

# Ship Structural Integrity of Aluminium Stiffener Panel for Consequence Reduction

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*Received: 13 December 2011 Accepted: 1 January 2012 Published: 15 January 2012*

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## Abstract

The aluminium stiffener panels in ship structure are paramount to ensure safety and to guarantee the structural strength and integrity of the ship. The aluminium stiffener panel is very important to ship building, especially when the ship faces collision or unstabilized structure; the aluminium stiffener panel tends to increase bending moment, vertical shear force and stresses. This study investigate the strength of the aluminium stiffener panel at the amidship bulkhead with different shapes and types in order to determine the strength of the aluminium stiffener from its features. AA 5083-H116 aluminium stiffener panel used has been approved by the recognized organization for shipbuilding. The aluminium stiffener panel has been tested using bending moment test and compressive load to obtain the highest endurance. Three types of aluminium stiffener panels, which are a flat shaped, L-shaped and T-shaped panel, are used in order to obtain the best panel ability for a better ship structural system. The aluminium stiffener panel is tested at the area where it is different to determine area where they are affected by extreme heat due to the welding results and fabrication. The result has showed that the aluminium stiffener panel in shipbuilding process effect in an area without extreme heat is more stable.

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**Index terms**— Ultimate strength, heat affected zone, collision damage, aluminium stiffener panel, bulkhead, amidships.

## 1 Introduction

a) Background the stiffener panel on ship structure is one of the support element from basic of building ship structure such as type flat bar, T bar and L bar used in shipbuilding construction, they are used commonly in the bulkhead and amidships. Study on ship strength and integrity determined from life cycle of ship and return of investment leads to ship own or spending more money on maintenance. Stiffened plates in ships revealed that other structures may be exposed to complex stress patterns due to simultaneously acting in-plane biaxial and shear stresses in design of such elements, buckling and ultimate strength are important issues researched by Brubak, L. and Hellesland J. (2008). Stiffened plates are required to resist extreme loading conditions, for example in term of axial compressive loads or lateral pressures studied by Khedmati M.R., and Ghavami K. (2009). The principal variables studied are the plate thickness, boundary conditions and the stiffener geometries beside the geometrical imperfection, the width of the welding heat affected zone (HAZ) and welding residual stresses are also examined.

The study involved of ship structure construction and testing of different part of aluminium stiffener panel to investigate be more strength because they can cause support load weight on the ship such as machinery, fuel, oil and other equipment. Aluminium stiffener should be more strengthen for support the ship body, Therefore, it is important to find ship structure in respect to fatigue to determine structural integrity. b) Inherent Problem Associated with Ship Structure integrity i.

43 The variation in the buoyant forces increased the bending moment, vertical shear force, stresses and amidships  
44 the buoyancy forces design in such situation will tend to 'hog' the vessel, if the trough is amidships the buoyancy  
45 forces will tend to 'sag' the ship. ii.

46 The stiffness against bending tend to increased by a hollow section with space between the stiffeners which  
47 is reduced by the twin-wall section shape compared to the single-wall stiffeners such as T-shaped or L-shaped  
48 stipulated by Ye N. and Moan T. (2007).

49 iii. Fatigue becomes the governing criteria in the design of the mid-ship stiffener/web frame connections at  
50 the top and bottom has studied by Ye N. (2007).

51 The study asses ship structure reliability strength of aluminium stiffener panel from outside pressure and  
52 consequential damages. The study investigated the aluminium stiffener strength by shape and type of stiffener  
53 at bulkheads and amidships and determined reliable effect of aluminium stiffener strength from their behavior.

## 54 2 II.

### 55 3 Methodology

56 The study process involves the following stages: a) Theoretical Modeling

57 The theory of stress and strain is compared with the value of lab test for validation purpose to deduce and  
58 recommendation as required. Compressive stress acts to reduce the length of the material (compression member)  
59 in the axis of the applied load is modelled.

### 60 4 b) Field Work at Shipyard

61 The plate of aluminium alloys 5083-H116 was prepared at shipyard before the construction the aluminium stiffener  
62 panel. The plate is cut and prepared to get the dimension based on the ship requirement. Aluminium stiffener is  
63 resized to deduce the parameter smaller than panel dimension suitable for the tester machine. The methods for  
64 fabricating aluminium stiffener panel are presented by MIG welding technique.

### 65 5 c) Laboratory Test Panel

66 The aluminium stiffener panel work at shipyard as followed by determination of the type and dimension. A three  
67 panel with L-shaped, T-shaped and flat shaped stiffeners fabricated from extruded aluminium profiles in alloy  
68 AA5083-H116, joined by welding, was defined.

### 69 6 d) Compression Test

70 The method of research to determined behavior of materials under crushing loads. Compressive stress and strain  
71 is calculated and plotted as a stress-strain diagram test purposed to determine ultimate strength of aluminium  
72 stiffener panel under load. The result determined when the frequency of breakage or limit of aluminium stiffener  
73 panel test. The specimen was prepared to test at universal testing machine the best environmental condition.  
74 For aluminium stiffener, good condition and room temperature to avoid the other effect on the test specimen is  
75 providing for the test.

### 76 7 e) Bending Test

77 Three-point bending test involve involved simple two-dimensional analysis of a simply supported aluminium  
78 stiffener panel loaded. The formation of the process zone and failure of the specimen are simulated in aluminium  
79 stiffener dimension steps, controlled by the displacement under the applied load. The load displacement diagram  
80 is deduced as final result for bending test.

### 81 8 f) Heat Affected Zone Test

82 The test specimen was conducted by hardness test to find the material properties in aluminium stiffener panel  
83 and material composition in the welding process.

84 The Vickers hardness test is conducted to measuring and assesses the extent of the structural weakness. The  
85 Hardness test required for welding process for construction of all type of aluminium stiffener panel. The Vickers  
86 Hardness test measurement was produced at allocated aluminium stiffener panel welding process for measurement  
87 on effected zone on panel extrusion.

### 88 9 g) Data Acquisition and analysis

89 The analysed for bending, compression test and Vickers hardness measurement has provided. The numerical  
90 analysis based on the result that was obtained from the compression test is provided. The theoretical modeling  
91 provided the theoretical and formulation of aluminium stiffener panel compressive strength. The comparison data  
92 from the compression test deduced the different of imperfection and fatigue of material strength. The reliable  
93 effect on aluminium stiffener panel from their behaviour with the characteristic of each type of stiffener panel  
94 dimension has determined. The classification society validation requirement process approval the license and ship  
95 seaworthiness is used for necessary checking of the result.

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96 **10 III.**

97 **11 Result and Discussion**

98 **12 a) Stiffener Panel Dimension**

99 Stiffener panel dimension is calculated theoretically according to suggested requirement and comparison is made.  
100 The bending test require the dimension of aluminium stiffener panel the values of thickness and area of body  
101 applied load, A. The length of specimen, L is same and width of specimen, b. The range of dimension L/b is 6.9  
102 of each specimen.

103 The total overall dimension for aluminium stiffener panel is likely to be the same with the bending test. The  
104 measurement weight of specimen, W slightly different and thickness of stiffener is also different. The flat bar (fb)  
105 is 3mm, T-bar (tb) is 4mm and angle bar (lb) is 5mm. The range of measurement is L/b that is 0.9 respectively.  
106 The aluminium stiffener panel has a cross sectional area with their body plating, have the area of dimension,  
107 sectional dimension of stiffener panel and type stiffener panel difference values and arrangement. The cross  
108 sectional area is analysed in Table 4.3 with specimen is considered. The final value of test response by bending  
109 test is shown in Table 4.5. This is required to determine the ultimate capacity load with the sample of specimen.  
110 The comparison has achieved their properties and strength values, the ultimate strength break the applied load  
111 with the stiffener panel. The aluminium stiffener is the most important in the local strength because the part  
112 is stable in that area and produced the higher strength and very reliable to use in the bulkhead amidships to  
113 prevent the consequential damage from outside.

114 **13 ii. Compression Test**

115 The result of angle bar process has show that is 8.671 kN was used to pressure the aluminium stiffener panel  
116 for testing the strength of aluminium stiffener panel. The higher load required for machine needs more applied  
117 load to damage their body until 4742.487 kN recorded. Finally the ultimate load applied with the body 5233.571  
118 kN for the angle bar specimen has recorded. The graph of compressive load against strain is shown in figure  
119 4.4. 4.9 showS the final result for compression test for requirement of test response determined a functional  
120 of each specimen in various side. The result has expected the difference in type of aluminium stiffener panel  
121 iss defined and determine the strength of aluminium stiffener panel in difference of ultimate strength. The  
122 variable of aluminium stiffener panel has required the energy of load collision in ship structure requirement of  
123 structural damage has reconsidered by owner ship to determine a value and loss of damage in their body. In  
124 the element of load of collision, the theoretical modeling energy of ship tonnage and energy load of collision is  
125 provided by the equation: The result showed that the aluminium stiffener panel area with lower heat is more  
126 stable and has reliability for approve in ship structural system. The stiffener panel strength isdetermined by the  
127 ultimate strength of the load collision applied. The effect of stiffener height on average tears length for the weld  
128 configuration shows increasing tearing threshold for a decreasing stiffener height. The deformation is slightly  
129 a symmetric with the centre in the plate and proceeds along the stiffener, when the tear reaches the weld it  
130 deviates around the weld and then proceeds along the weld and plate intersection. The importance of structural  
131 dimension of specimen prevents the outside pressure from structural damage and collapse. b) Recommendations  
132 i. The following recommendation is proposed for future improvement of this study Firstly, the actual design  
133 study compared application to a ship structure design. Also, prediction of the possible impact on structural  
134 design, development arising from these conditions is that navies have increasingly turned to the application of  
135 classification society processes and resources to help them in establishing and applying technical criteria for naval  
136 ship design and construction including those related to the ship structure. Furthermore, the study of innovative  
137 designs for maximum the crashworthiness in an accidental impact is necessary. Lastly, probabilistic approach to  
138 consequent evaluation of damaged stability and vessel survivability can be researched from this study.E T (mJ)  
139 =  $\frac{1}{2} \times (M \text{ stiff } V^2) \text{ k} -1 \text{ E load (mJ) = E T /2 (M stiff } V^2) -2$

140 ii.



Figure 1: Graph 4 .

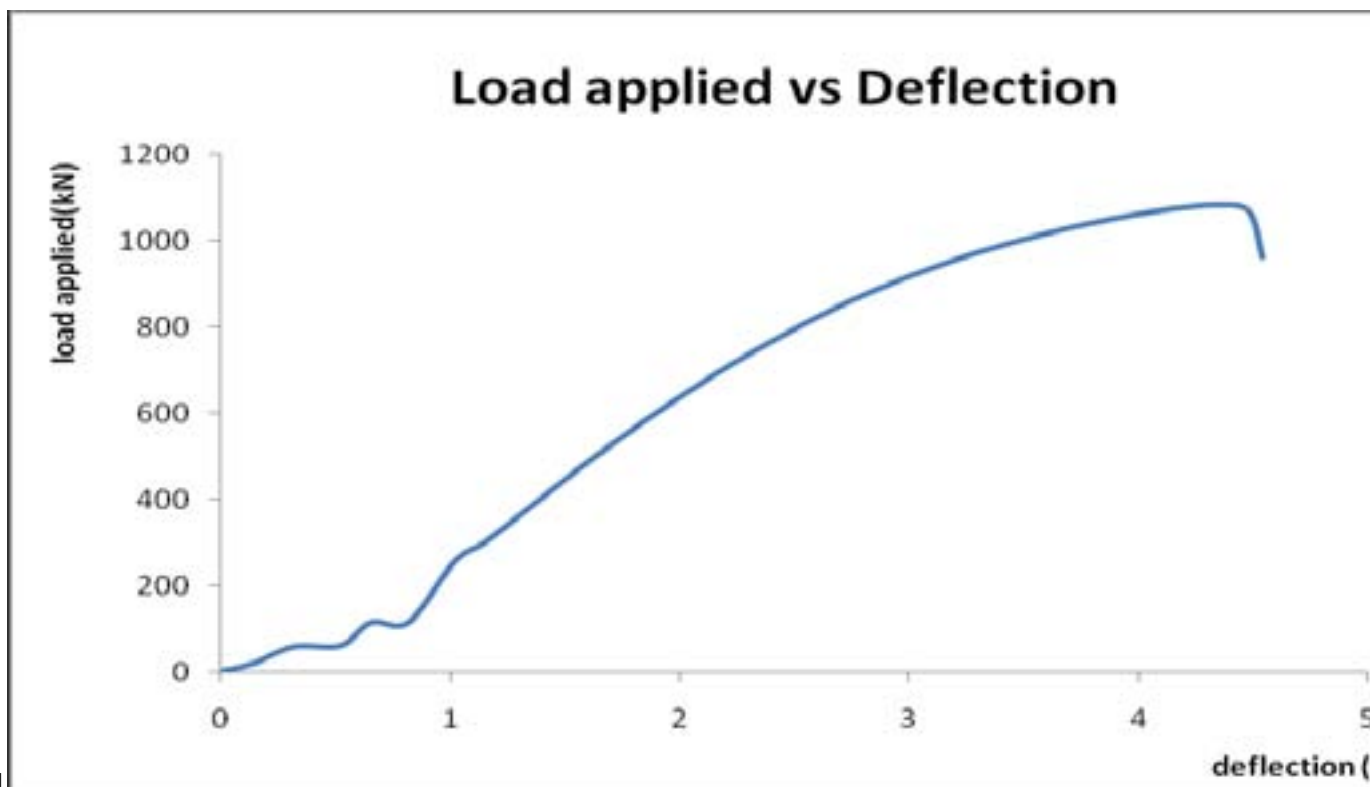
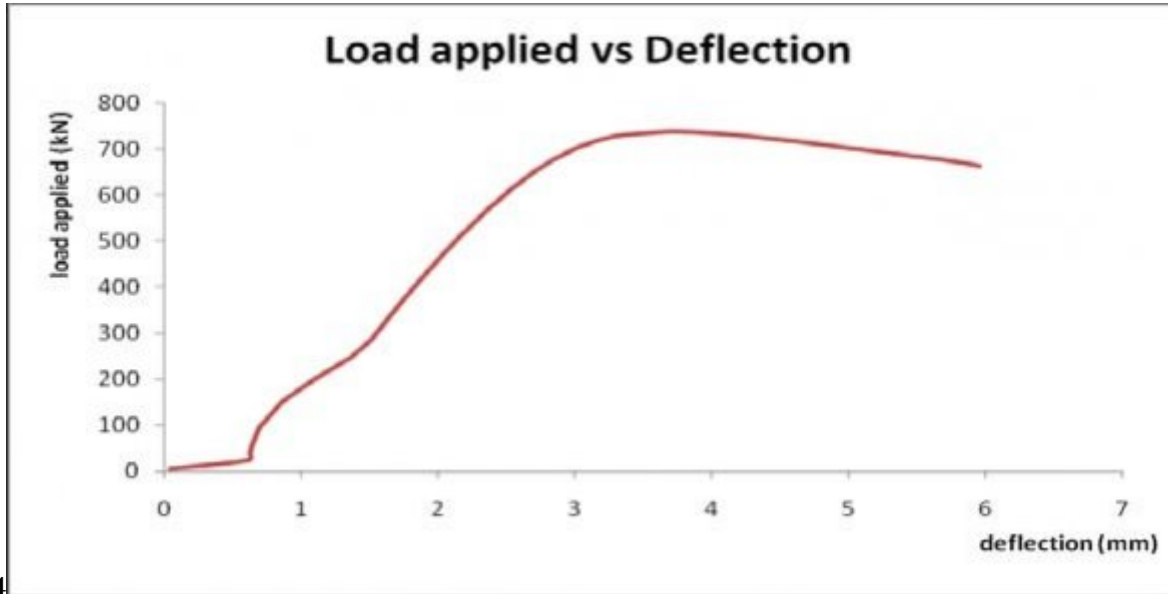
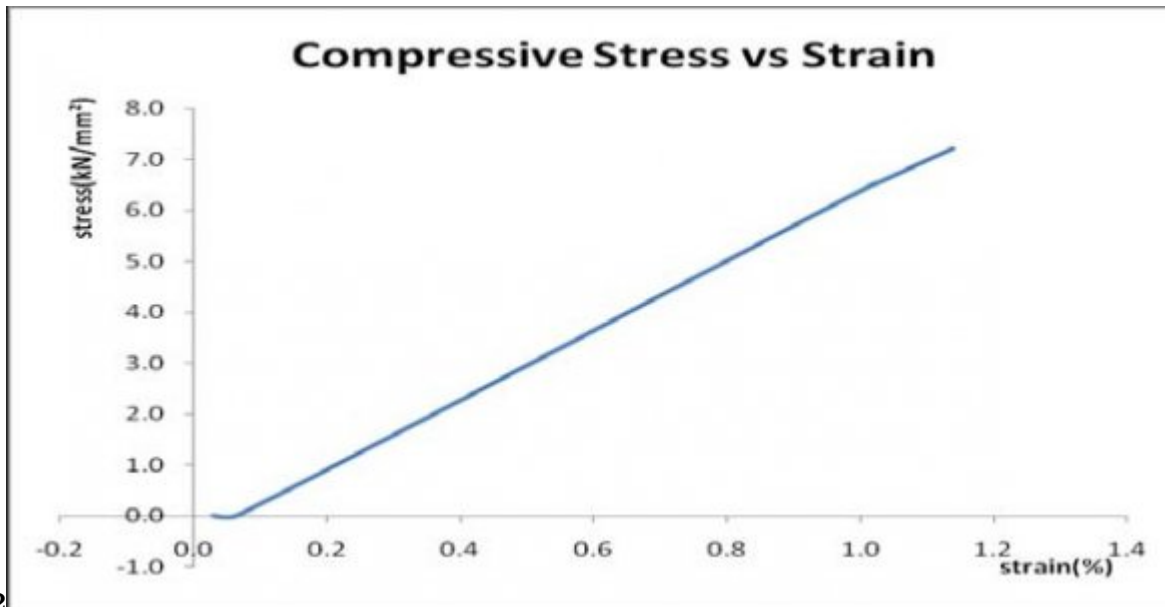


Figure 2: Figure 4 . 1 :



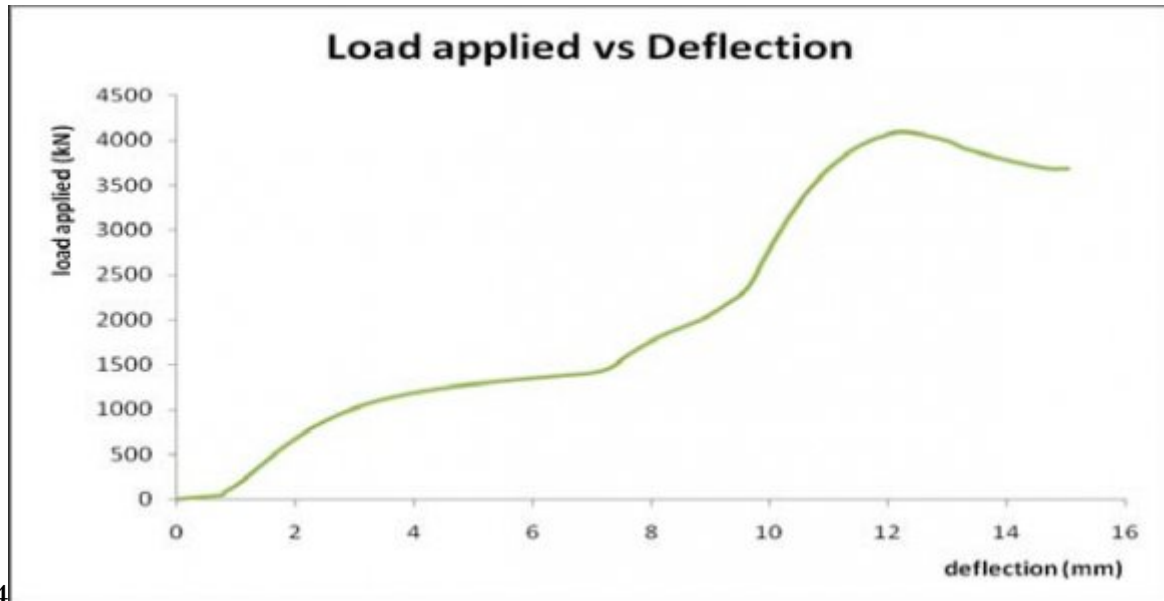
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Figure 3: Figure 4 .



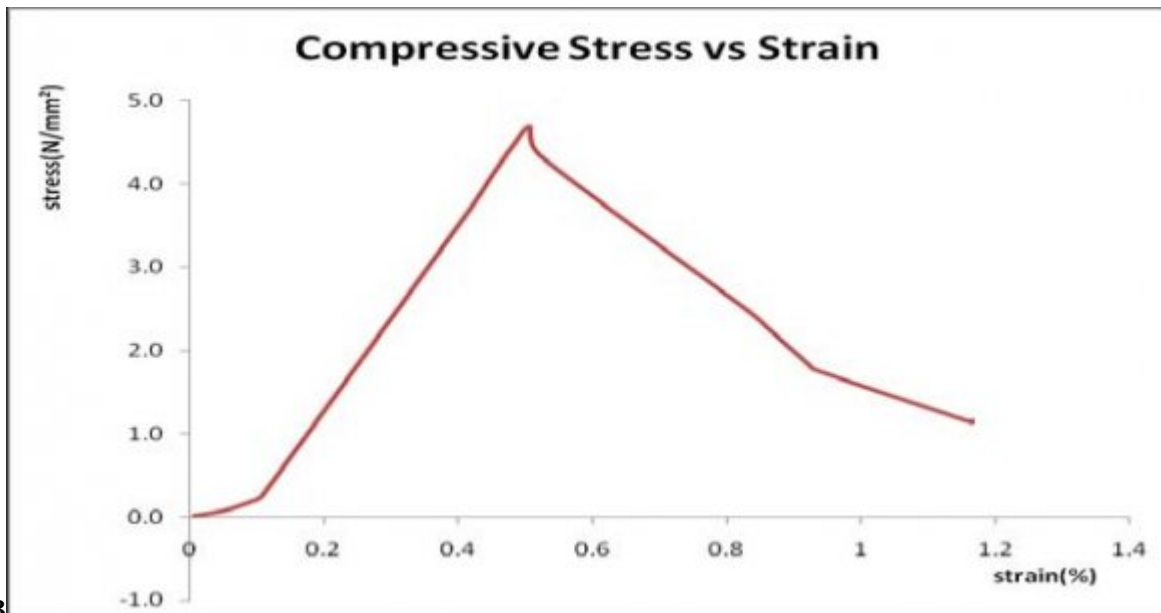
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Figure 4: Figure 4 . 2 :



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Figure 5: Figure 4 .



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Figure 6: Figure 4 . 3 :

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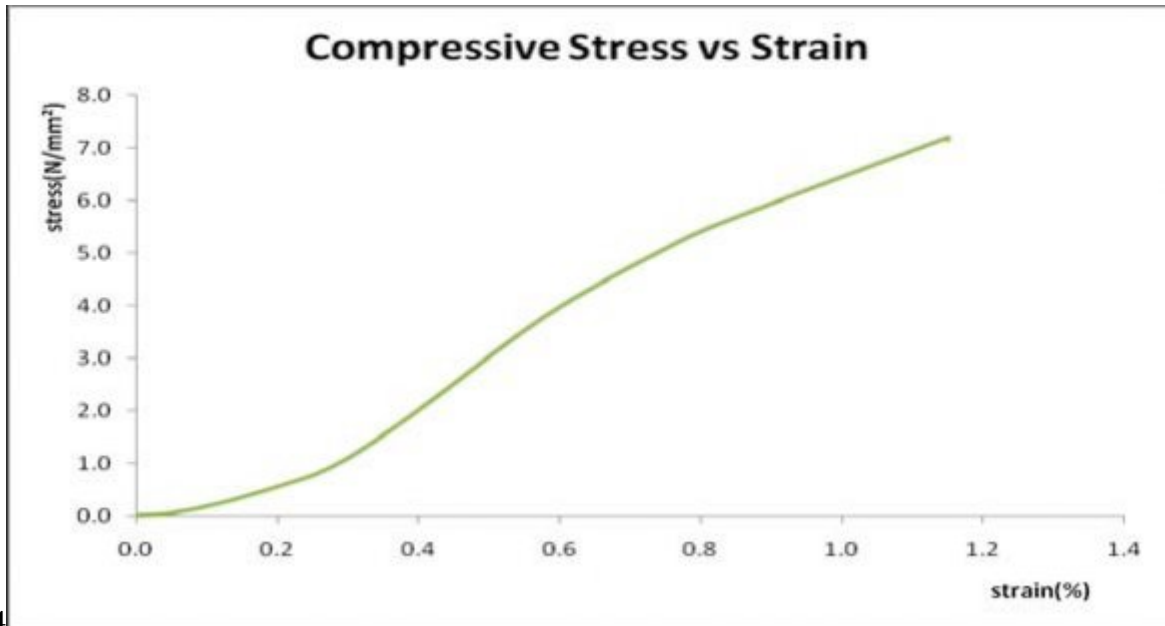


Figure 7: Figure 4 . 4 :

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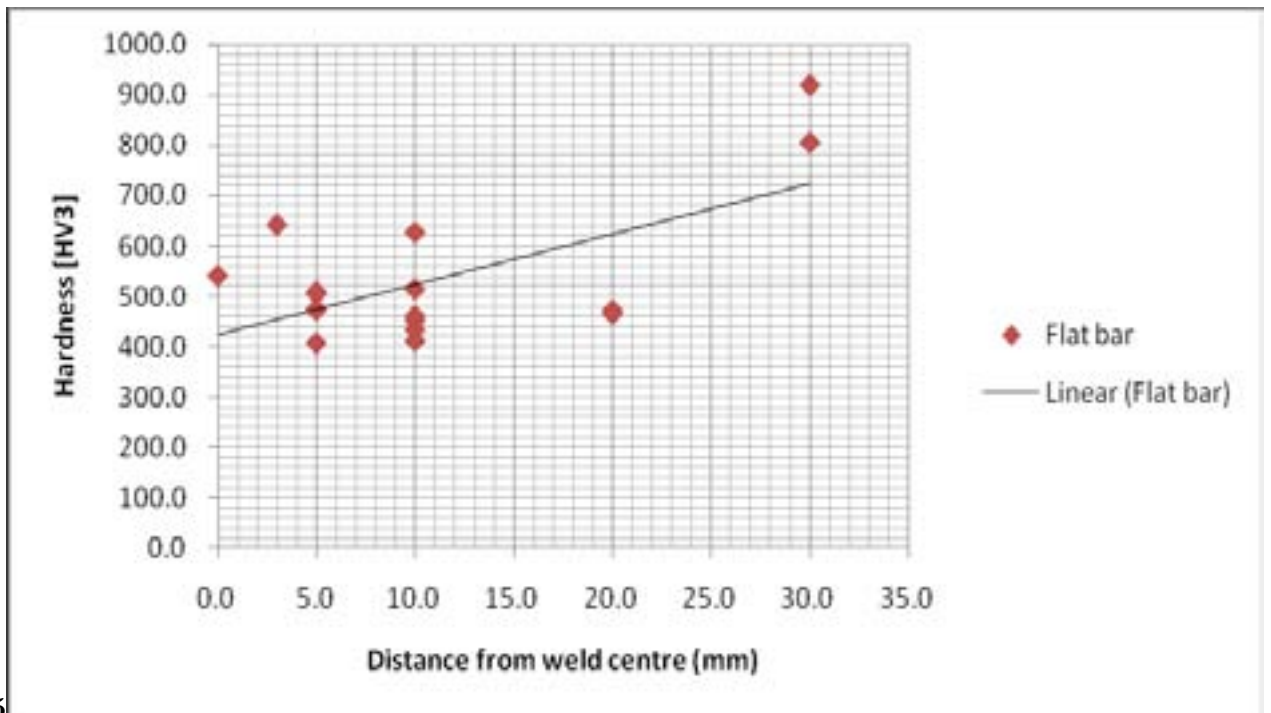


Figure 8: Figure 4 . 5 :

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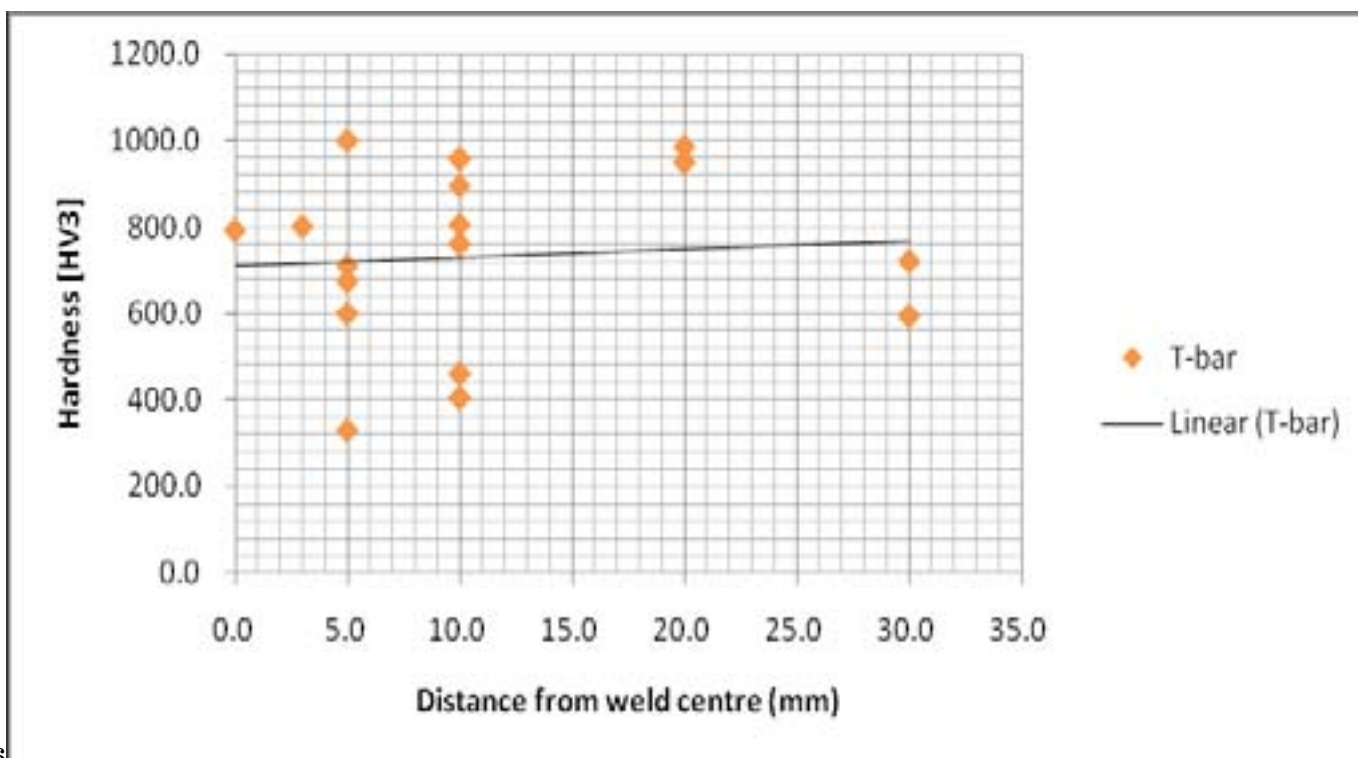


Figure 9: Figure 4 . 6 :

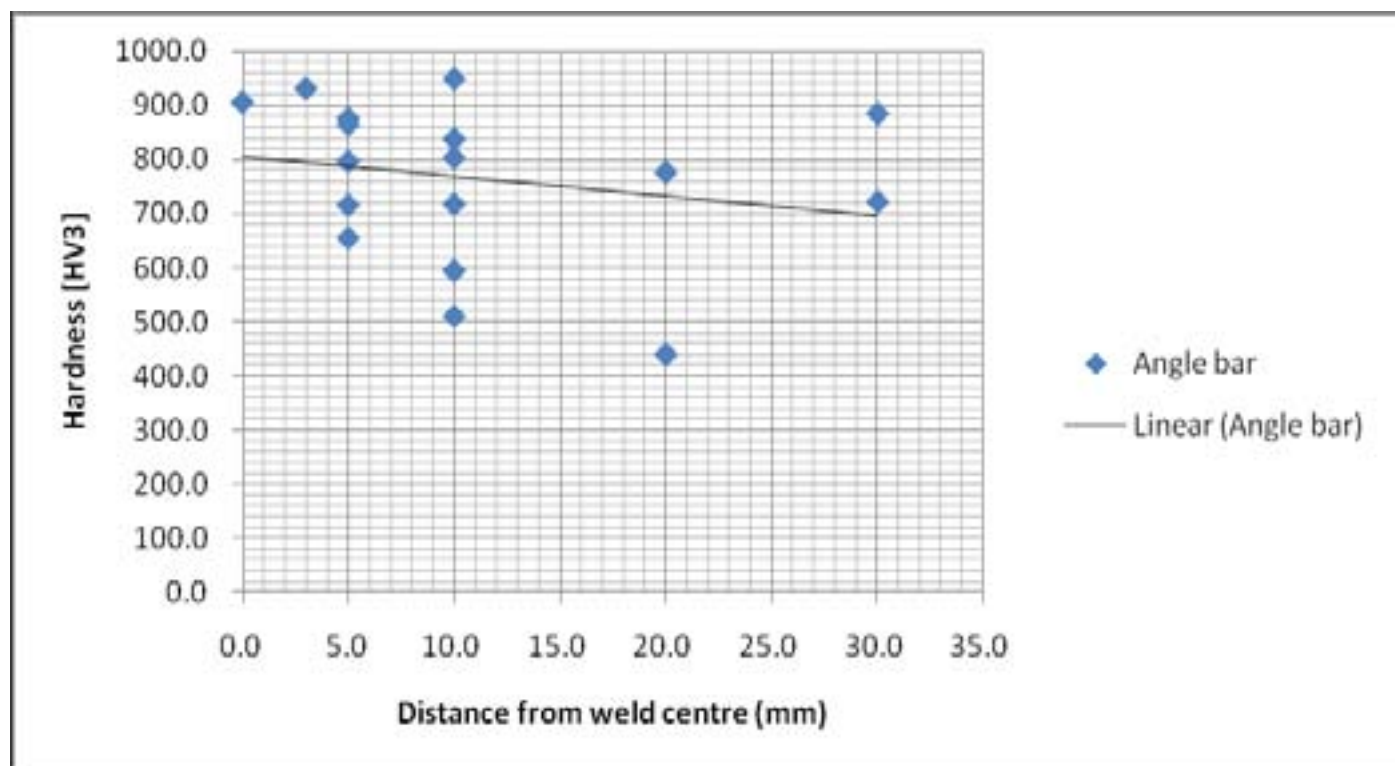


Figure 10: Ship

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3 : Cross-Sectional Area Type Of Aluminium Stiffener Panel

Type specimen	Cross-section (nominal values)	a (mm)	b (mm)	t (mm)	t w (mm)	h w (mm)	t f (mm)	b
Flar bar (fb)	345				50	4	3	51 - -
T-bar (tb)	345				50	4	4	47 4 50
Angle bar (lb)	345				50	4	5	46 5 50

[Note: © 2012 Global Journals Inc. (US)]

Figure 11: Table 4 .

4

Type Specimen	I (mm <sup>4</sup> )	r	Stiffened plate β	? W 0 max /L (×10 <sup>-3</sup> )
Flar bar (fb)	33162.7	5.6604	0.87966	0.001023
T-bar (tb)	34607.6	5.0077	0.65974	0.001157
Angle bar (lb)	40556.7	4.8488	0.52779	0.001195

b) Ultimate Strength And Maximum Load On Aluminium Stiffener Type  
i. Bending Test

Figure 12: Table 4 .

45

Type specimen	Max. Load,k (N/mm <sup>2</sup> )	Deflection (mm)	Test Response Break,k	Elastic Modulus,E (N) (N/mm <sup>2</sup> )	Yield Strength (N/mm <sup>2</sup> )
Flat bar	0.051	5.952	6513.113	0.091	0.16
Tbar	0.185	15.030	36077.32	0.332	0.184
Angle bar	0.042	4.537	9445.379	0.076	0.114

Figure 13: Table 4 . 5 :

49

Type	E (N/mm <sup>2</sup> )	Yield point (N)	Max.load Fu (N/mm <sup>2</sup> )	Test Response				
				Break (N)	Extension Vu (mm)	Stress ? u (kN/mm <sup>2</sup> )	Strain ? u (%)	kb/EA
(fb)	20.701	19090	0.23	4696	4.661	4.690	1.165	27.33
(tb)	38.692	51449	0.43	50890	4.583	7.157	1.151	90.71
(lb)	38.138	46681	0.424	51323	4.553	7.218	1.138	92.81

Figure 14: Table 4 . 9 :

4

Specimen	E (kN/m <sup>2</sup> )	M stiff (kg)	F u (kN)	V u	Tonnage of ship (ton)	E T (mJ)	E load (mJ)
Flat bar	2.07	0.38	19.09	0.16	1000	14.08	211.43
					2000	28.16	422.86
					3000	42.24	634.28
					4000	56.32	845.71
					5000	70.4	1057.14
T-bar	3.81	0.72	51.44	0.16	1000	14.08	1987.18
					2000	28.16	3974.36
					3000	42.24	5961.54
					4000	56.32	7948.72
					5000	70.4	9935.90
Angle bar	3.87	0.64	46.68	0.16	1000	14.08	1627.92
					2000	28.16	3255.85
					3000	42.24	4883.77
					4000	56.32	6511.69
					5000	70.4	8139.61

IV. Conclusion and Recommendation

a) Conclusion

Figure 15: Table 4 .

.1 Acknowledge

141 I would like to thank Faculty of Maritime Studies and Marine Science (FMSM), Universiti Malaysia Terengganu  
142 for their assistance extended to facilitate the journey of this Final Year Academic Projects. The most appreciation  
143 is intended for Mr. Ir. Oladokun Sulaiman as supervisors who provide guidance and assistance throughout this  
144 project. At same, thanks for  
145  
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