Preface

Plate is a very common structural element in various activities of civil, mechanical, aerospace, marine and other engineering fields. The use of composite materials in laminated plates is gaining popularity due to its high strength/stiffness to weight ratio compared to the conventional materials. Laminated plates with different fibre orientations or having a sandwich construction with low strength core and high strength face sheets provide unique solution where weight minimization is one of the major concerns.

The most important feature of laminated plate is that it is comparatively weak in shear. This phenomenon is quite significant in case of sandwich plates due to wide variation of materials between core and face. As such the effect of shear deformation should be incorporated properly in the analysis of these layered structures. Development of an appropriate mathematical model for an accurate analysis of composites and sandwich laminates is one of the prime requirements to assess the strength and stability of these structures under different conditions. The refined higher shear deformation theory (RHSDT) has been proved to be most suitable for this purpose with reasonable economy and accuracy.

Moreover, the problem becomes further complex if inter-laminar imperfections are introduced in the plate.

The finite element method is proved to be the most powerful and versatile numerical tool for structural analysis due to its accuracy and generality. As a result, several commercial software packages based on this method have been developed for the analysis of structures including laminated plates. However, almost all of these software packages have the capability of modeling the

transverse shear only up to a certain limit where the effect of inter-laminar imperfections cannot be included in the plate model.

In the exploitation of the plate model (RHSDT), it is realized that there is a genuine requirement for the development of new finite elements since very few elements have the capability of accommodating the plate theory (RHSDT) in an appropriate manner.

The present study is made on the development of an efficient and accurate modelling for the analysis of laminated composites and sandwich plates with imperfect layer interfaces based on an efficient layer-wise plate theory (RHSDT). A new triangular finite element is developed for the present purpose.

In this thesis, a detail investigation is made on static, vibration and buckling analysis of composites and sandwich laminates with imperfect layer interfaces while the case of perfect interface has been restored as a special one.

The content of the thesis is divided in five different chapters, which are as follows:

In **Chapter 1**, a general introduction along with the objective and scope of the present study is described.

Chapter 2 gives a review of the literature related to the scope of the present investigation. The developments of different shear deformation theories for the analysis of laminated composites and sandwich plates including inter-laminar imperfections are discussed, which is followed by the subsequent development of new finite elements for that purpose. The literature available on static, free vibration and buckling analysis of this structure is also included at the end of this chapter.

The detail formulation for the proposed analysis of laminated plate is presented in **Chapter 3**. The formulation is based on the refined higher order shear deformation plate theory. The effect of imperfection is incorporated in the

formulation by using a linear spring-layer model. The formulation of the six noded new triangular element developed for the present purpose has been described in detail. The formation of the element stiffness matrix, mass matrix and the geometric stiffness matrix are presented separately. The solution technique used for different analyses and its computer implementation are presented at the end of this chapter.

Chapter 4 deals with the application of the proposed formulations described in Chapter 3 by solving several numerical examples on static, free vibration and buckling of composites and sandwich laminates with or without inter-laminar imperfections covering different features such as convergence, shapes, boundary conditions, material properties, number of layers, fibre orientations, internal discontinuity and so on. Discussions are made on the results obtained in different problems. In many cases, the present results are compared with the published results. A large number of new results are presented for different types of analysis.

The summary and conclusions of the present study are presented in **Chapter 5** where the scope of future research is also discussed.

A list of references is furnished at the end of the thesis.