International Journal of Scientific Engineering and Research (IJSER)
www.ijser.in
ISSN (Online): 2347-3878, Impact Factor (2015): 3.791

Investigation on Static & Dynamic Behaviour of Stiffened Panels

Praveen kumar B. R.[1], Premkumar .R[2]

[1]PG Thermal engineering, SNS College of technology, India
[2]PG Thermal engineering, SNS College of technology, India

Abstract: ***Stiffeners are secondary plates or sections which are attached to beam webs or flanges to stiffen them against out of plane deformations .Almost all main bridge beams will have stiffeners. However, most will only have transverse web stiffeners, i.e. vertical stiffeners attached to the web. Deep beams sometimes also have longitudinal web stiffeners. It is this rigidity which engineer attempt to utilize when they design thin walled structure such as door, plate girders, box girders and so on. This restraint can be provided by folding the plate along parallel lines, which lie in the longitudinal direction, or restraining a plate is to provide longitudinal stiffener, which are additional plate elements whose planes are inclined to that of the plate. This paper aims to design and develop the light weight, high strength stiffened panels for shaper frames and Machine tool structures. A variety of simple analysis methods have been developed for the analysis of stiffened panels. These methods typically belong to one of the following classes: analysis based on smeared properties, simple plate analysis under simple supports, and accurate linked or segmented plate analysis or finite strip analysis. The more complicated or detailed modeling usually employs discredited models such as finite element and boundary element analysis.***

Abstract: Stiffeners, performances, structure

1. Introduction

The concept of a stiffened plate has been developed and now a stiffened plate panel forms the basic building block of many thin steel structures. The stiffened panel with closed cross section as shown in has considerably greater resistance to twisting moments than single connected or so called open sections.

1.1 Types of Stiffeners

There are two principal types of stiffener which is illustrated in the figure 1.1

- Longitudinal stiffeners, which are aligned in the span direction.
- Transverse stiffeners, which are aligned normal to the span direction of the beam.

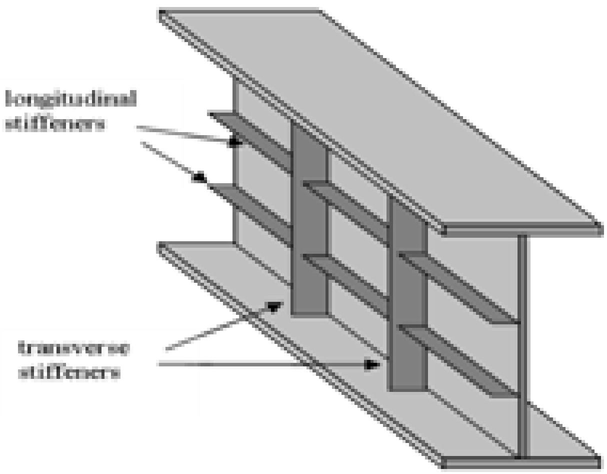


Figure 1.1: Stiffeners

1.2 Transverse Stiffeners

Transverse web stiffeners are usually provided at bearing positions and these are known as bearing stiffeners. For future maintenance it is good practice to provide bearing stiffeners at jacking points (for when girders have to be raised to free bearings for replacement). Other transverse stiffeners are called intermediate transverse web stiffeners.

It is usually necessary to provide intermediate stiffeners on main beam webs for the practical purpose of connecting torsional bracing between the beams. If so, the chosen bracing positions will determine the positions of at least some of the stiffeners. However, for beams with no bracing, such as transverse girders in a ladder deck bridge, or if plan bracing is being used, there may be no practical necessity for intermediate stiffeners at all. The requirement for intermediate transverse web stiffeners is determined by the verification of the shear resistance - this will indicate where stiffeners are needed, and where stiffeners extra to those for bracing are needed.

1.3 Longitudinal Stiffeners

Longitudinal stiffeners should not be necessary on any part of a section that is never in compression nor on any part of the section that is classified as class 1, 2 or 3 in accordance with EN 1993-1-1 clause. Even if the part of the section is classified as class 4, longitudinal stiffeners may still not be required. To determine if the beams have sufficient bending strength without longitudinal stiffeners, the procedure is to follow EN 1993-15.

To determine if longitudinal stiffeners are required on the web to give the main beams sufficient shear strength, the procedure is as for intermediate stiffeners, i.e. to verify the shear resistance of the beam to EN 1993. If longitudinal stiffeners are to be provided they are to be verified by checking the adequacy of the effective stiffener section to act as a column as required by EN 1993.

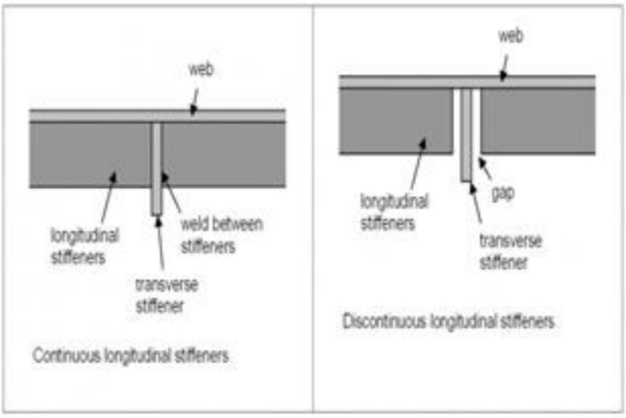


Figure 1.2: Continuous and discontinuous longitudinal stiffeners

The marine industry has rapidly expanded its use of aluminium, primarily for the construction of high-speed commercial and military vessels. The quest for higher speeds and cargo capacity has led to rapid development of new designs where weight savings is critical. In these applications, the higher strength-to weight ratio of an aluminium structure gives it an important advantage over a traditional steel structure. In the space of just over a decade, aluminium high-speed vessels (HSVs) have evolved from 30m passenger-only vessels operating in protected waters, to vessels over 120m long, carrying both passengers and vehicles, and operating on exposed routes. This rapid increase in vessel size and capability has led to an urgent need for new engineering tools capable of investigating the hydrodynamic and structural response of these vessels. Problems such as fatigue cracking and local structural damage has plagued many aluminium HSVs, increasing their operating costs and further underlining the need for new engineering tools capable of accurately predicting such phenomenon.

Examples of design optimization techniques and design for various performance factors such as structural instability, crashworthiness, damage tolerance, and post buckling strength will be presented. The discussion will focus mainly on the design optimization of stiffened plates and stiffened cylindrical shells or panels.

2. Literature Review

Hung-Chien Doet al (2013) [2] reduces weight of hull structures designed for a very large carrier plays an important role as the economic efficiency is the most significant aspect. It is known that the traditional allowable working stress approaches with high safety and reliability; it means that the hull structural weight is higher than the actual requirement in operation. Recently, the limit state approach has been widely applied for analysis and assessment of marine structures, the limit strength of structures is determined by nonlinear finite element analysis (FEA) method.

Tavakolia H.R.et al (2013) [10] studied to determine the dynamic response of the stiffened plates considering the effect of stiffener configurations. Several parameters, such as boundary conditions, mesh dependency and strain rate, have been considered in this study.

Malleswara Swamiet al (2012) [6] made a complete analysis of a machine bed for both static and dynamic loads. Then investigation is carried out to reduce the weight of the machine bed without deteriorating its structural rigidity and the accuracy of the machine tool by adding ribs at the suitable locations.

Pravin P. Hujare et al (2011) [7] the primary motivation for stiffening a plate is structural efficiency conservation of weight with no sacrifice of strength or reduction of critical buckling loads. The stiffeners are used to increase the strength of door plate for various pressures loading condition. A door consists of stiffened plate can be designed through effective distribution of material to resist stresses and minimize deflection.

3. Design of Steel Plate

In order to study the performance of the stiffened panels under static and dynamic condition stiffened panels are designed for different dimensions by varing the number of stiffeners along transverse and longitudinal directions and both. The design of stiffened panels are discussed in this chapter in a lucid manner.

Initially, the steel plate is taken to study the effect of stiffners on the static and dynamic behaviour. The dimensions and material properties are enlisted in the table 3.1

Table 3.1: Dimensions of stiffened panels

Dimensions	Length(mm)	950
	Width(mm)	800
	Height(mm)	50
Material properties	Young's modulus (N/m^2)	$2e^{11}$
	Poisons ratio	0.3
	Density (kg/m^3)	7860

3.1 Without Stiffner Plate

Using the dimensions mentioned in the table 3.1, the steel plate is modeled which is shown in the figure 3.1. The weight of the stiffened panel is estimated using the following calculation.

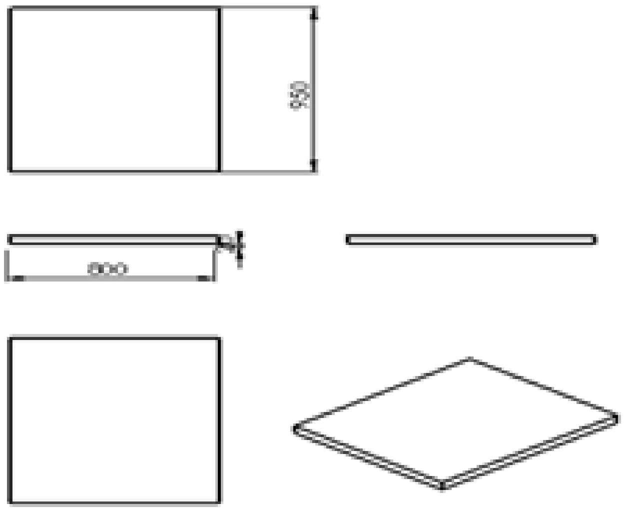


Figure 3.1 Without stiffner plate

3.2 Weight Caculation of Without Stiffner Plate

Weight of the plate = volume × density = (800×50×950) ×7.8 = 296.4 kg

3.3 With Stiffner Plate (Transverse)

3.3.1 REctangular Section

In this stiffener plate, the weight has to be reduced to an extent by the addition of stiffeners as shown in figure 3.2.

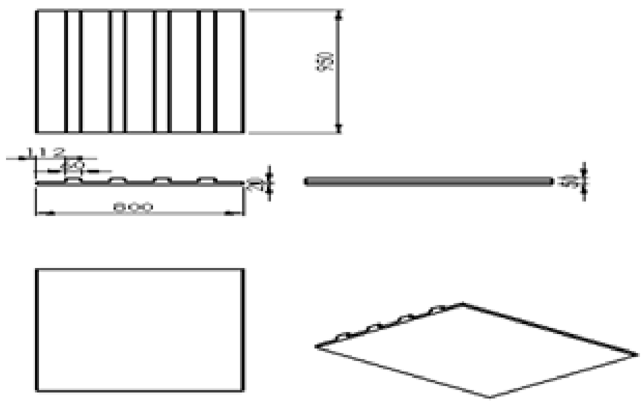


Figure 3.2: Rectangular section

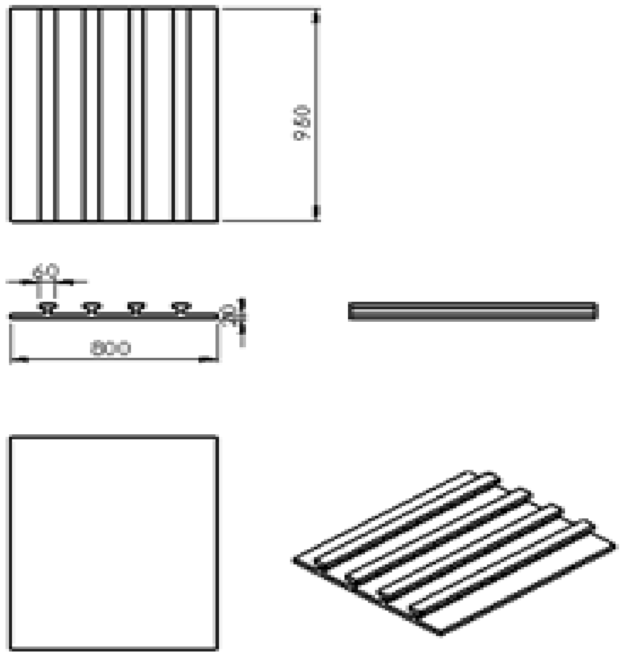
Weight of the base plate = volume ×density
= (800×20×950) ×7.8 e^{-6}
= 118.56 kg
Weight of the stiffener = volume × density
= {(60×30×950) ×7.8 e^{-6} }
= 53.352 kg
Total weight= weight of the base plate + weight of the stiffener = 118.56 + 53.352
= 171.912 kg

Table 3.2: List of Various Dimensions

Sr. No	Dimensions of stiffener (mm)			Weight(kg)
	Width	Thickness	length	
1	100	30	950	229.71
2	166.66	30	950	229
3	64	30	950	189.67
4	87.5	30	950	196.6

3.3.2 T-Section

Weight of the base plate = volume × density
= (800×20×950) ×7.8 e^{-6} = 118.56 kg .



All the dimensions are in mm
Figure 3.3: T-section

Weight of the stiffener = volume × density
= section 1 +section 2
= {(20×20×950) ×7.8 e^{-6} } +
((60×10×950) ×7.8 e^{-6})
= 7.41×4
=29.64 kg.
Total weight =118.56+29.64
= 148.2 kg.

Table 3.3: List of Various Dimensions (T- section)

Sr. No	Dimensions of stiffener (mm)					Weight(kg)
	Width		thickness		length	
	Section 1	Section 2	Section 1	Section 2		
1	40	120	20	10	950	160.77
2	25	75	20	10	950	163.02
3	36	108	20	10	950	161.01
4	45	135	20	10	950	160.04

4. Analysis of Stiffened Panels

Step 1: Set preferences.

- Main Menu> Preferences
- (check) “Structural”
- [OK]

Step 2: Define constant material properties.
- Main Menu>Pre-processor> Material Props> Material Models
- (double-click) “Structural”, then “Linear”, then “Elastic”, then “Isotropic”
- “EX” = 2E11
- “PRXY” = 0.3
- [OK]

- (double-click) "Density"
- "DENS" = 7860
- [OK]
- Material> Exit.

Step 3: Define element types

- Main Menu>Pre-processor> Element Type> Add/Edit/Delete
- [Add...]
- "Structural Solid" (left column)
- "Tet10node187" (right column).
- [OK].
- Toolbar: SAVE_DB.

Step 4: Modelling

By using the key points enlisted in table 4.1, the modelling can be carried out and final model is shown in the Figure 4.1

1. Main menu>Pre-processor>modelling>create>key points>In active CS

Table 4.1: Key points

Key point	X	Y	Z
1	0	0	0
2	800	0	0
3	800	20	0
4	0	20	0
5	50	20	0
6	50	50	0
7	150	50	0
8	150	20	0
9	200	20	0
10	200	50	0
11	300	50	0
12	350	20	0
13	350	50	0
14	450	50	0
15	450	20	0
16	500	20	0
17	500	50	0
18	600	50	0
19	600	20	0
20	650	20	0
21	650	50	0
22	750	50	0
23	750	20	0

2. Pre-processor>modelling>create>lines>straight lines>joining the key point lines.
3. Pre-processor>modelling>create>areas>arbitrary>By lines>pick up the key point lines.
4. Main Menu>Pre-processor>Modelling> Operate> Extrude> Areas> By XYZ Offset

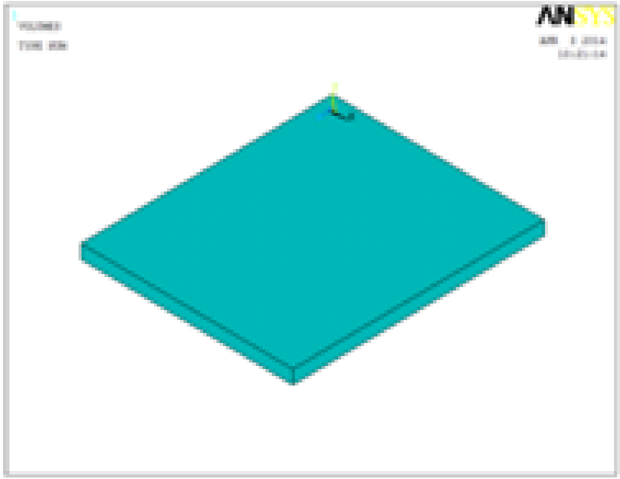


Figure 4.1: Without Stiffener

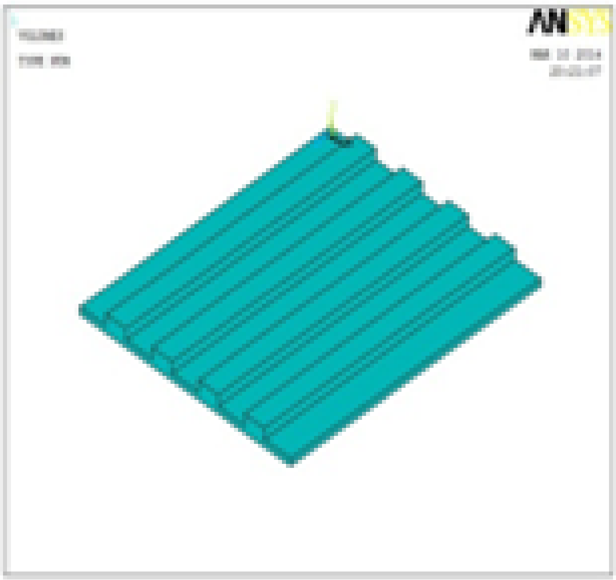
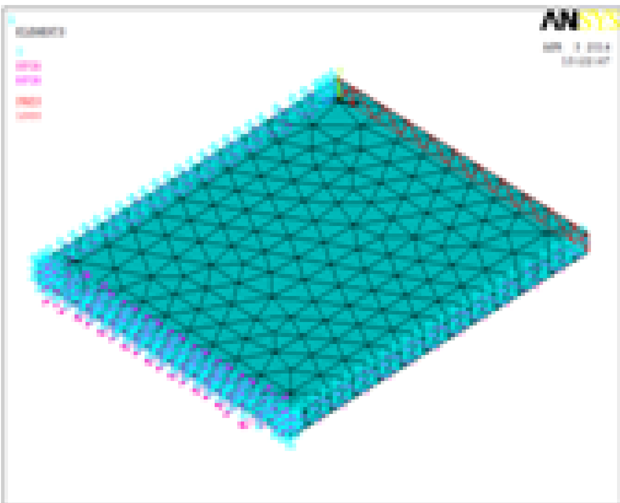
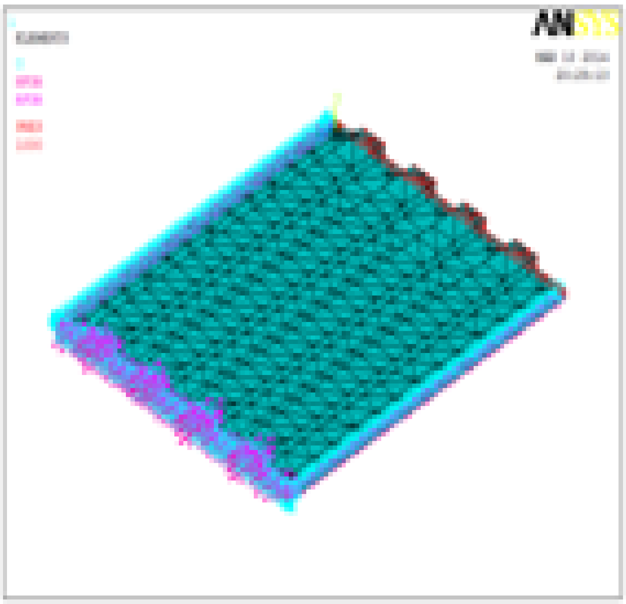


Figure 4.2: With Stiffeners

4.1 Boundary Conditions

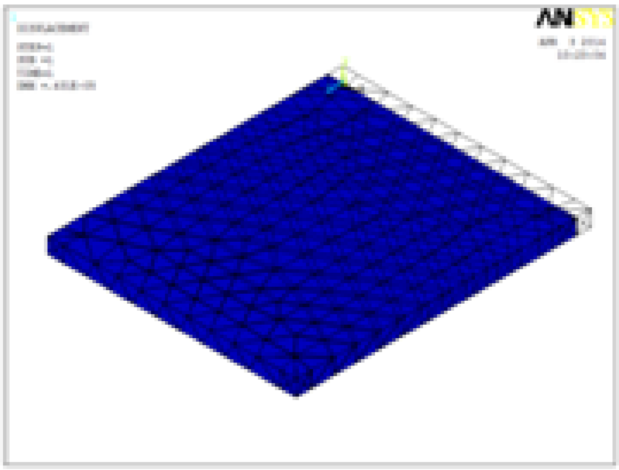


4.3.: Without stiffner plate



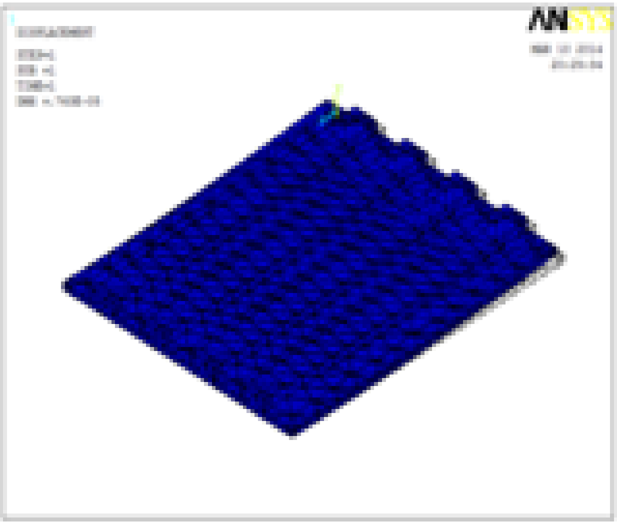
4.4: With stiffner plate

4.2 Static Analysis-Maximum Deformation



4.5: Without stiffner Plate

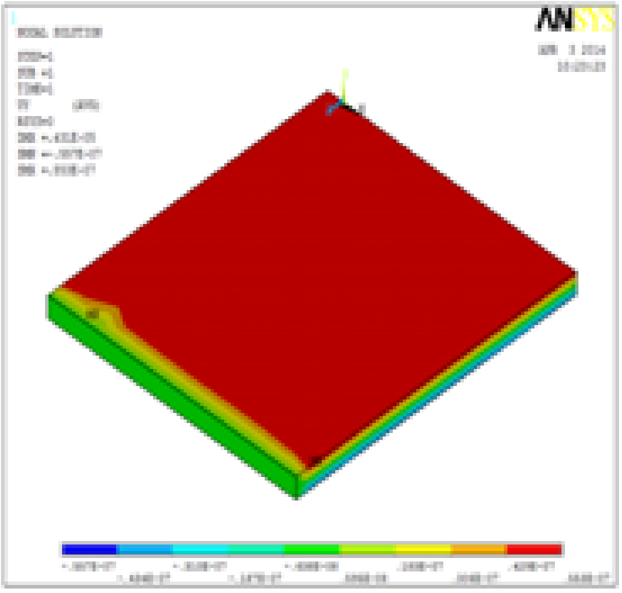
The maximum deformation is 0.431 e^{-5}



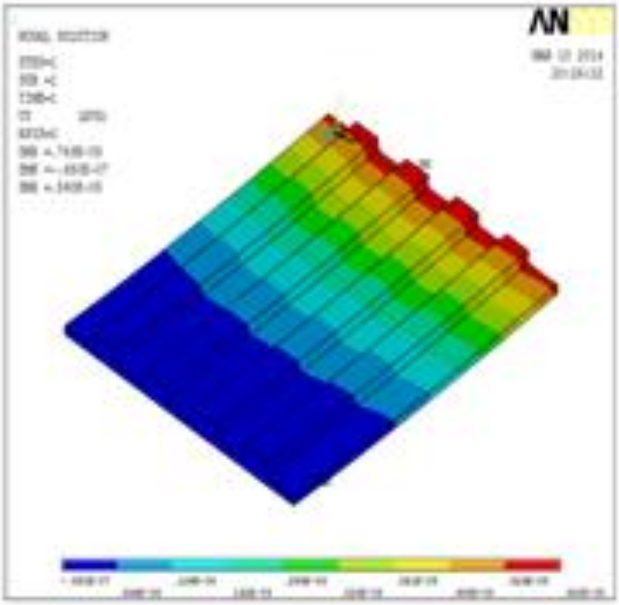
4.6: With stiffner plate

The maximum deformation is 0.764 e^{-5}

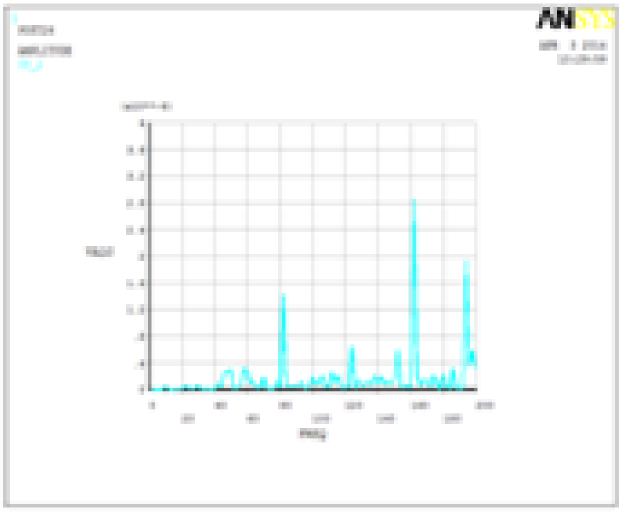
4.3 Static Analysis-Y Component Displacement



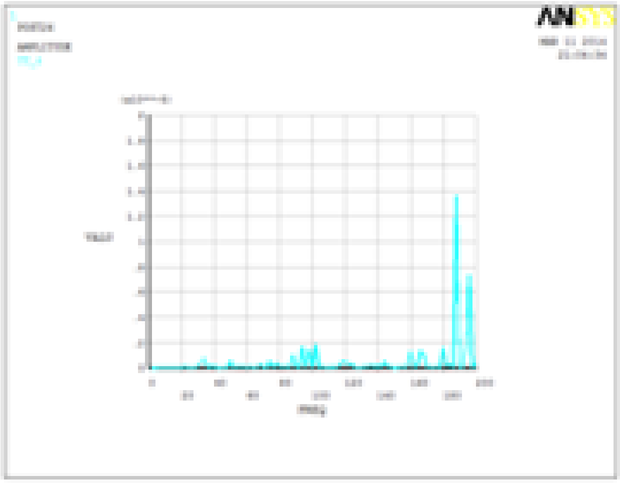
4.7 The maximum stress is 0.553e^{-7}



4.8: The maximum stress is 0.590e^{-5}



The maximum Amplitude is 2.8 e^{-6}

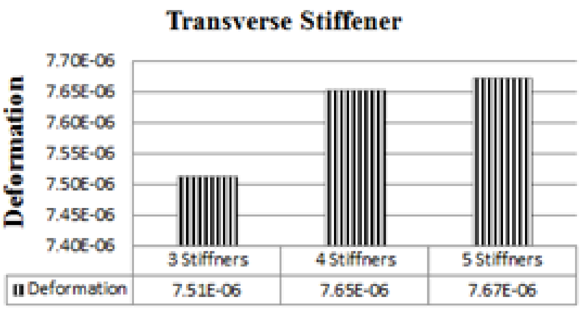


The maximum Amplitude is 1.3 e^{-6}

5. Results and Discussions

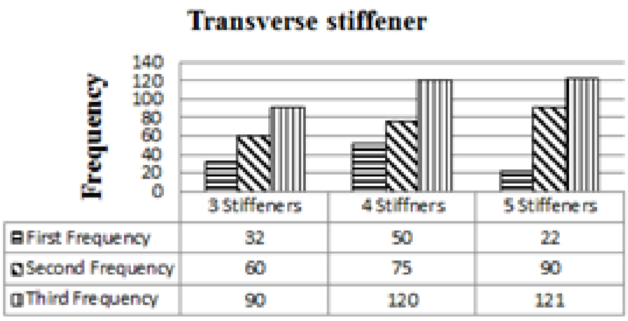
Some of the results in rectangular plates

The maximum deformation is 7.67e-6



5.1 Static results

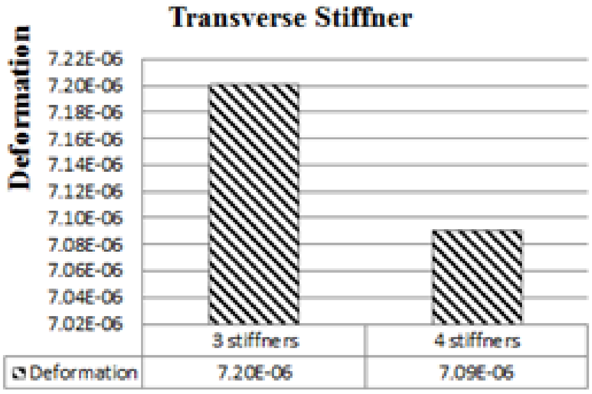
The maximum frequency is 120Hz



5.2 Dynamic Response

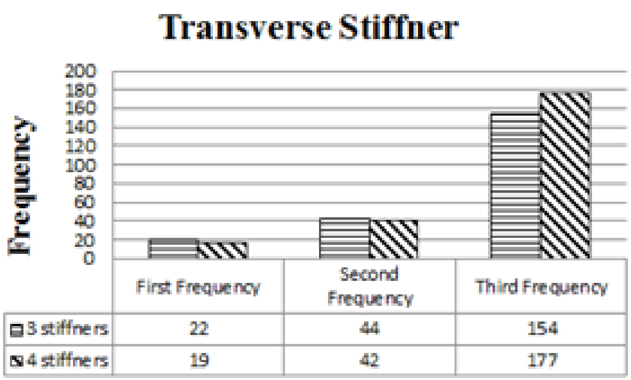
5.1 T-Section

The maximum deformation is 7.20e-6



5.3 Static Response

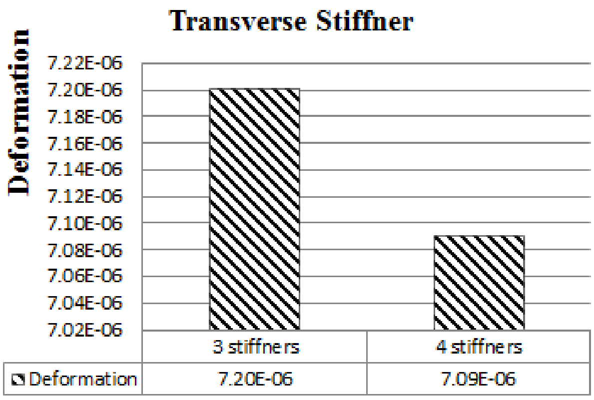
The maximum frequency is 180Hz



5.4 Dynamic Result

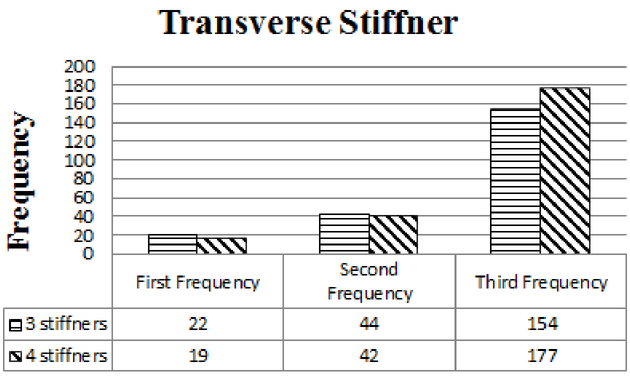
5.2 L-Section

The maximum deformation is 7.20e-6



5.5 Static Results

The maximum frequency is 180Hz



5.6 Dynamic Result

6. Conclusion

The static and dynamic behaviour of stiffened panels has been investigated using numerical analysis software. In order to improve the static and dynamic behaviour of the shaper machine frames, it can be redesigned into stiffened panels.

The shaper machine frame is designed as a stiffened panelsin (Rectangular-section, T-section, L-section). From the results indicated that the cross and horizontal stiffener can increase the specific stiffness by4% to 8% weight reduction and its dynamic performances is also better with increases in the first natural frequencies. The modified design is effective in improving the static and dynamic structural performances of machine tool structures.

Reference

[1] DhrubaJ "Re-Examination of Design Criteria for Stiffened Plate Panels" Ship Structure Committee U.S. Coast Guard June 1994.
[2] Hung-Chien Do "Ultimate limit state assessment of stiffened panel structures for very large ore carrier via nonlinear finite element method"International Journal of Recent advances in Mechanical Engineering (IJMECH) Vol.2, No.2, May 2013.
[3] Lars Brubak "Semi-analytical post buckling analysis of stiffened plates with a free edge" Dept. of Math., University of Oslo Research Report in Mechanic October 2008.
[4] Ming-Wei Hsieh "Investigation on the blast resistance of a stiffened doorStructure" Journal of Marine Science and Technology, Vol. 16, No. 2, pp. 149-157 (2008).
[5] Matthew Collette "Strength and Reliability of Aluminium Stiffened Panels" School of Marine Science and Technology Faculty of Science, Agriculture and Engineering University of Newcastle June 2005.
[6] Malleswara Swami "Design and structural analysis of CNC vertical
[7] milling machine bed" International Journal of AdvancedEngineering Technology E-ISSN 0976-3945.
[8] Pravin P. Hujare "Design and analysis of door with stiffened plate" International Journal of applied engineering I JAE 1 (2011) 30-36.
[9] Syathabuthakeer. S. "Structural redesigning of a CNC lathe bed to improve its static and dynamic characteristics" International journal of engineering.
[10] Salgado N.K "An object oriented system for damage tolerance design of stiffened panels" Engineering Analysis with Boundary Elements 23 (1999) 21–34.
[11] Tavakoli H.R. "Numerical dynamic analysis of stiffened plates under blast loading" Latin American journal of solid and structures 11(2014) 185 – 199.
[12] Thayamballi "Mechanical collapse testing on aluminium stiffened panels for marine applications"ship structure committee 2008.
[13] Yong Chen "Ultimate strength analysis of stiffened panels using a beam-column method" International Journal of applied engineering 2003