Finite Element Analysis of thin-walled beams joined by spot welding

[1]Dipak Vilas Patil, [2]Dr. Kaushal Prasad, [3]Ganesh A Sankpal, [4]Tushar V Kavatkar

[1]Lecturer, [2]Professor, [3,4]Assistant Professor
Department of Mechanical Engineering
Finolex Academy of Management & Technology, Ratnagiri.
Mumbai University

***Abstract* – An approach to FEA simulation by using ANSYS WORKBENCH 14.0 is presented for vibration analysis of thin-walled beam shells typical of automotive structures, which are fabricated by joining sheet metal stampings along the two longitudinal edges with periodic spot welds.The specimens are subjected to free-free boundary conditions. The effect of the profile of a beam on vibration characteristics of thin-walled beams joined by spot welding is studied. A discrete models of three different profiles of beam was built in CAD software and Finite Element Analysis was carried out to find out the natural frequencies & mode shapes of the thin-walled beams.Resistance spot welding (RSW) method is used to join the two hat sections of the thin-walled beams to cut weight and lower the cost.**

A designer should have concentrate on the strength of component by introducing the changes in plate's geometry that will reduce the vibration and noise of the structural models and increases the strength of the structures. In this work Finite element analysis was carried out to study the effect of profile of a beam section on the vibration characteristics of thin-walled beams joined by spot welding at free-free boundary conditions.

***Index Terms* –Spot-weld, thin-walled beam, Natural frequency, modes, FEA.**

I. INTRODUCTION

This paper gives an overview of the finite element analysis of thin-walled beams joined by spot welding. The study investigates the effect of the profile of a beam on vibration characteristics of thin-walled beams joined by spot welding. Thin-walled elements are the most common components of the supporting structures of vehicles, earth-moving machines and protective structures. The few examples of thin-walled structures are girders (beams, pillars and thin walled profiles).

The shape of the thin-walled profile and the technology of its manufacture are the main factors which determine impact energy absorption by the car's stringers (beams) [1]. One such manufacture technology consists in joining together, by resistance spot welding, two open omega-shaped profiles made of steel characterized by very high strength and plasticity to form one closed profile. Such beams are mounted in the car's front part to absorb impact energy in the case of an accident.These types of structures have wide application in automotive industries [2]. Automotive bodies and many other structures are composed of metal sheets joined by spot welds. Spot weld joints lead to high stress concentration in the joined plates. Excessive stresses and premature failure occurs due to improper design. A designer significantly concentrates the strength of component by introducing the changes in its geometry and weld patterns that will reduce the vibration and noise of the structural models. Also increases the strength of the structures. The optimum design of geometry can be obtain optimal performance i.e. good strength to the composed structures.

Although many researchers have been published regarding vibration analysis of stiffened laminated plates and shells [1-2-3-10-11]. It was found that stiffeners profile and its arrangement have great effect on the natural frequencies and mode shapes of the plates [2- 3-10]. Experimental analysis of composed structures, including setup is studied [1-2-11] to find the natural frequencies using FFT analyzer. In this FEA analysis different spot welded stiffened structures are studied for modal analysis to find natural frequency and mode shapes. Xin Zhang et al. investigated the effect of the size of the welds diameter and pitch of the weld on the strength analysis of spot weld joints [4].Also in the some literature, there are few studies about optimization of spot welded structures [6-9]. Ahmet H Er`tas et al. optimized the spot welded plates for maximum fatigue life. They suggest that number of spot welds significantly affects the fatigue strength. Sheet thickness and material are studied to the strength requirements of the structures.

II. DETAIL DESCRIPTION OF ALL STRUCTURAL MODELS

The different structural models investigated for this study, its brief information given below. Models are made of mild steel (CR) material. It consist total three structures having two plates with hat section joined together by twenty spot welds.
Plate's thickness 1.5 mm
Plate length 565 mm
Spot weld diameter 6 mm
Spot weld spacing 60 mm

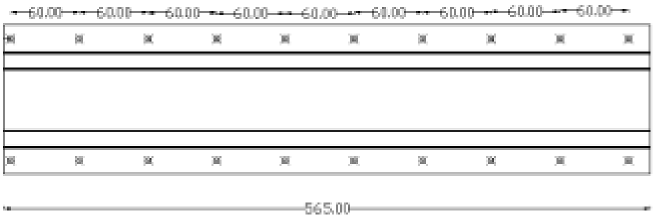


Fig.1 Weld pattern P1 [2, 11]

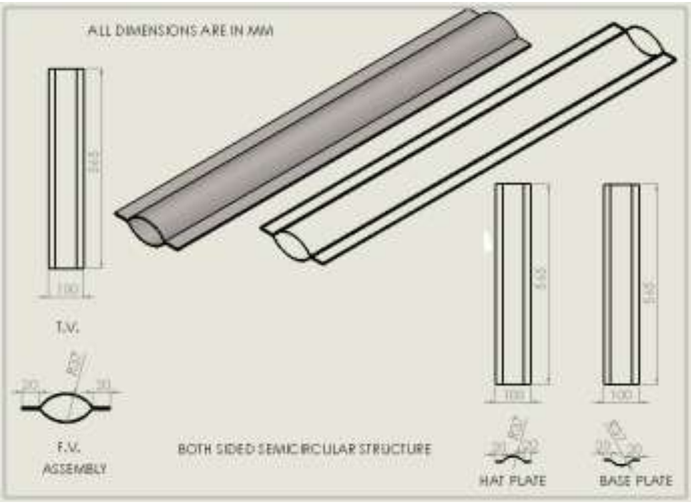


Fig.2 Structure S1

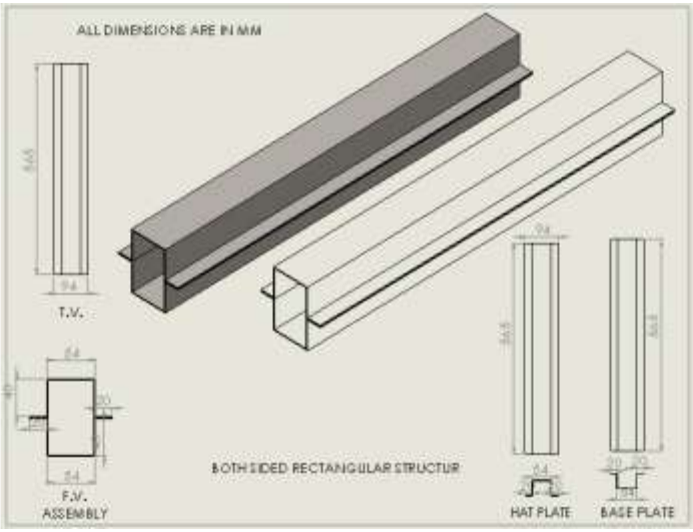


Fig.3 Structure S2

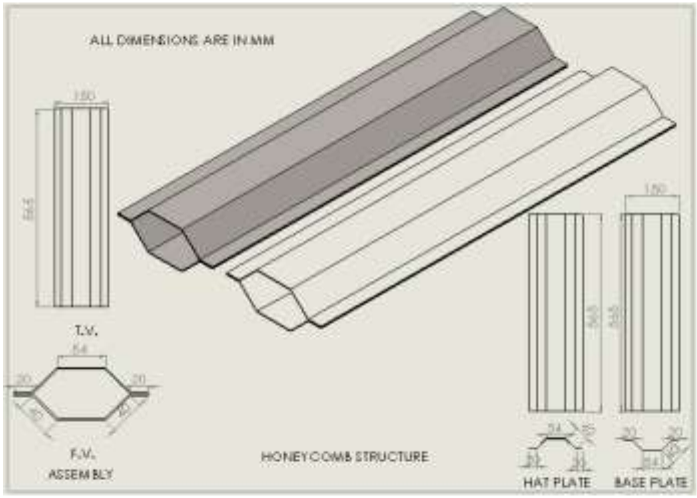


Fig.4 Structure S3

III. FINITE ELEMENT ANALYSIS

This is most representative technique to prepare the model of structural object. FE models are generated to obtained detailed response of structures and to determine structural characteristics. F.E Models are more practical because they predict realistic structural response. This Section describes the geometrical and finite element modelling process in detail. Also brief information regarding analysis of structural models is included. The following mentioned design of experiment matrix used for this study. To found out more accurate natural frequencies the mesh optimization technique is used. After mesh optimization 0.009 m mesh size is selected for analysis.

TABLE I
DESIGN OF EXPERIMENT MATRIX

Design of experiment	**Structure 01**	**Structure 02**	**Structure 02**
Pattern1	S1P1	S2P1	S3P1
Weight	1.4705 kg	2.3152 kg	2.3211kg

TABLE II
MATERIAL PROPERTIES

Properties	**values**
Density	7850 kg /m3
Element Size	9.e-003 m
Poisson's Ratio	0.3
Young's Modulus	2.e+011 Pa

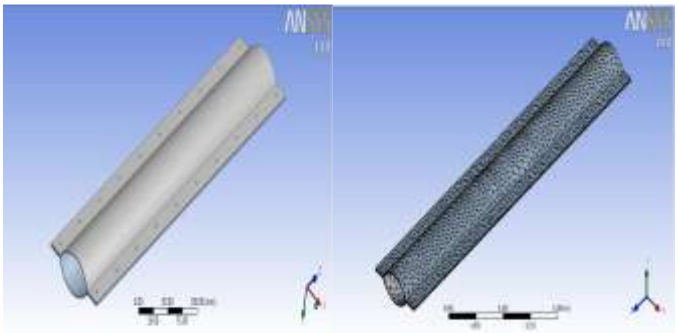


Fig.5 Spot weld model &meshing of structure S1P1

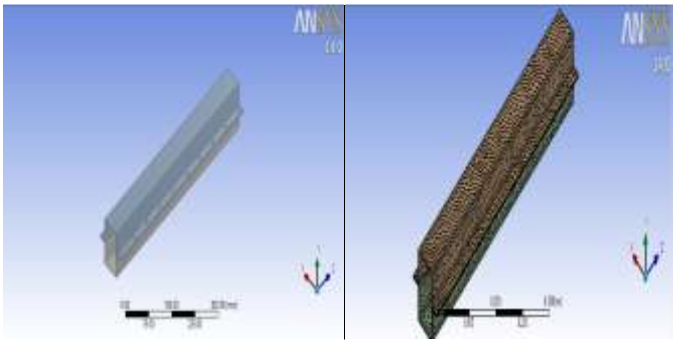


Fig.6 Spot weld model &meshing of structure S2P1

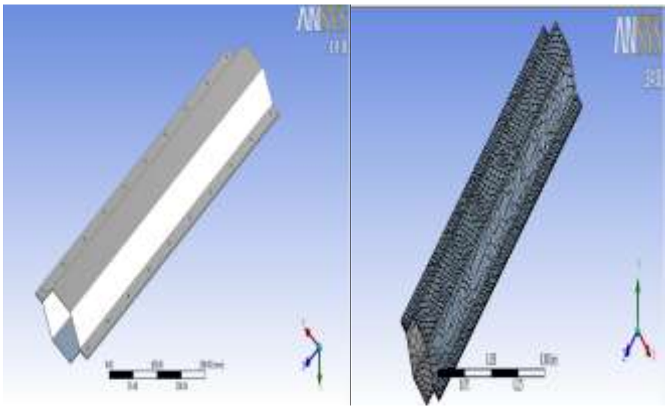


Fig.7 Spot weld model &meshing of structure S3P1

A. *Finite Modal Analysis of Structural Models*

Modes are inherent properties of structure and are determined by material properties (mass, damping and stiffness), and boundary conditions of the structure. Each mode is defined by natural frequency, mode shape (modal parameters).If either the material properties or the boundary conditions of a structure change its modes will change. Also natural frequencies are different due to different mass and stiffness. This study includes the various structures. So, material size, shape and mass are different at same boundary condition. Thus analysis of structures is carried out by observing natural frequencies of the same structures.

B. *Flow of Work And Methodology For Modal Analysis of Structural Models*

1) Start
2) Create the geometry of the structural models using SolidWorks12 software
3) Export geometry file in .STEP form
4) Open the ANSYS WORKBENCH 14 software
5) Import the same geometry file
6) Implement spot weld condition of the structural model as per required design
7) Set the meshing size and complete the meshing
8) Select number of modes to be found out
9) check file for errors before analysis
10) obtain the results
11) Stop

C. *Frequencies of All Structural Models And Mode Shapes*

The result includes frequencies of all structural models in Hz. First six modes are the rigid modes. Therefore remaining four modes are considered for analysis.

TABLE II

RESULTS OF MODAL ANALYSIS USING ANSYS WORKBENCH

Structure	**Frequencies in Hz**			
	Mode 7	**Mode 8**	**Mode 9**	**Mode 10**
S1P1	515.21	1320.8	1410.6	1538.5
S2P1	522.52	528.53	578.69	586.02
S3P1	491.53	494.93	594.37	602.25

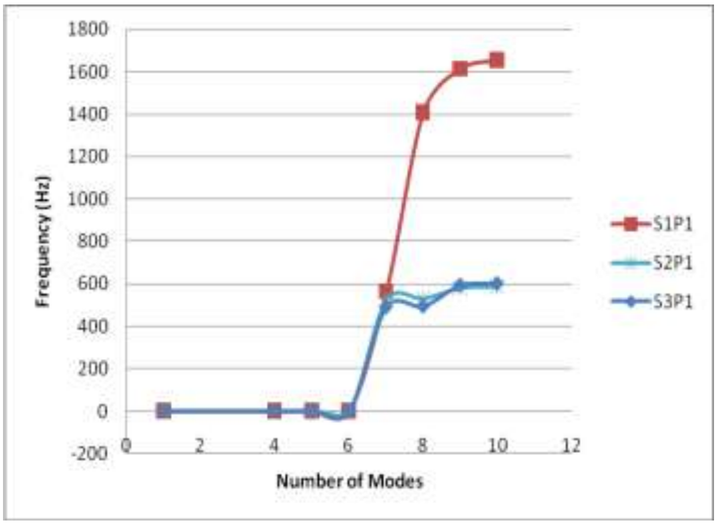


Fig.8 Variation of natural frequencies of three structures

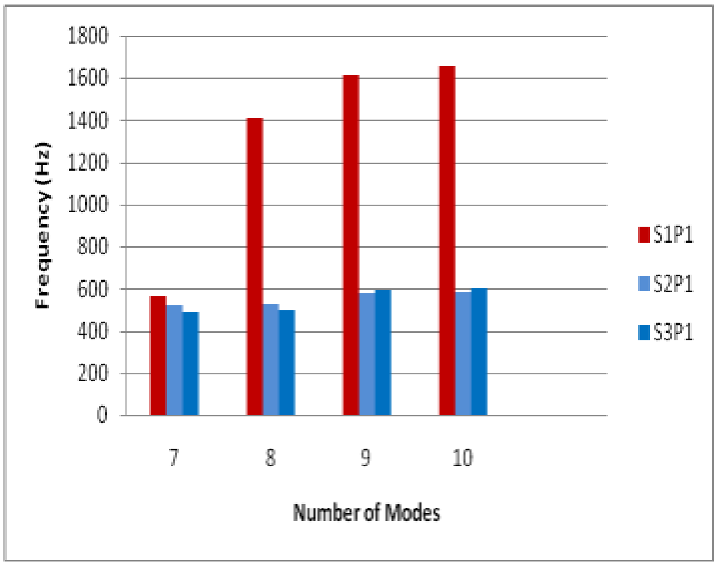
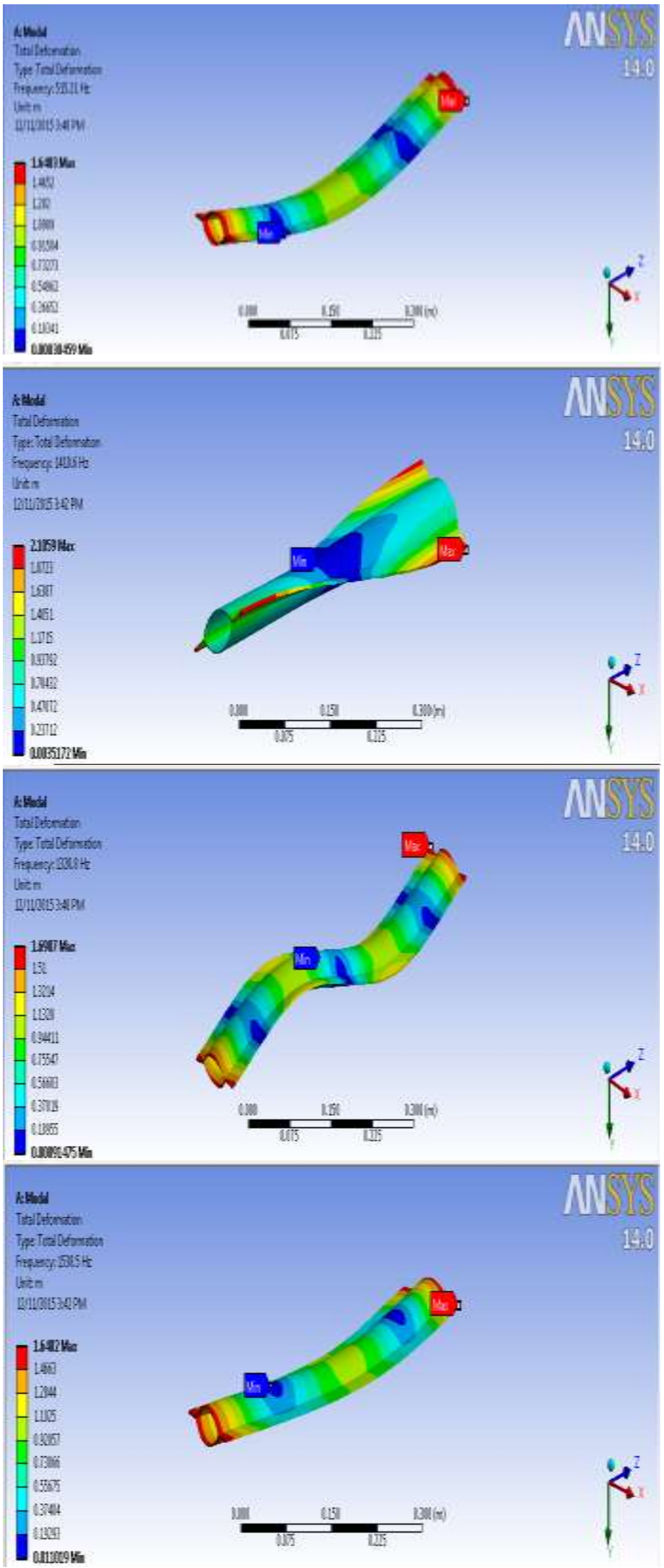
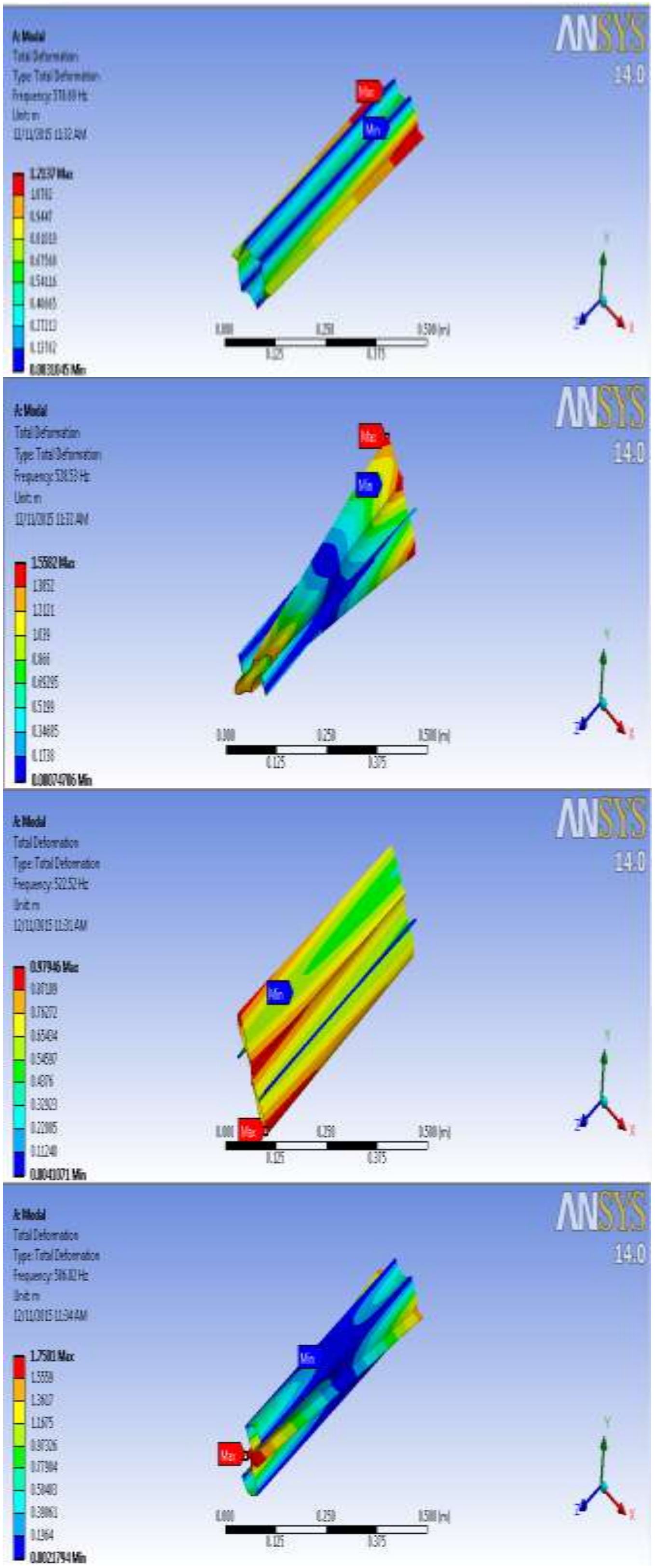


Fig.9 Comparison of natural frequencies considering mode shapes.

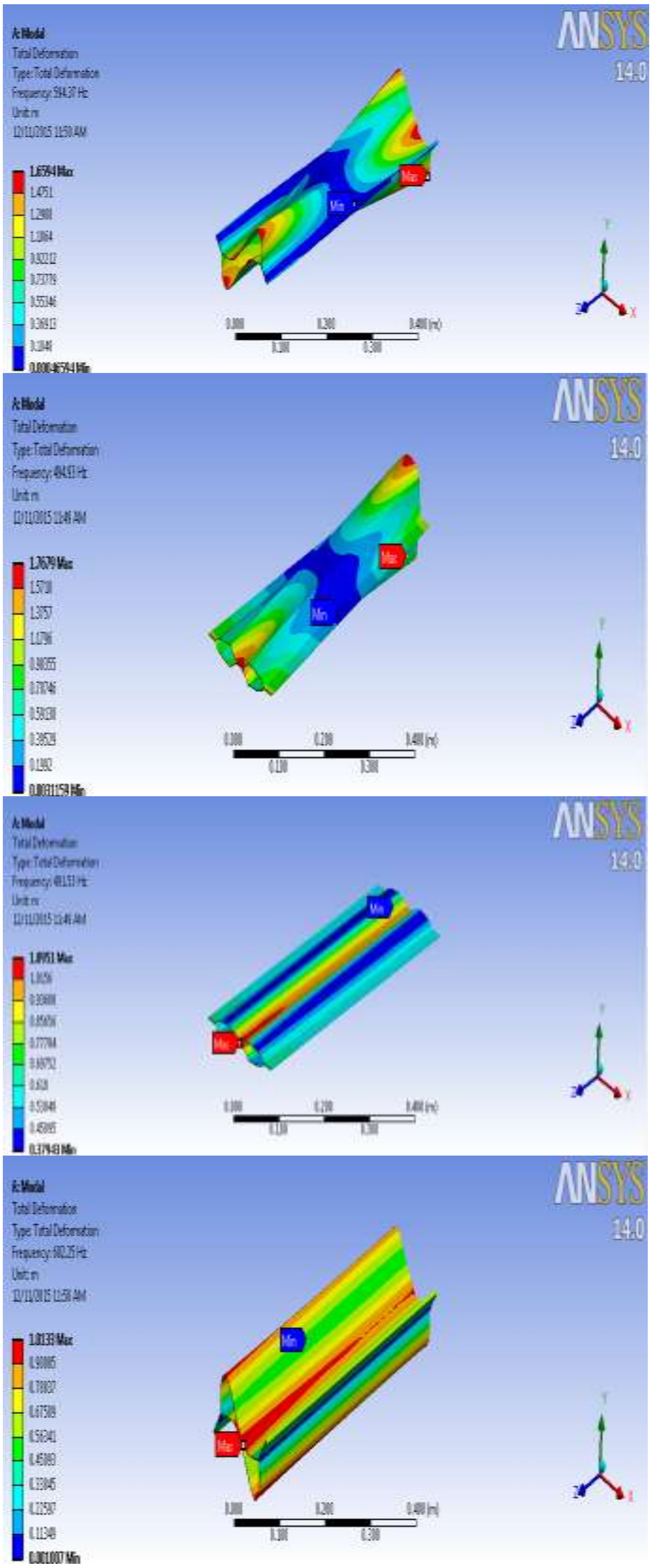
D. Mode shapes of S1P1



E. Mode shapes of S2P1



F. *Mode shapes of S3P1*



IV Conclusions

From the above FEA results, it is revealed that, the shape and size of beam has great influence on natural frequencies as compared to mass and weld pattern. As mass changes the natural frequency changes. The increasing mass of the thin beam decreases the natural frequencies of the plate for free-free boundary conditions

The natural frequency of Structure S1P1 is high and Structure S3P1 has a lowest frequency for all modes. From the mode shapes it is seen that Structure S2P1 & S3P1 is more stable as its variation of natural frequency is less compare to structure S1P1.

The selection of profile of thin beam and weld pattern depends upon the excitation frequency of the system in order to avoid resonance condition of the system. The structures having less frequency are useful for the application where high excitation frequency and the structures having high frequency are useful for the application where less excitation frequency.

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