International Journal of Enhanced Research in Science Technology & Engineering, ISSN: 2319-7463
Vol. 3 Issue 9, Sept.-2014, pp: (58-65), Impact Factor: 1.252, Available online at: www.erpublications.com

Dynamic Analysis Plates with Spot Welded Stiffeners

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Abstract: In this paper we are going to study the structures of plate with spot welded stiffeners using HyperMesh and LsDyna software under the loading conditions for dynamic analysis. These structures mainly consists two parts i.e. Upper and lower part which are joint together using spot weld. Spot welding is most preferred and widely used method for joining the metal sheets in automotive and many other industrial assembly operations. The finite element (FE) modeling of plates with spot welded stiffened structures and its dynamic analysis is research area of this paper.

Keywords: Stiffener, Structures, Dynamic analysis.

I. INTRODUCTION

Spot welding is one of the most widely used techniques for many of the applications where stiffened structures of sheet metals are used due to its easiness and cost effectiveness. Within this dynamic analysis of spot welded stiffeners focus is on study of effect of spot weld patterns and profiles of stiffeners on proposed stiffened structures. The stiffened structures are widely useful in engineering applications mainly for the application of steel plates for hulls of ships, steel bridges and aircraft structures etc.

The applications like automotive bodies and other stiffened structures contain thousands of spot welds. For the analysis of spot welded stiffened structures, a very detailed model is necessary and various finite element (FE) models have been proposed [4, 5].For the analysis of a large scale model such as an automotive body is impractical. Because these models having large degree of freedom leads to excessive computational effort. Thus the major requirements of spot welded stiffened structures are studied which represents all characteristics with small degree of freedom and to predict accurately their influence on such type of the structures or applications. Thus considering the above mentioned applications twelve types of structures are proposed and studied for dynamic analysis.

A spot weld is materialized by clamping the sheets with two pincers while applying a force and transmitting current. The electrical resistance due to sheet metal contact generates sufficient heat at the metal surfaces to melt the metal. Thus nugget develops and sheet metals are joined. Spot weld joints provides localized connection thus lead to high stress concentration in the joined plates.

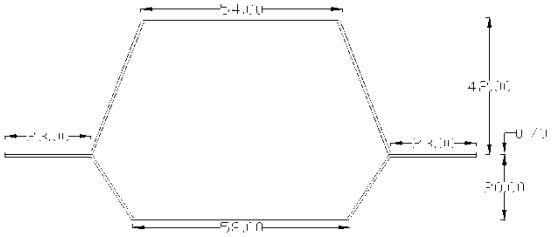
Recently spot welded structures are studied for modal analysis to obtained natural frequencies using Finite Element Analysis (FEA) and experimental modal analysis method [1]. In the literature, there are some studies about optimization of spot welded structures. [2, 3] investigate the optimized spot weld structures and maximum fatigue life of structures. Sheet metal thickness and materials are also studied for the strength requirements of the structures for such types of applications. The effect of the size of the welds diameter and pitch of the weld on the account of absorbed energy is studied [4].

Some researchers have been published on vibration analysis of stiffened laminated plates and shells. It was found that stiffeners profile and its arrangement have great effect on the natural frequencies and mode shapes of the plates [5]. Experimental analysis of composed structures and model updating are studied [6, 7] to find the natural frequencies using Fast Fourier Transform (FFT) analyzer.

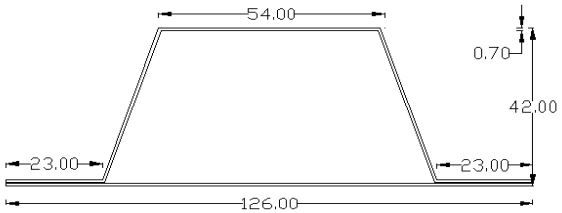
In this study dynamic analysis of spot welded stiffened structures is carried out to analyze the strength of the structures. Dynamic analysis is mostly proffered in automobile industries for the crashworthiness analysis.

II. DETAIL DESCRIPTION OF ALL STRUCTURAL MODELS

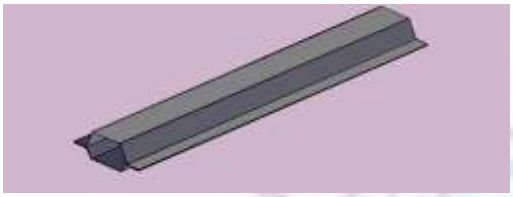
The different spot welded structural models are made of mild steel are studied, its brief structural information given below.



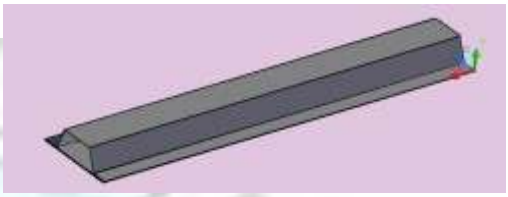
(a) Section View of Structure 1 (S1)



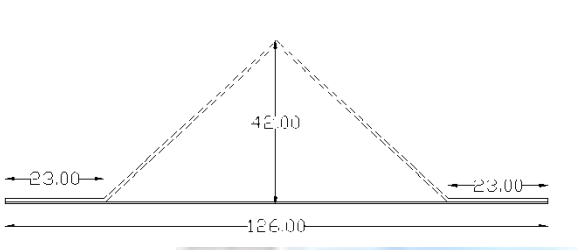
(b) Section View of Structure 2 (S2)



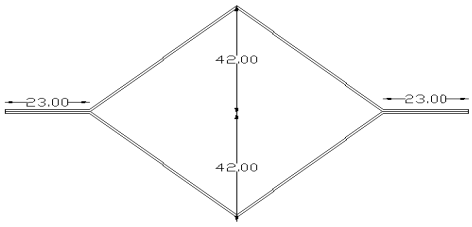
3D Cad Model of Structure S1



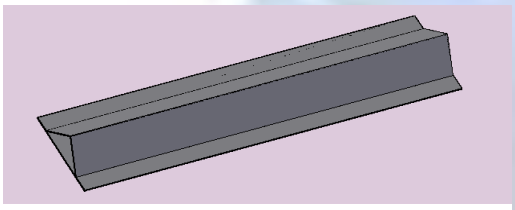
3D Cad Model of Structure S2



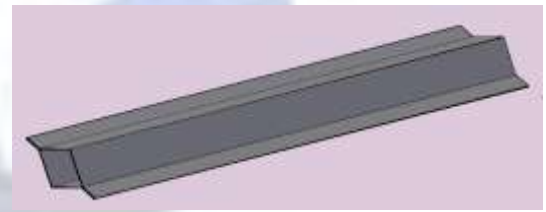
(c) Section View of Structure 3 (S3)



(d) Section View of Structure 4 (S4)



3D Cad Model of Structure S3



3D Cad Model of Structure S4

Figure 1. Shapes of different structural models with dimensions

A. Structural models:

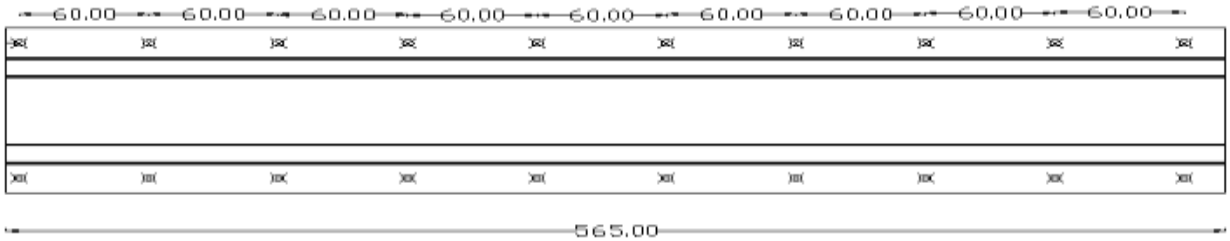
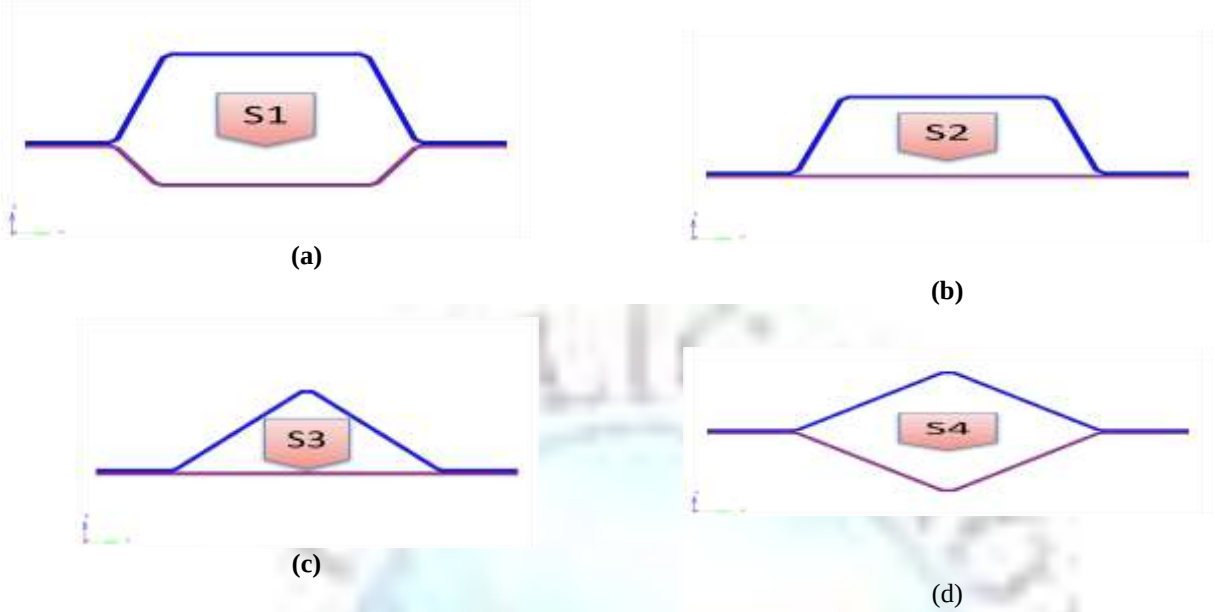


Fig. 2 Top view of structural model

Fig. 2 describes the dimensional details of weld patterns. Diameter of each spot weld is 5mm.This study includes the effect of weld patterns on characteristics of the structures.

B. **VARIOUS SECTIONS AND THEIR NOMENCLATURES:**



(a) **(b)**

(c) (d)

Figure 3. Sections of different structures and their nomenclature

C. **VARIOUS SPOT WELD PATTERN AND TEIR NOMENCLATURES** :

The various spot weld patterns to be tested as given below

(a) Weld pattern P1 **(b) Weld pattern P2**

(c) Weld pattern P2

Figure 4. Top view of various spot weld patterns and their nomenclature

III. DYNAMIC 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 modeling process in detail.

Also brief information regarding analysis of structural models is included. The following mentioned design of experiment matrix used for this study.

Table 01: Design of Experiment Matrix

Design of experiment	Section 1	Section 2	Section 3	Section 4
Pattern1	S1P1	S2P1	S3P1	S4P1
Pattern2	S1P2	S2P2	S3P2	S4P2
Pattern3	S1P3	S2P3	S3P3	S4P3

A. DYNAMIC ANALYSIS OF STRUCTURAL MODELS:

Structural dynamic analysis is mainly concerned with finding out the behavior of a physical structure when subjected to force. A dynamic analysis is also related to the inertia forces developed by a structure when it is excited by means of **dynamic loads applied suddenly. A dynamic load is one which changes with time. If it changes slowly, the structure's response may be determined with static analysis, but if it varies quickly, the response must be determined with a dynamic analysis. In this dynamic analysis displacement given to the structures keeping one end fixed with respect to time. This is the way to perform dynamic analysis in LsDyna.**

B. FLOW OF WORK METHODOLOGY FOR DYNAMIC ANALYSIS OF STRUCTURAL MODELS:

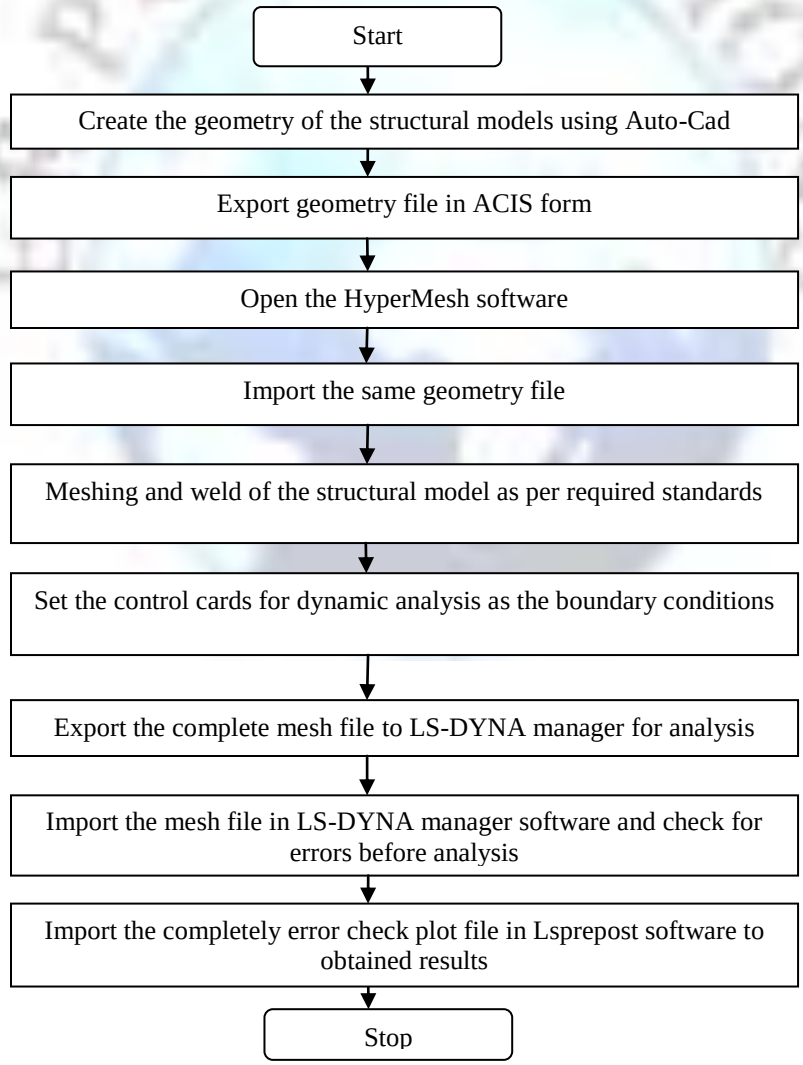


Figure 5. Flow chart of methodology of Dynamic analysis

C. FINITE ELEMENT (FE)MODEL SET UP FOR DYNAMIC ANALYSIS:

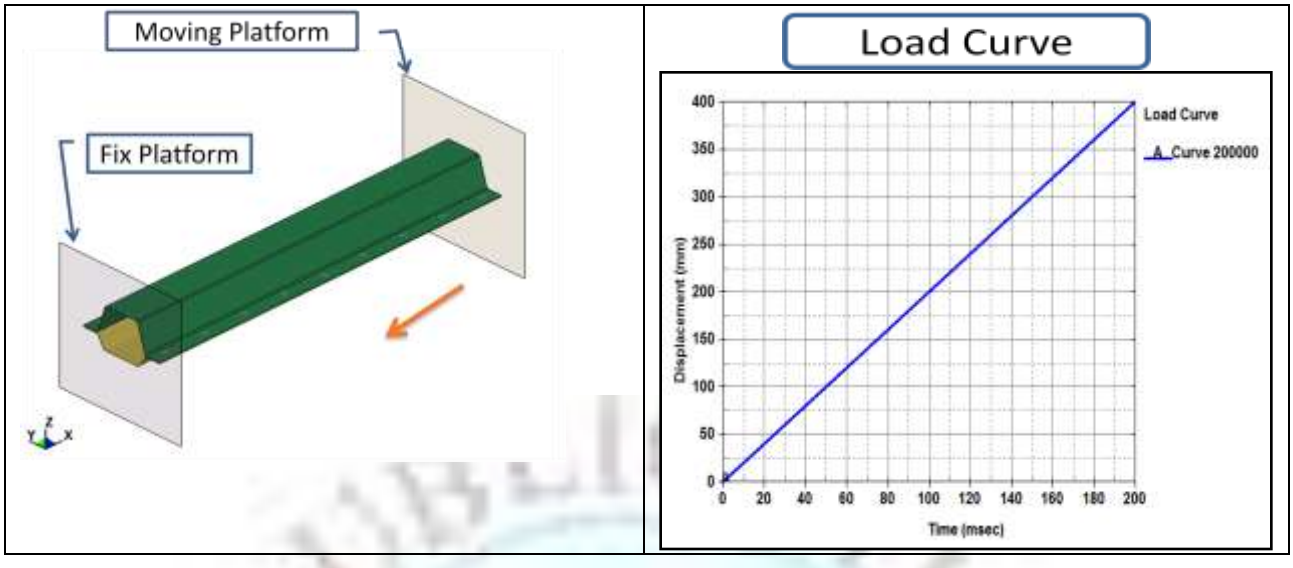


Figure 6. Finite element model set up for dynamic analysis

In this finite element model set up one end of the structure is fixed and other end is free for the displacement. For the displacement of free end of the structure load curve is defined in software. Thus internal energies of the structures are determined for the analysis. The results in the form of graph (Material energies vs. time) are included in section IV.

D. DYNAMIC ANALYSIS REPORT OF STRUCTURE S1P1 :

Dynamic analysis report of structure S1P1is included in this literature. The procedure of dynamic analysis of other structures is similar to structure S1P1.

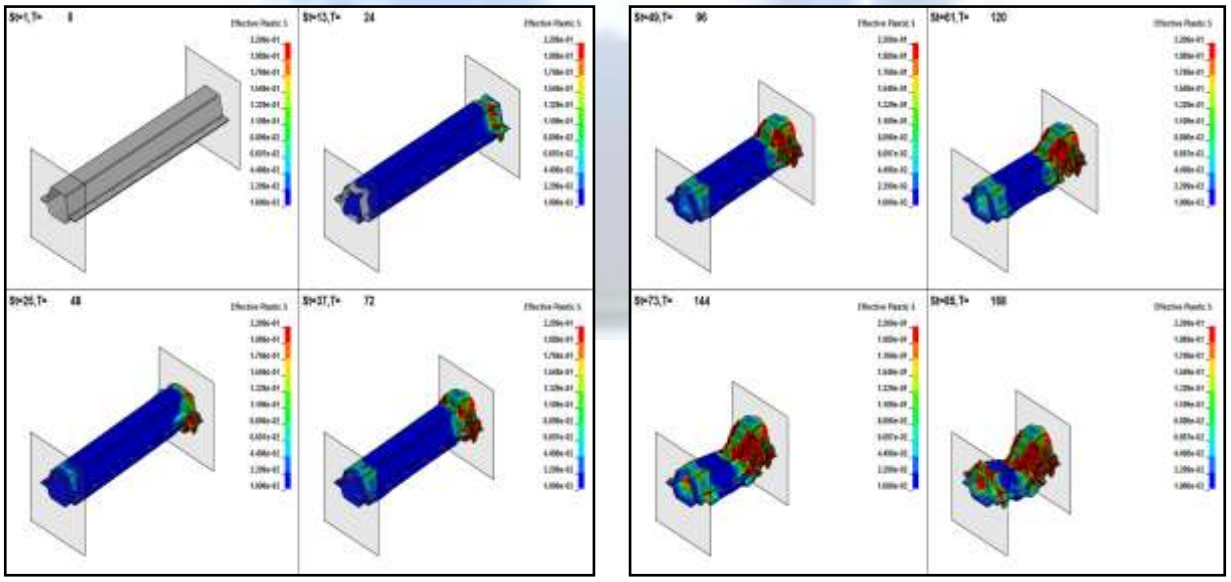


Figure 7. Dynamic analysis of structure S1P1

This report includes structural changes during displacement at different location and at different time interval. In these figures **st** represents set number and **T** represents time in milliseconds. Similarly other spot welded stiffened structures are analyzed.

IV. DYNAMIC ANALYSIS RESULTS

The result includes material energy of upper section and lower section of all structural models in KJ. Dynamic analysis results of all the structures are as follows.

S1P1

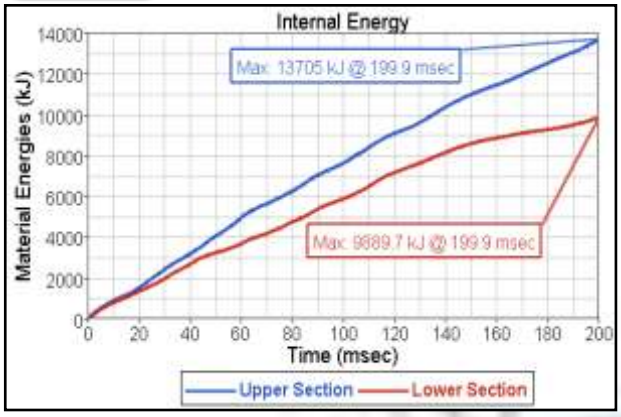


Figure 8. Dynamic analysis result of structure S1P1

S1P2

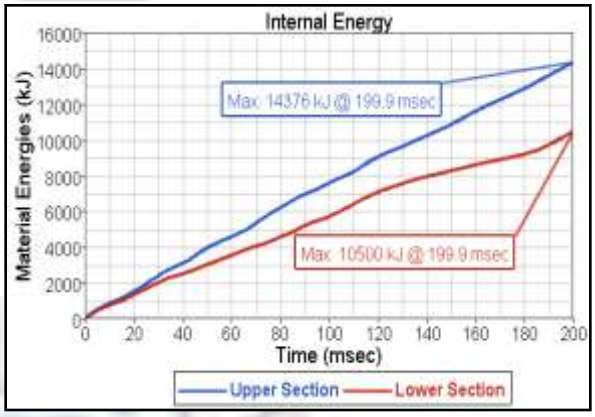


Figure 9. Dynamic analysis result of structure S1P2

S1P3

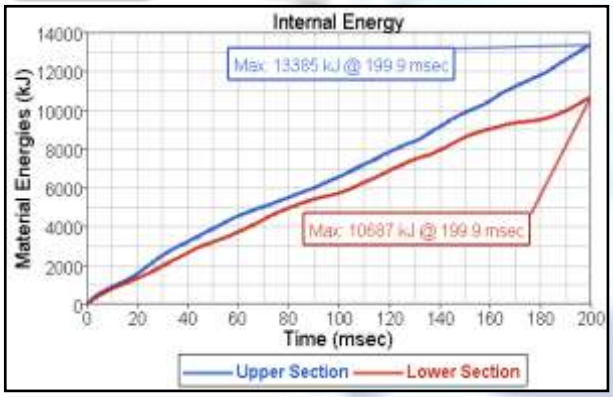


Figure 10.Dynamic analysis result of structure S1P3

S2P1

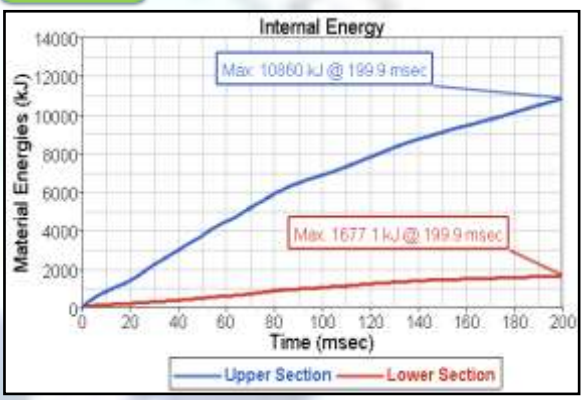


Figure 11. .Dynamic analysis result of structure S2P1

S2P2

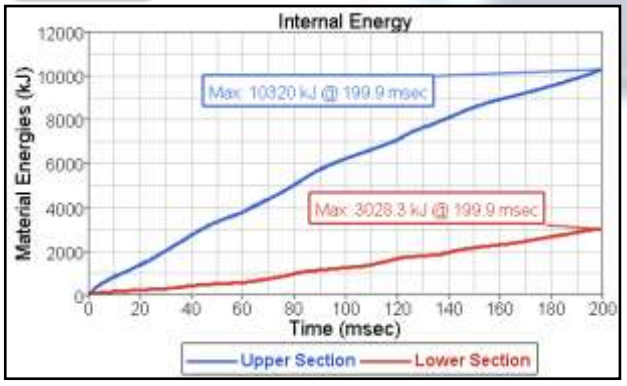


Figure 12. Dynamic analysis result of structure S2P2

S2P3

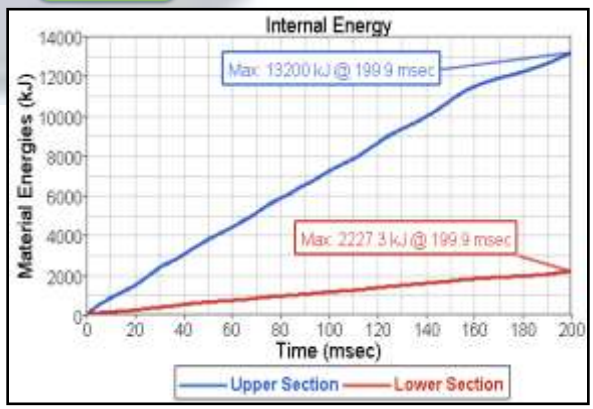


Figure 13. Dynamic analysis result of structure S2P3

S3P1

S3P2

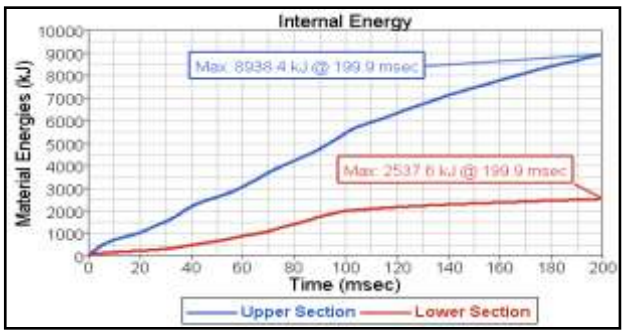


Figure 14. Dynamic analysis result of structure S3P1

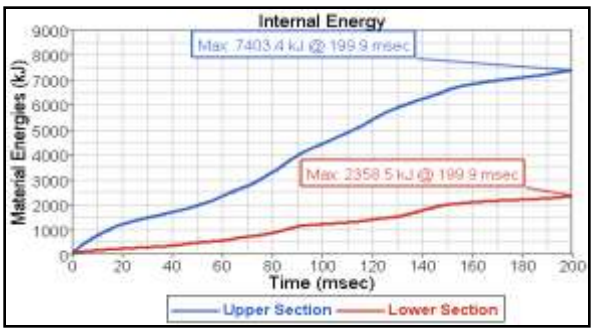


Figure 15. Dynamic analysis result of structure S3P2

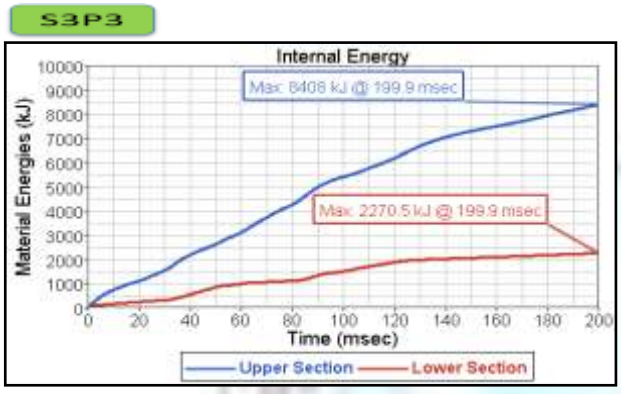


Figure 16. Dynamic analysis result of structure S3P3

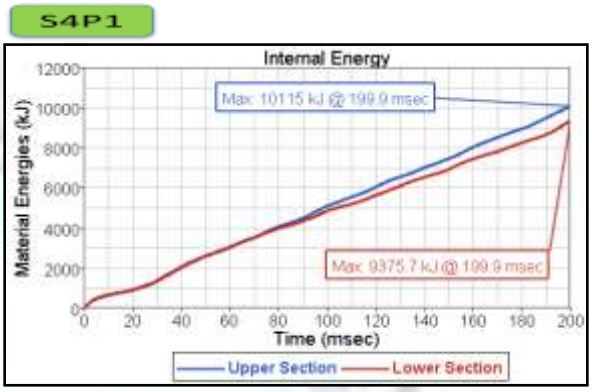


Figure 17. Dynamic analysis result of structure S4P1

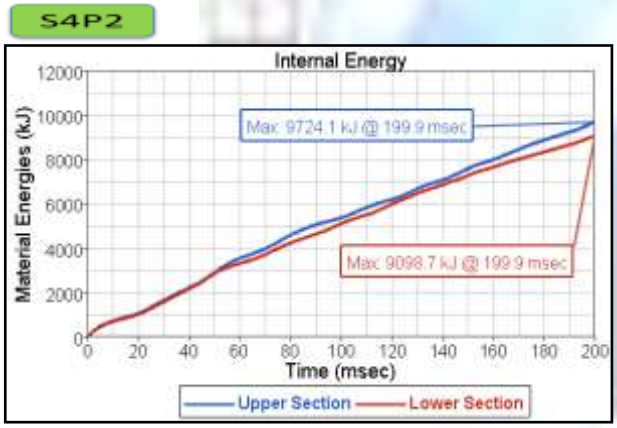


Figure 18. Dynamic analysis result of structure S4P2

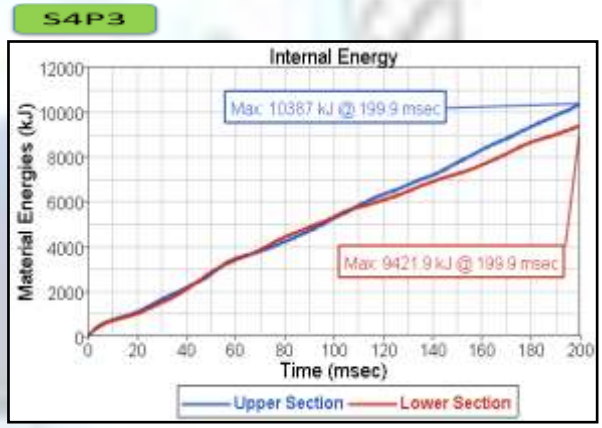


Figure 19. Dynamic analysis result of structure S4P3

DYNAMIC ANALYSIS RESULT SUMMARY

Table -02 Results of Dynamic Analysis

Internal Energy	S1P1	S1P2	S1P3	S2P1	S2P2	S2P3	S3P1	S3P2	S3P3	S4P1	S4P2	S4P3
Upper Section	13705	14376	13385	10860	10320	13200	8938.4	7403.4	8408	10115	9724.1	10387
Lower Section	9889.7	10500	10687	1677.1	3028.3	2227.3	2537.6	2358.5	2270.5	9375.7	9098.7	9421.9
Total	23594.7	24876	24072	12537	13348.3	15427.3	11476	9761.9	10678.5	19490.7	18822.8	19808.9

CONCLUSIONS

From the dynamic analysis of all the structures, following conclusions are made:

1. From the dynamic analysis study, it can be conclude that structure S1 and S4 has good internal energy that means these structures can shows good performance under loading conditions.
2. From the above FEA and experimental results, it is revealed that, the profile of stiffener and weld pattern having much more influence on the structural models.
3. The selection of profile of stiffeners 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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