

Abstract

The fiber reinforced plastics (FRP) have been widely used in engineering structures due to their design versatility as well as high specific stiffness, strength to weight ratios etc. Application of composite in the marine field is growing steadily. Glass fibre reinforced plastics (GFRP) are extensively used in the construction of boat hulls including yachts, life boats, dinghies, canoes, speed boats, fishing boats and passenger launches. GFRP has been successfully used in military and commercial hovercrafts. Naval applications of FRP include mine counter measure vessels, landing craft, fast patrol boats etc. The mechanical properties of FRP composites show a high degree of variability. As a result conventional failure analysis capabilities based on pure deterministic approaches cannot provide suitable safety margins for the design of FRP structures. So, there is need to incorporate the probabilistic approaches.

The aim of this work is to perform the reliability analysis of the FRP composite plate with material properties, strength, geometric properties and the load uncertainties. A reliability method is developed based on the response surface approach. The method proposed, combines the finite element method, conventional response surface method and First Order Reliability Method. The reliability analysis of FRP composite plates with and without stiffeners for various ply schemes and boundary conditions subjected to transverse static and dynamic load is performed by the proposed method. Further the proposed method allows predicting the sensitivity indices of the random variables.

In the FEM part a first order shear deformation theory is used to formulate the eight noded iso-parametric quadratic plate element with 40 degrees of freedom. The static as well as transient vibration analysis is performed. The Newmark's time integration with constant average acceleration method is employed for the transient vibration analysis. Apart from this, the first ply failure analysis for both the static and dynamic case is performed to obtain the deterministic first ply failure load, which is considered as transverse load in reliability analysis, using different failure theories. In order to apply the response surface, a set of random variables is initially selected. The basic random variables include the transverse load, mechanical properties, lamina strengths, geometrical properties and material density (for dynamic case) of the plate. The initial response surface function is selected based on the performance function criteria. Here, the

first ply failure criterion has been used as the performance function. The mean value of the random variables is considered as the initial design point. The actual design point is obtained by FORM. The response surface function is obtained by Bucher and Bourgund's linear interpolation scheme. After sensitivity analysis, the variables with low or no sensitivity are treated as deterministic in the final reliability analysis.

From the results obtained it is concluded that response surface approach would serve as an alternative computational approach for the estimation of probability of failure and identification of the important parameters of the performance function in case of composite laminates. This method reduces the computational time as compared to the conventional reliability methods for composite structures. Consequently, for the reliable and economic design of composite plates, it is important to reduce the computational time and selecting the random variables that have significant effect on the safety of the plate.

Key words: Composite; Response surface method; Reliability analysis; Sensitivity analysis; First ply failure analysis, Finite element analysis; Transient vibration analysis