffness and geometric stiffness matrices of one-dimensional beam elements by exact shape functions. These individual element matrices are used to form the system load and stiffness matrices of two dimensional plates. It can be concluded that the finite grid method as an approximate numerical method has an acceptable error rate considering that it provides practical and modeling facilities for thin plate solutions.

REFERENCES

[1] C.R.C. Lima, J.M. Guilemany, “Adhesion improvements of Thermal Barrier Coatings with HVOF thermally sprayed bond coats”, Surface and Coatings Technology, vol.201,no.8,pp.4694–4701,15 January 2007,.

[2] E. Carrera and S. Brischetto, “Analysis of thickness locking in classical, refined and mixed multilayered plate theories”, Composite Structures, Vol 82(4), 549-562, 2008.

[3] A.L. Cauchy, “Sur l’equilibre et le mouvement d’une plaque solide” Exercises de Matematique, 3, 328-355, 1828.

[4] G. Kirchhoff, “Über das Gleichgewicht und die Bewegung einer elastishen Scheibe”, J Angew Math, 40, 51-88, 1850.

[5] Wilson, EL" Three dimensional static and dynamic analysis of structures, Computers and Structures Inc., Berkeley,2002.
[6] Karasin, A., Dogruyol, M., Akdogan R., and Ugurlu, M.A., "Finite grid method for deformation of thin rectangular plates", IOSR Journal of Mechanical and Civil Engineering, 136(4), 69-73,2017.
[7] R.Akdogan, A. Karasin, "Deformation of Thın Plates Using Finite Grid Method", International Engineering, Science and Education Conference, 01-03/12/ 2016, Diyarbakır, 2016.
[8] Karasin A., Isık E., Oncu M.E., and Karasin I.B., " Extension the Finite Grid Solution for Annular Plates on Elastic Foundation", The Second Mediterranean Natural Sciences and Engineering Congress, 26-29/06/ 2018, University of Podgorica, Montanegro, 2018.
[9] Matlab R2015a " The language of technical computing", MathWorks Inc. Massachusetts, USA, 2015.
[10] Sap2000 V18.1.1, "Structural analysis program", Computer and Structures Inc., USA, 2016.
[11] ANSYS Workbench V14.5, "Engineering simulation platform", ANSYS Inc., Delaware, USA,2013.
[12] Timoshenko S., and Woinowsky-Krieger, S., (1959). Theory of plates and shells. McGraw-Hill Book Company, USA,1959.

★★★