Available online at www.sciencedirect.com

ScienceDirect

Procedia Technology 24 (2016) 148 – 154

Procedia Technology

International Conference on Emerging Trends in Engineering, Science and Technology (ICETEST - 2015)

An Integrated Kirchhoff Element by Galerkin Method for Free Vibration Analysis of Plates on Elastic Foundation

Ragesh.P.P [a,*], V.Mustafa [b], T.P.Somasundaran [b]

[a]*Associate Professor, Govt. Engineering College Kozhikode, Calicut-673005, India*
[b] *Professor, National Institute of Technology Calicut-673601, India*

Abstract

Plates resting on elastic foundations have many engineering applications, especially in the area of structural engineering. Conventionally these foundation systems can be analyzed using regular plate bending element and discrete soil springs. The present work aims an element formulation which is suitable for dynamic analysis of such elastic foundation systems without the use of explicit discrete soil springs. The scope of the work includes free vibration analysis of an isotropic rectangular plate on elastic foundation with various boundary conditions for different thickness and varying properties of foundation. In this paper, finite element modelling has been done for a rectangular isotropic plate by using a four nodded Kirchhoff rectangular element having three degrees of freedom per node, combined with Winkler model of elastic foundation. Here the formulation has been carried out by integrating the properties of the rectangular plate with properties of elastic foundation using Galerkin weighted residual approach instead of the common methods in use like potential energy approach. Numerical modelling has been carried out by developing a MATLAB code and the results of free vibration analysis obtained are in good agreement with the results reported in earlier studies.

Peer-review under responsibility of the organizing committee of ICETEST – 2015

Keywords: Winkler model; Kirchhoff theory; Galerkin’s method;

* Corresponding author. Tel.: +91-9446590688; fax: +91-495-2383220.
*E-mail address:*rageshpp_phd11@nitc.ac.in

Peer-review under responsibility of the organizing committee of ICETEST – 2015
doi:10.1016/j.protcy.2016.05.021

1. Introduction

Plates resting on elastic foundation have a lot of application in structural engineering such as foundations of buildings and other structures, swimming pools, storage tanks, floor systems of buildings, airfield and highways pavements etc. So many numerical methods have been developed by researchers to solve this plate-bending problem. Among these numerical methods the finite element method is the most popular and simple one. The topic plate bending has been an intensive research area since the introduction of the finite element method and even now remains to be one of the very active research fields. This may be, mainly due to the wide application of plate elements in engineering as mentioned above and also it is very complex to model the bending plate elements. The complexity of modelling plate elements mainly due to the difficulties of finding suitable shape functions that preserve continuity of strain and also satisfying the conditions of compatibility in the case of thin plates. Another difficulty which affected the development of successful thick plate bending elements is the failure of finite element formulations based on thick plate theory to yield satisfactory results when plate thickness becomes too small.

The numerical modelling of structure-subsoil interaction problem is mathematically a quite complex phenomenon because the response of subgrade is governed by so many factors. A simple and most widely used one is plate element with Winkler foundation model where it is assumed that the subsoil consists of linear discrete elastic springs, means each spring is independent of the others. Usually, the analysis of plates on an elastic foundation is developed based on the assumption that the reaction forces of the foundation system are proportional to the deflection of the plate at that point.

Nomenclature

h	thickness of plate
L	length of square plate
w	central deflection of plate
k_s	modulus of subgrade reaction
D	flexural rigidity of plate
ω^2	natural frequency
ν	poissons ratio

2. Modelling the behavior of Plates

2. 1.General

Plates are defined as structural members with very small thickness when compared to its other dimensions. Slabs used in engineering structures, bearing plates used under columns, parts of mechanical components etc. are some common examples of plates. The plate bending behavior depends very much on its thickness. Hence, theories used for the analysis plates can be classified into following three groups, namely (i) thin plates with small deflections, (ii) thin plates with comparatively large deflections and (iii) thick plates.

Mainly there are three theories in use for the analysis of plates, namely: Classical plate theory or Kirchhoff theory (for thin plates), thick plate theory or Mindlin theory also known as first order shear deformation theory (for thick plates) and third order shear deformation theory (for laminates).The most widely used plate theory is classical or Kirchhoff plate theory that neglects the effect of deformation by shear through the thickness of plate. But the effect of shear deformation becomes considerable when the thickness of plate increases. For this reason, it is very clear that deformation due to shear should be taken into account especially for the analysis of plates with considerable thickness. Mindlin plate bending element which includes the effect of shear deformation is comparatively simple to use for analysis of bending plates. But the main problem with Mindlin plate element is that it cause shear locking when the plate becomes too thin. Kirchhoff plate elements with three degrees of freedom per node has been used to model the plate elements in this paper and consider plates with moderate and very small thickness.