UNIVERSITI TEKNOLOGI MARA

DEVELOPMENT OF A NOVEL FAILURE PREDICTION TOOL (CHYCLOP) USING ANALYTICAL METHOD FOR HYBRID COMPOSITE LAMINATES BASED ON COMBINED LAMINATION AND FAILURE THEORIES

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ABSTRACT

Failure of a structure could be catastrophic and thus the mechanism of failure needs to be understood well. At present, physical tests have been the common approach for failure assessment and prediction. Depending only on physical test is very costly, tedious and time consuming. As an alternative, FE programming is an option but it requires strong theoretical and mathematical knowledge, in addition to the competency in computer programming skills. Analytical approach is also an option but when it involves composite materials, the calculation will become very complex and require high-level mathematical computation. Considering all these, there is a need for an accurate failure prediction tool, yet simple to use. However, until today there is no software or computer program to perform failure analysis of hybrid composite laminates analytically based on all three lamination theories and various failure theories. Accepting this challenge, this study is aimed to develop a MATLAB program as a novel failure prediction tool for hybrid composite laminates based on combined lamination and failure theories, to comprehensively validate the program, to assess the effect of various combined lamination theories, failure theories and angle of fiber orientation on the hybrid composite laminates, and finally to propose a new failure theory with interaction terms as it could accurately determine the ply-by-ply failure of hybrid composite laminates. The output of this study, a MATLAB program that functions as a novel failure prediction tool (named and copyrighted as CHyCLOP or Compendious Hybrid Composite Laminates Failure Load Predictor) for hybrid composite laminates based on combined lamination and failure theories has been successfully developed equipped with a user-friendly Graphical User Interface (GUI). In general, the main results unveil a good agreement with various past experiments and numerical results. The FPF results are found to be more accurate (average 10% error) compared to LPF results for the data of below 45°. However, for the data above 45°, LPF is found to be more accurate (average 15% error). CHyCLOP also success in reducing the percentage error (11.4%) on the 15° in contrast to the past experiment, compared to past FE (38.8%) and by past analytical program (29.4%). In comparison with other past numerical method, the average percentage error is 10.0% and, in most cases, error was found to be less than 5%. This strongly indicates that the validated developed MATLAB program (CHyCLOP) can be accepted as a new tool to investigate the effect of displacement and failure analysis of composite laminates and hybrid composite laminates. Regarding the third Research Objective, it is found that the different lamination theories and failure theories show no significant effect based on ANOVA (P value = 0.999) for lamination theories and average of 3% different for failure criteria. Nevertheless, for certain range of fiber angles, the results show some variation of error. Based on all these analyses and results, finally a new failure criterion with interaction which can accurately determines ply-by-ply failure of hybrid composite laminates is also proposed. In addition, this novel criterion has been proven to be useful in generating accurate failure curves for hybrid Kevlar-Glass epoxy composite laminates and hybrid Glass-Kevlar epoxy composite laminates. In conclusion, this study proves that the developed novel failure prediction tool, can be very useful in estimating the displacement and failure load of hybrid composite laminates. The study has also contributed to enhancing knowledge about failure assessment of hybrid composite laminates under uniaxial tension load by applying various approach based on combined lamination and failure theories. This study is novel as to date, no similar study has been reported.

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