



Polymer matrix composites are finding increasing uses world over in high technology as well as day-to-day applications during the last four decades because of their potential properties. These materials are characterized by high specific stiffness and specific strength and enhanced dimensional stability, impact resistance, fatigue resistance and corrosion resistance. But the potential properties can be achieved only by proper analysis and design of composite materials / structures. The structures undergo various loading conditions such as static, quasi-static, dynamic, impact, ballistic impact, blast and fatigue during their service life. Fatigue is one of the critical loading conditions.

**E Yantra Composite** is a unique and efficient software product which can give solutions for fatigue of composites. From this software effective use of polymer matrix composites and their behavior under fatigue loading can be clearly understood. Fatigue behavior can be represented in terms of fatigue damage mechanisms, residual stiffness, residual strength and remaining life of composite structures. Estimating remaining safe life, rehabilitating for extended life and designing the structures for intended life are the important requirements. At the initial stage of analysis and design itself, long term behavior of composite materials / structures can be evaluated. Some typical application areas are: aircraft, aerospace vehicles, windmills, bridges, automotive components, ship structures, pressure vessels, mechanical elements, sports goods and other structural components.

**E Yantra Composite** software product consists of an exhaustive data resource on thermomechanical, fracture and fatigue properties of different composites. Other main components of E-Yantra Composite are: feast-static software for the static analysis of composite materials / structures and feast-fatigue software for the fatigue analysis of composite materials / structures. The fatigue behavior can be evaluated either by stress-life, strain-life or fracture mechanics approach. Ease of operation with Graphical User

Interface (GUI), accuracy of results and graphical presentation of the results are the special features of the software.

## **Capabilities of each software product**

### **1) Composite Data Resource**

Composite Data Resource consists of experimentally obtained thermomechanical, fracture and fatigue properties for different materials. Advanced algorithms are also provided for generating properties for different materials. The data resource is organized in five parts.

Databank1 (DB1) consists of thermomechanical properties for a variety of 3D orthotropic materials. Specifically, 9 elastic properties, 9 strength properties, 9 strain properties, 3 coefficients of thermal expansion, 3 thermal conductivities, 3 coefficients of moisture expansion and stress-strain curves are included. All the thermomechanical properties can also be generated using micromechanics, inverse micromechanics and feast-algorithms. The special features of this software are: generation of properties at different temperatures as well as with moisture content. Possible effects of broken fibers and misalignment of fibers are also considered in the analysis. DB1 also consist of thermomechanical properties of fibers and matrices. Current properties of fibers considering possible degradation of the properties because of hygrothermal effects can be determined using inverse micromechanics. Properties of laminae can be determined using micromechanics. The thermomechanical properties included are for both transversely isotropic and isotropic fibers and resins.

DB2 consists of S-N curves for different materials as well as residual stiffness data. Algorithms are provided for the generation of additional S-N curves in a class of materials for different fiber volume fraction, stress ratio, frequency and stacking sequence. DB3 consists of strain-life curves and the associated information for different materials.

DB4 consists of fracture properties for different materials. Specifically, critical strain energy release rate and critical stress intensity factor for Mode I, Mode II and Mode III as well as for mixed mode are included. Crack growth resistance curves (R

curves) for mechanical as well as thermal loading are included. Critical strain energy release rates for Mode I and Mode II as a function of number of cycles are also included.

DB5 consists of experimentally determined thermomechanical properties for transversely isotropic composites. This is used for inverse micromechanics.

## **2) Composite Analyzer**

Composite Analyzer is an efficient software for the analysis of laminated composites under general inplane loading and end moments. Elastic, hygrothermal and strength behavior of different laminated structures can be obtained. The analysis is based on lamination theory. The inputs required for the analysis are: laminate configuration, layer elastic, hygrothermal and strength properties and loading conditions. The output obtained are: thermomechanical properties of laminates, stress state, strength ratio, tensile, compressive and shear strengths of the laminates, stress-strain diagrams and 2D failure envelopes. The strengths and failure envelopes are obtained using maximum stress theory, maximum strain theory, Tsai-Hill and Tsai-Wu quadratic failure theories. The software has a capability to obtain stress-strain diagrams and failure envelopes in graphical form. A data bank consisting of thermomechanical properties for different materials is also a part of the software.

## **3) Composite Fatigue**

Composite Fatigue is a unique and efficient software product which can be used for fatigue analysis of composite materials / structures. The fatigue behavior can be evaluated either by stress-life, strain-life or fracture mechanics approach.

Main components of Composite Fatigue are: feast-static software for the static analysis of composite materials / structures and feast-fatigue software for the fatigue analysis of composite materials / structures.

Feast-static consists of analytical methods based on advanced algorithms. Composite Fatigue is compatible with commercially available finite element analysis software packages. Currently interface is provided with commercially available finite element analysis software package ANSYS. Fatigue analysis can be carried out using Composite Fatigue.

The stress-life approach provides residual stiffness, residual strength, damage index and remaining life for different composite materials / structures whereas the fracture mechanics approach provides details about transverse crack initiation and formation of additional cracks, crack density, crack saturation state, delamination initiation and propagation at the crack tips and residual stiffness and remaining life.

Composite Fatigue covers structural assemblies, notched composites, temperature effect, environmental effect and effect of composite laminate configuration in addition to different structural elements. Different loading conditions such as uniaxial, general inplane, transverse, block and random can be analyzed using Composite Fatigue.

Composite Fatigue along with Composite Data Resource and Composite Analyzer can be used for fatigue analysis of a variety of structural elements and assemblies.

**Following products are under development:**

- Composite designer
- Composite pressure vessel
- Composite mechanical elements
- Composite rehabilitator
- Fatigue of metallic structures
- Fatigue of polymeric materials
- Fatigue of elastomeric materials
- Fatigue of sandwich structures

**Special features of *E Yantra Composite***

- Unique, efficient, multipurpose and indigenously developed software product at a premier Institution in India,
- Consists of an exhaustive data resource,
- Feast-static consists of analytical methods for static analysis,

- ❑ Compatible with commercially available finite element analysis software packages for static analysis,
- ❑ Fatigue analysis and design is possible by stress life, strain life and fracture mechanics approaches,
- ❑ Can give the environment of composites laboratory,
- ❑ Can give the environment of fatigue engineering laboratory,
- ❑ Composite analyzer covers portion of first course on polymer matrix composites,
- ❑ Composite fatigue along with composite analyzer, composite designer and composite data resource can be used for post graduate and doctoral projects,
- ❑ Can be used for academic research and industrial consultation,
- ❑ Can be used for fatigue analysis and design of high performance products,
- ❑ Can be used for the evaluation of current status and remaining life of components in use,
- ❑ Can be used for fatigue analysis and design of composite structures / assemblies

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