Journal of Physics: Conference Series **738** (2016) 012120 doi:10.1088/1742-6596/738/1/012120

Free vibration of laminated composite stiffened hyperbolic paraboloid shell panel with cutout

Sarmila Sahoo

Department of Civil Engineering, Heritage Institute of Technology, Kolkata, India

Email: sarmila.sahoo@gmail.com, sarmila.sahoo@heritageit.edu

Abstract. Composite shell structures are extensively used in aerospace, civil, marine and other engineering applications. In practical civil engineering applications, the necessity of covering large column free open areas is often an issue and hyperbolic paraboloid shells are used as roofing units. Quite often, to save weight and also to provide a facility for inspection, cutouts are provided in shell panels. The paper considers free vibration characteristics of stiffened composite hyperbolic paraboloid shell panel with cutout in terms of natural frequency and mode shapes. A finite element code is developed for the purpose by combining an eight noded curved shell element with a three noded curved beam element. The size of the cutouts and their positions with respect to the shell centre are varied for different edge conditions to arrive at a set of inferences of practical engineering significances.

1. Introduction

Composite shell structures are extensively used in aerospace, civil, marine and other engineering applications. Civil engineering applications often require covering large column free open areas and in such cases, thin shells instead of flat plates are used as in airports, parking lots, hangers, and the like. Automobile industries and medical plants applications require entry of north light through the roofing units as an additional requirement. At times, to save weight and also to provide a facility for inspection, cutout is provided in shell panels. In practice the margin of the cutouts are stiffened to take account of stress concentration effects. In civil engineering construction, hyperbolic paraboloid shells are aesthetically appealing although they offer less stiffness than other doubly curved shells. Moreover, civil engineers use laminated composites to fabricate these shell forms due to high specific stiffness and strength properties. Realizing the importance of laminated composite doubly curved shells in the industry, several aspects of shell behaviour such as bending, buckling, vibration, impact etc. are being reported by different researchers. The present investigation is however, restricted only to the free vibration behaviour of composite stiffened hyperbolic paraboloid shell panels with cutout.

Free vibration study of doubly curved shells was done by Qatu [1], Liew and Lim [2], Chakravorty et al [3], Shin [4], Tan [5], and Kant et al [6]. Qatu et al. [7] reviewed the work done on the vibration aspects of composite shells during 2000 - 2009 and observed that most of the researchers dealt with closed cylindrical shells with little attention to other shell geometries. Hyperbolic paraboloid shells with cutout (stiffened along the margin) are far from complete in the existing literature. Accordingly, the present endeavor focuses on the free vibration behavior of composite hyperbolic parabolic shell with cutout (stiffened along the margin) with concentric and eccentric cutouts and considers the shells to have various boundary conditions.