Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 144 (2016) 156 – 161

Procedia Engineering

www.elsevier.com/locate/procedia

12th International Conference on Vibration Problems, ICOVP 2015

Dynamic Characterization of Connections in Plane Frames using SFFEM

Vasudev Upadhye[a], Mira Mitra[b], Sauvik Banerjee[a,b*]

[a] *PhD Research Scholar, Civil Engineering Department, IIT Bombay, Powai, Mumbai 400076, India*
[b] *Assistant Professor, Aerospace Engineering Department, IIT Bombay, Powai, Mumbai, 400076, India*
[a,b*] *Associate Professor, Civil Engineering Department, IIT Bombay, Powai, Mumbai 400076, India*

Abstract

In the construction of civil engineering structures, two or more members are often rigidly connected to increase the structural integrity. These rigid joints are often designed with bolts, rivets and welding. The actions of in-service loading and environmental effects, or fabrication errors make these joints semirigid, which ultimately reduces the structural reliability. Realistic dynamic analysis of these structures requires accurate modelling of rigidity of joints. Dynamic analysis of plane frames can be accomplished by combining spectrally formulated Rod and Euler-Bernoulli Beam element. In this study, a six parameter spectral plane frame joint element is formulated using linear and rotational springs to account for semi-rigidity of joints. Methodology and experimental set up for evaluation of dynamic characteristics of connections is discussed in this paper.

Peer-review under responsibility of the organizing committee of ICOVP 2015

Keywords: Connections; Frames; Spectral element method; Semirigid.

1. Introduction

In steel frame structures various types are connections are employed viz. single web, double web, bottom seat, top and bottom seat, stiffened seat connection etc. Also, the various types of connections for column base are used like slab base, gusseted base etc. The dynamic response of different connections is necessarily required to be

* Corresponding author. Tel.: +91-22-2576-7301; fax: +91-22-2576 7302.
E-mail address: sauvik@civil.iitb.ac.in

Peer-review under responsibility of the organizing committee of ICOVP 2015
doi:10.1016/j.proeng.2016.05.019

accurately modeled so that exact dynamic stiffness of connections can be incorporated in dynamic analysis of frames. Spectral analysis of plane frames is illustrated by M. Martin et al. [1, 5] by combining formulation of spectral deep rod element and Timoshenko beam element. A four parameter spectral joint model for bolted connection in beams is presented by Usik Lee [2].

A six parameter spectral element joint model is formulated taking into account three DOFs at each node viz. u, v and θ for axial, translational and rotational displacement. The formulation is done in such a way that it can be used to represent any type of joint in plane frame structure. This joint element is proposed to be used along with a spectral frame element formulated by combining spectral elementary rod element and spectral Euler Bernoulli beam element. The details of the proposed element are shown in the figure (1).

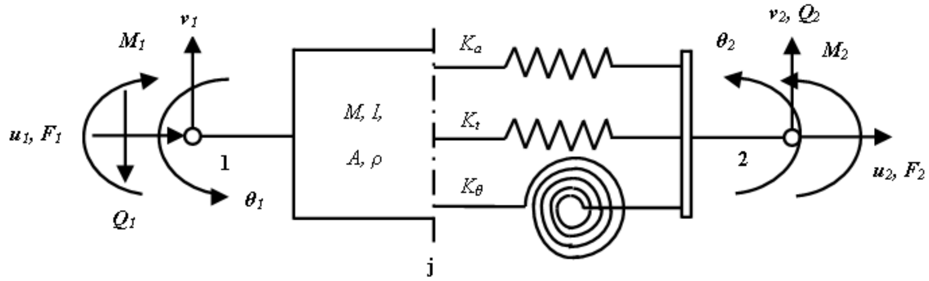

Fig. 1. Equivalent Six Parameter Joint Model

The formulation is done in such a way that it can be used to represent any type of joint in plane frame structure. This joint element is proposed to be used along with a spectral frame element formulated by combining spectral elementary rod element and spectral Euler Bernoulli beam element. The details of the proposed element are shown in the figure (1).

2. Methodology

2.1 Transfer Matrix for the Joint Model

The transfer matrix of the joint model is derived by using the sign conventions defined in figure (2). Using kinematic continuity and dynamic equilibrium conditions of the mass system and four pole techniques discussed by S. K. Clark [3], the transfer matrix equation of the mass system is derived as given by equation (1). The quantities F, Q, M are axial force, shear force and bending moment and u, v, θ are respective axial, transverse and rotational displacements. The quantities ρ, A, M, I are respectively density, area of cross section, mass and moment of inertia of the connection. The quantities subscripted by 1 are at node 1 and the quantities subscripted by j are at the junction between the inertia system and the spring system. The spring stiffnesses K_a, K_t, K_θ are axial, transverse and rotational stiffness of the connection.

$$\begin{Bmatrix} F_1 \\ u_1 \\ Q_1 \\ v_1 \\ M_1 \\ \theta_1 \end{Bmatrix} = \begin{bmatrix} 1 & \rho A\omega^2 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & M\omega^2 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & I\omega^2 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{Bmatrix} F_j \\ u_j \\ Q_j \\ v_j \\ M_j \\ \theta_j \end{Bmatrix} \tag{1}$$

Similarly, the transfer matrix equation for the spring system is obtained by using sign conventions defined in figure (3) which is as given by equation (2).