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The Influence of the Stiffened Plate Distance to the Ultimate Strength under Blast Loading Condition

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ABSTRACT

The ultimate strength is one of the most important aspect in all design criteria. Blast or explosion may takes place on the offshore structure and it is a catastrophic failure with small probability and cannot be predicted. The stiffened plate distance has significant influence to the ultimate strength under blast loading condition. In order to know the influence, the analysis must be conducted. In the present study, the analysis of the influence of the stiffened plate distance is performed using The Non-Linear Finite Element Method (FEM) code ANSYS. The investigation of the stiffened plate is located at the deck part of the structure. The stiffened plate distance is varied to know the influence due to blast loading. The blast loading is assumed to be applied in vertical direction combined with the uniaxial thrust. The fixed supported of boundary condition is applied along the side of the stiffened plate. The result obtained by the FE analysis for the influence of the stiffened plate to the ultimate strength under blast loading is compared for any stiffened plate distance and the behavior of the ultimate strength including post ultimate strength is also presented in this paper.

Keywords: Stiffened plate, blast loading, finite element method, ultimate strength

1. INTRODUCTION

One of the most important aspects in structural design is to analyze upon the ability of the structure to require the objective of the design including that the structure will not fail under any activities condition. A structure may fail in the operation due to some cases those are; an extreme environmental, overload than the structural capacity and other factors caused by human error which may affect the structural effectiveness. Blast or explosion is an accident increased rapidly in volume with danger energy exploded, sometimes with spending of high temperature and produced gas unpredictable. Blast affect pressure at the local place where it may occur. Fire, blast or explosion and other accident which may effect of collapse to the offshore structure to all or partially which cause dead, cost, material and environmental pollution. Because of these accidents, the consideration must be given in the structural design, layout of the facilities and equipment to minimize the incident. In conjunction with this, the structural design under blast loading condition is strictly conducted. The influence of structural dimension such as number of stiffener, section property, distance and so on is included in the calculation especially for the ultimate strength assessment.

In the present study, the analysis of the influence of the stiffened distance is performed using The Non-Linear Finite Element Method (FEM) code ANSYS. The investigation of the stiffened plate is located at the deck part of the structure. The stiffened plate distance is varied to know the influence due to blast loading. The blast loading is assumed to be applied in vertical direction combined with the uniaxial thrust. The fixed supported of boundary condition is applied along the side of the stiffened plate. The result obtained by the FE analysis for the influence of the stiffened plate to the ultimate strength under blast loading is compared for any stiffened plate distance and the behavior of the ultimate strength including post ultimate strength is also presented in this paper.

2. FINITE ELEMENT MODEL

A series of Finite Element analysis (FE analysis) is carried out in this study. The stiffened plate model with various distances is taken to be considered for the ultimate strength calculation.

The boundary condition is assumed to be fixed alongside of the stiffened plate. Four cases are considered in the analyses those are; two stiffeners with 600 mm of distance, two stiffeners with 800 mm of distance, three stiffeners with 600 mm of distance and three stiffeners with 800 mm of distance. The blast loading is applied in vertical direction perpendicular to the area of the plate combined with the uniaxial thrust. The fine meshes are performed to obtain good accuracy of the ultimate strength calculation. The finite element model of the stiffened plate is illustrated in fig.1 as follow and the analysis condition is also shown in fig. 2.

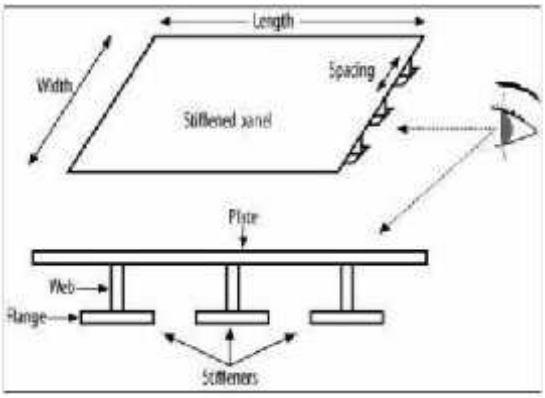


Figure 1. Stiffened plate

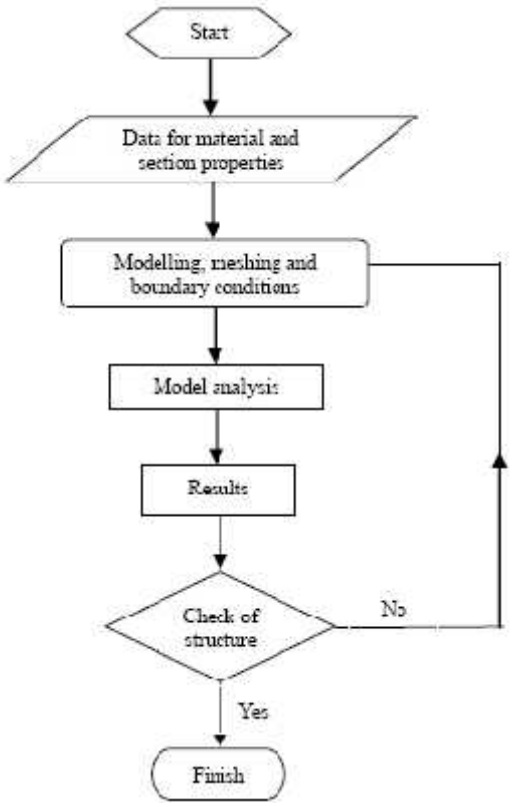


Figure 2. Flow chart

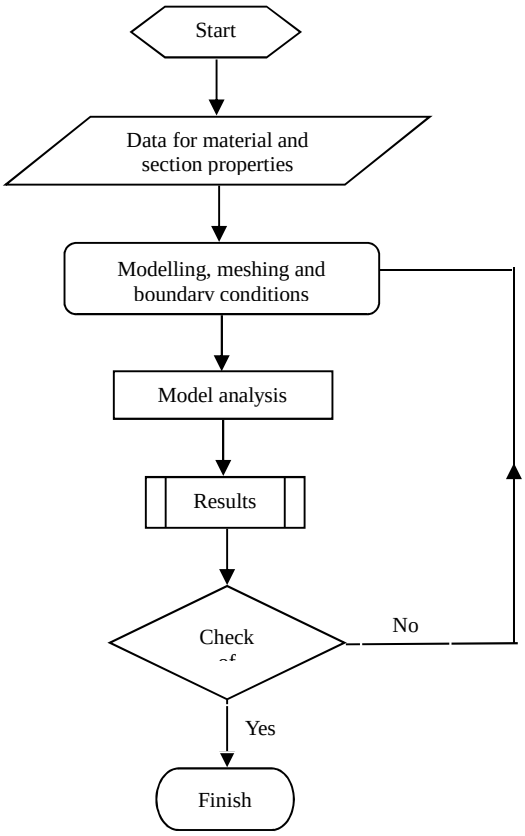


Fig. 3 and Fig. 4 illustrate the boundary condition for two and three stiffeners. The yellow color indicates the boundary condition where it is applied to all sides of the stiffened plate and it is assumed to be fixed. It is considered that the T profile is used for both models.

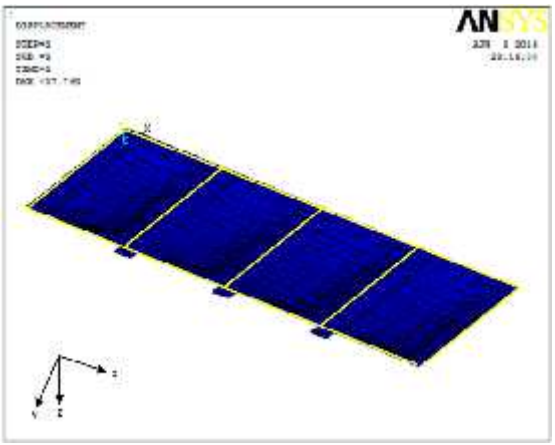


Figure 3. Boundary condition for two stiffeners

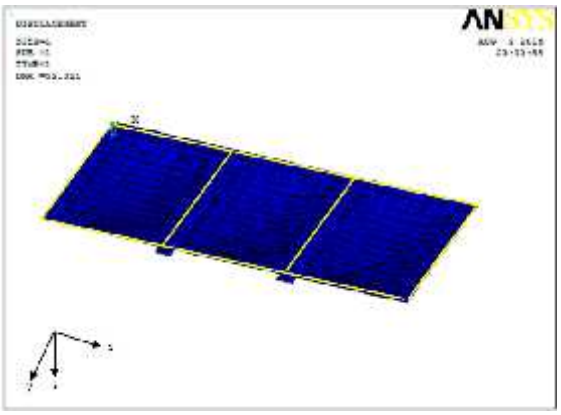
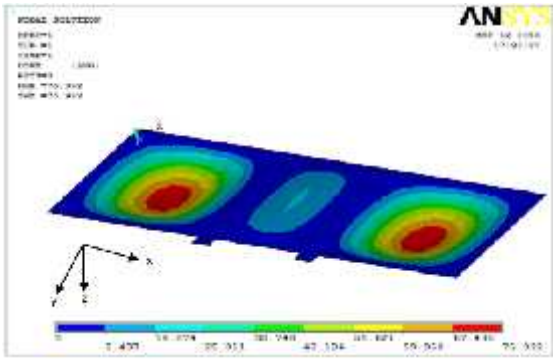


Figure 4. Boundary condition for three stiffeners

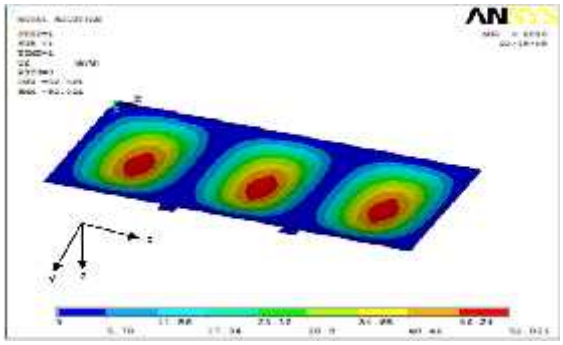
3. RESULT AND DISCUSSION

The analysis of the ultimate strength for plate and stiffened plate have been investigated by some researchers such Wibowo [1] considered the influence of stiffened plate distance using finite different method and Kumar [2] use a new stiffened plate element for the analysis of ship structure. The analysis was performed by finite element method. The advance of the plate and stiffened plate analyses was also performed by Szilard [3] and Timoshenko [4]. In the present study, the influence of the stiffened plate distance is analyzed using the finite element method called ANSYS. The result obtained is summarized and discussed including the behavior of the progressive collapse for stiffened plate under blast loading condition.

Fig. 5 shows the deformed shape of two stiffeners with 600 mm and 800 mm of distance. It is found that the critical deformed is located in the middle of each area of the stiffened plate. An expected result obtained by FE analysis correspond with the blast loading condition since that is distributed in the area of the plate.

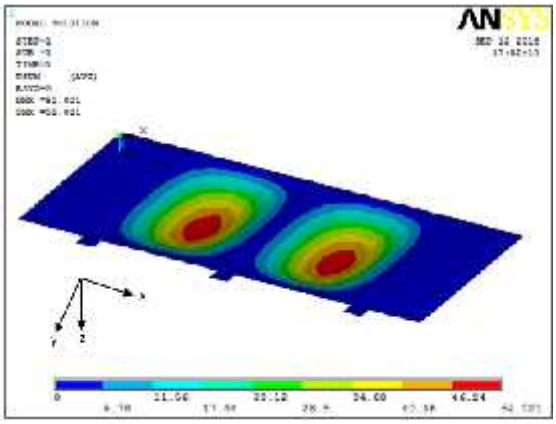


(a) With 600 mm of distance

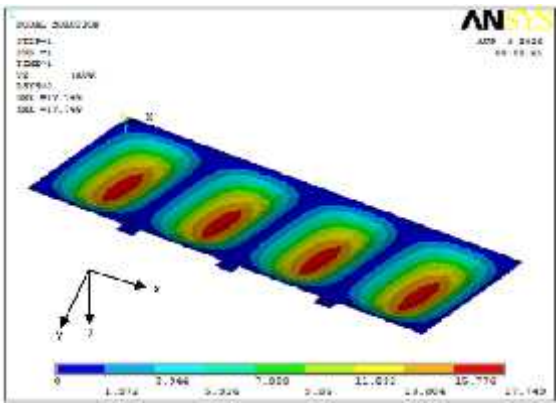


(b) (b) with 800 mm of distance

Figure 5. Deformed shape of two stiffeners



(a) With 600 mm of distance



(b) with 800 mm of distance

Figure 6. Deformed shape of three stiffeners

Fig. 6 shows the deformed shape for three stiffeners with 600 mm and 800 mm of distance. Again, it is found that the deformation takes place in the middle of each area of the stiffened plate. The result obtained by FE analysis correspond with the blast loading condition since that is distributed in the area of the plate is expected. Fig. 7 express the stress-displacement relationship. It is observed that stress increased followed by displacement, then dropdown when unloading occurs.

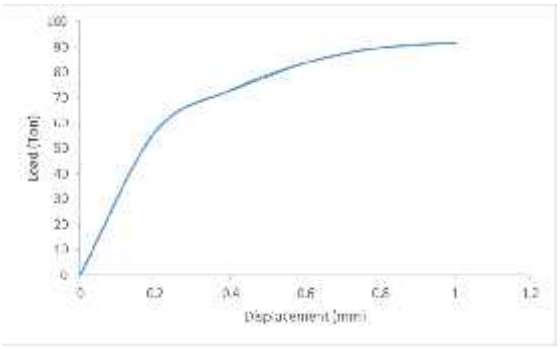
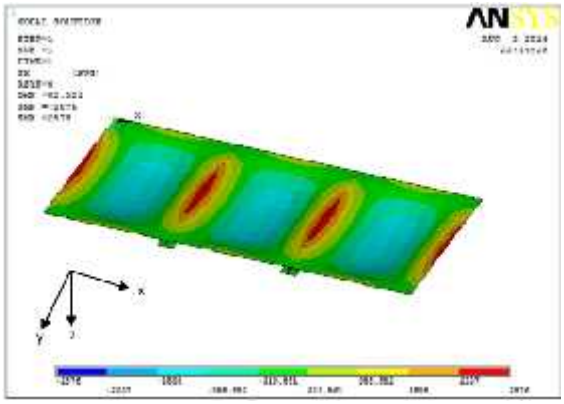
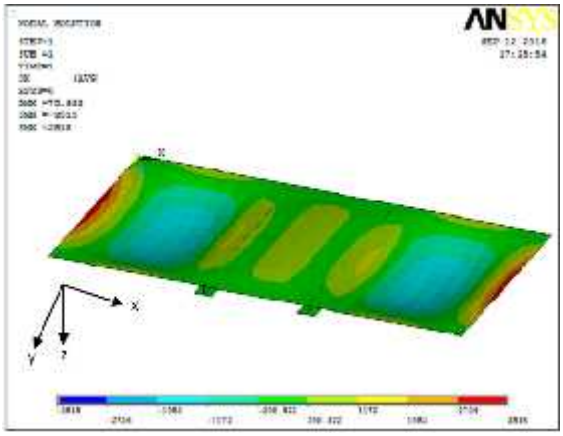


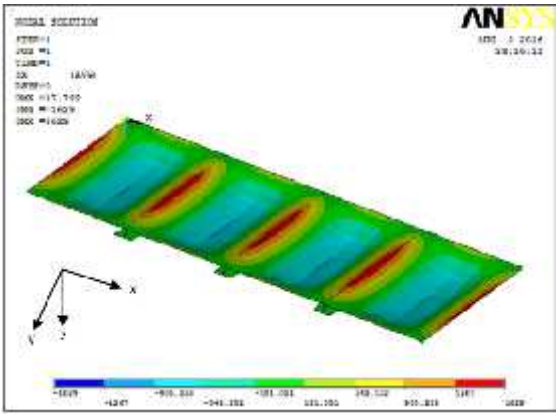
Figure 7. Stress-displacement relationship



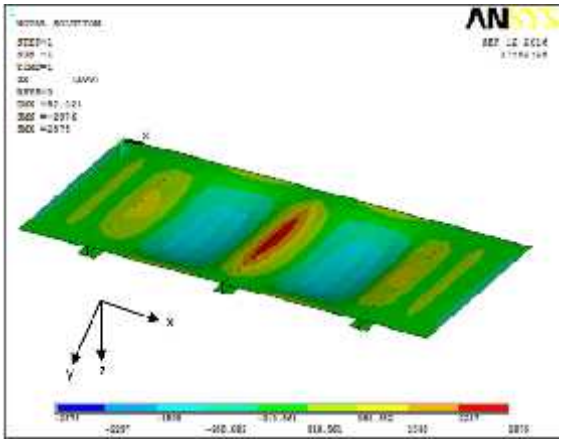
(a) with 600 mm of distance



(b) with 800 mm of distance
Figure 8. Von Misses Stress Distribution for two stiffeners



(a) with 600 mm of distance



(b) (b) with 800 mm of distance
Figure 9. Von Misses Stress Distribution for three stiffeners

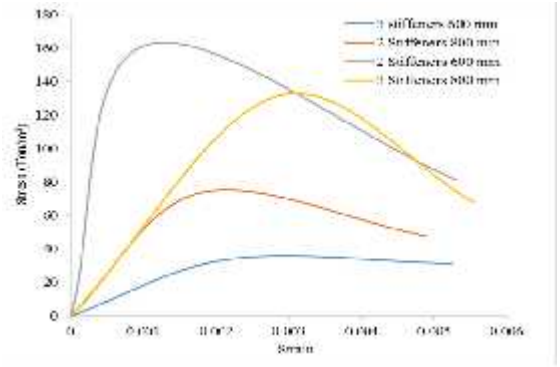


Figure 10. Stress-strain relationship

Fig. 10 describes the comparison of the ultimate strength for stress-strain relationship four cases. According to figure that two stiffeners with 600 mm of distance gives larger ultimate strength, then followed by three stiffeners with 800 mm, two stiffeners with 800 mm and three stiffeners with 600 mm of distance. It is also observed that the bending stiffness is also decreased.

4. CONCLUSIONS

The influence of the stiffened plate distance to the ultimate strength has been obtained by using FE analysis. The following conclusions can be drawn:

1. An expected result of the influence of the stiffened plate distance to the ultimate strength is significant since the stiffener distance is completely different.
2. The influence of stiffened plate distance gives effect to deformed shape and stress concentration with two and three stiffeners.

REFERENCES

[1] Wibowo, L.A. (2010). Analisa Pengaruh Jarak Penegar Terhadap Besar Lendutan dengan Metode Beda Hingga, Jurusan Teknik Perkapalan ITS, Surabaya.
[2] Kumar, S. & Muhkopadya, M. (2000). Finite Element Analysis of Ship Structure Using A New Stiffened Plate Element, Dept. of Ocean Engineering and Naval Architect, Indian Institut of Technology, Kharagpur. India.
[3] Szilard, R. (1974). Theory and Analysis of Plates, Classical and Numerical Methods. Prentice Hall Inc, Englewood Cliffs, New Jersey.
[4] Timoshenko, S.P & Krieger, S.W. (1959). Theory of Plates and Shells, 2nd Edition. Mc Graw-Hill Kogakusha Ltd, Tokyo, Japan.