CHAPTER - 6

Conclusions and Scopes of Future Work

This chapter deals with summary of overall works done and contribution made by author in the study. It also provides a quick review of the results obtained here as well as discussion for the future study for optimization of specific weight of the hat-stiffened panels. The research work presented in this thesis has broadly focused on optimizing the smeared extensional stiffness ratio of stiffeners to that of skin for maximum buckling load per unit area of the 60^0-hat stiffened panel and 75^0-hat stiffened panel. Non-linear buckling behaviour on hat-stiffened panel has been carried out with simulated FE model by using ABAQUS and compared with experimental results up to the failure load.

6.1 Conclusions

In this study, a novel research work has been presented in the field of buckling behaviour of the hat-stiffened panels under edge compression load. The FE results have been verified with analytical method and laboratory experiments. Numerical studies have been carried on the panel of dimension 762 mm x 762 mm with variation of pitch length (84.67 mm to 381 mm) and depth (25 mm to 55 mm) of the 60^0-hat-stiffeners and 75^0-hat-stiffeners with a fixed top width of 25 mm. Based on the results obtained in various methods as reported in chapter 3 to chapter 5, the following major observations are summarized:

Linear buckling numerical simulation has been performed on the laminated composite hat-stiffened panel under edge compressive loading. Parametric studies on buckling of the hat-stiffened panels are carried out with variation of pitch length of stiffeners, number of stiffeners, panel orthotropy ratio and smeared extensional stiffness ratio of stiffeners to that of skin with three different plies configuration. On basis of the results presented in chapter-3 following conclusions are drawn:

- For design of the maximum buckling capacity of the stiffened panel, 60^0-hat-stiffened panel is preferable with less pitch length and greater D_1/D_2. Also depth of stiffener should be as small as possible to prevent the local buckling of the panel.
- For optimization of $(EA)_S/(EA)_P$ of the hat-stiffened panel, the optimum $(EA)_S/(EA)_P$ increases with decreasing A_{11}/A_{22} for all different D_1/D_2 and it also increases with increasing D_1/D_2 for all similar skin.
- For maximum buckling load per unit area of the panel, 60^0-hat-stiffener performed better in comparison to 75^0-hat-stiffener in all cases.
- For better design of the hat-stiffened panel, the pitch length and depth of the hat-stiffener can be obtained with the help of optimum $(EA)_S/(EA)_P$ for different skin and orthotropy ratio D_1/D_2 of the panel.

Buckling of the laminated composite hat-stiffened panels has been analyzed by artificial neural network. For optimization of hat stiffened panels, based on results and discussions presented in the chapter-4, it is observed that ANN can be used efficiently for prediction of buckling load with different types of loading condition. The following conclusions are drawn here:

- The results show that ANN is a good analytical computational tool for optimization of the laminated composite stiffened panel.
- The well trained Neural network gives the best result with the help of network architecture 4-7-2-1.

- The maximum and minimum percentage difference of ANN predicted and FEA results are obtained as 2.193% and 0.064% respectively.

In the chapter-5, the pre-buckling and post buckling analyses have been performed on the hat-stiffened panel under edge compression load by laboratory experiments and finite element simulation using ABAQUS. The experimental results have been obtained on two number of hat-stiffened panels with equally spaced stiffeners. The buckling behaviour of the panel has been carried out with laboratory experiment and compared with finite element model result. The following conclusions are drawn:

- The compressive load-axial displacement curve of the experiments has co-related well with simulated FE model results for the buckling behaviour of the panel up to the failure load.
- From strain analysis, the local buckling of skin has been observed before the global buckling of the panel. A damaged has been observed near the skin-stiffener and de-bonding occurred between skin-stiffener of the panel during failure of the hat-stiffened panel.
- The out of plane displacement pattern shows that the compression failure originated at edges of the panel and finally failure of the panel happened due to de-bonding between skin-stiffener and plate.

6.2 Scope of Future Work

The present study can be extended in future for optimization of specific weight of the different types of hat-stiffened panel with application of the numerical techniques based on optimization technique such as Genetic Algorithm. The numerical studies can be performed on the laminated composite complex structures under edge compressive loading with application of finite element method as well as artificial neural network. Non-linear buckling analysis may be performed on the laminated composite with different types of hat-stiffened panel subjected to dynamic loading. Finite element method can be extended to non-linear static and dynamic analyses of different types of shells structures with different parameters.