



**TO STUDY THE PHYSICAL AND
MECHANICAL PROPERTIES OF
TEXTILE COMPOSITE'S LAMINATES
PRODUCED BY ORIENTING FABRIC
LAYERS DIFFERENTLY.**

SUMMARY

**THE MAHARAJA SAYAJIRAO UNIVERSITY OF
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**FOR AWARD OF DEGREE OF
DOCTOR OF PHILOSOPHY
IN
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SUBMITTED BY
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Composites have emerged as the most promising class of engineering materials providing new prospects for modern technology. Composites are characteristically used due to their high strength-to-weight and stiffness-to-weight ratios. The penetration of composite material is aggregated due to the demand for high-strength lightweight material and improved fuel efficiency. When this material is also lightweight, there is a tremendous potential advantage over conventional materials. A good understanding of composite behaviour becomes necessary to realise these properties. A composite material consists of three phases as matrix, reinforcement and interface phase between matrix-reinforcement. The interaction and composition of these three phases decides the performance of the composite.

Textile composites are composed of textile reinforcement like fibre, yarn and matrix combined with a binding matrix which is usually a polymer. These materials are usually considered in load bearing applications in number of sectors. Target application areas for textile composites are primarily within the aerospace, marine, defence, land transportation, construction and power generation sectors. Textile polymer composite laminate (TPCL) are engineered, tailor-made and fabricated to meet the requirements of structural applications. The anisotropic nature of TPCL is exploited to attain this aim.

In this work, a comprehensive review of the research work was carried out in field of textile composite starting with introduction to the subject covering various reinforcement types and matrices available covered in chapter 2. Considering the advantage provided in terms of structural stability and damage tolerance by woven textile composite due to their basic interlacing structure, here woven textile fabric was considered as reinforcement material. Here, first section basically covers the manufacturing of woven fabric samples successively on CCI rigid rapier sample looms and single end warping machine. Various new modifications were done on both the machines in terms of passage of material and new modified machine parts fabricated to accomplish this aim of weaving Carbon tow successfully. Details of this is mentioned in chapter 3. The Hybrid composite materials have currently received great attention from researchers due to their excellent potential applications when compared to the non-hybrid single fibre-reinforced composites. This advantage is being attained

by using hybrid woven fabric consisting of different yarn type in warp and weft with required thread count and weave parameters. For this purpose, fabric samples consisting of 6K and 12K Carbon tow as warp and weft respectively were woven with required parameters. In most composite materials processing, material costs make up a substantial share of the overall component cost. Consequently, to obtain a cost-effective hybrid composites with the required properties appropriate material selection is done wherein HDPE yarn as warp along with Carbon and Kevlar as weft yarn.

Second section, deal with the preparation of textile composites using hand lay-up technique, by stacking the layers of hybrid fabrics differently at varied skew angles with fabric layers of varied weave structure and reinforcing yarn. Specific orientation has been used to enhance and compare the properties of these TPCL in particular directions

Composite materials have to be engineered systematically and interactively to achieve optimum material characteristics. For this purpose, in this work aim was set at investigating the physical and mechanical properties of the composite material as well as the constituent used. Third section deals with the with the testing and analysis of prepared hybridised composites for physical and mechanical properties such as tensile, flexural, impact and damage resistance. According to the working conditions optimisation of properties was done. Mechanical properties of textile polymer composite laminate can be influenced and can be tailored by the orientation of the fibres, fibre content, weave patterns of the two fibres, lay-up sequence of the laminates, their combination capacities and fibre-to-matrix interface. Composite materials achieve the majority of their beneficial properties from a strong bond between reinforcement and matrix. Thus, effect of manufacturing and composition in terms of skew angle, weave parameters and reinforcement yarn type were studied. In this work, to provide an accurate understanding of the mechanical properties of fabricated TPCL different testing techniques like tensile, flexural, impact and damage resistance are being used. These TPCL undergoes certain failure mechanism. The SEM techniques was used to analyse the failure and damage caused due to the mechanical testing.

Textile composites are fibrous, structured, hierarchical materials so understanding these terms is necessary to numerical modelling of textile composites. Last section covers the development of numerical model to understand the effect of tensile properties of different lay-up angle composites was done. To have a better understanding of the mechanical properties of composite, numerical modelling of tensile properties by using FEA and Ansys software was done using stiffness matrix.

The result and discussion were encompassing tabulation of the results and their analysis. It represented an elaborate discussion on physical properties and mechanical properties of all developed samples like tensile strength, flexural strength impact strength and damage resistance strength. A comparative analysis of mechanical properties between each sample was addressed. The details about the microstructural defects and enhancement of those defects in the selected samples was done to understand the failure mechanism in each of the mechanical test performed.

In the conclusion, the work summarises the important criteria to be taken care of while weaving of high-performance yarns like Carbon and Kevlar at laboratory scale. The various modifications carried out through fabrications of different parts and change in the normal weaving material path have been stated. The research work is summarized as orientation of fabric layers differently in view orientation angle (skew angle), weave structure and type of reinforcement has effect on tensile, flexural, impact and damage resistance properties of textile polymer composite laminate (TPCL).

SEM analysis was used as tool to understand the different forms of failure mechanism microscopically for different TPCL having all the three parameters of variation viz. skew angle, weave structure and type of reinforcement yarn for mechanical properties like tensile, flexural, impact and damage resistance. Different failure mechanism like fibre fracture, fibre pull out, matrix cracking, fibre/matrix debonding, fibre kinking, fibre splitting and delamination observed have been stated.

To optimize the effect of orientation angle (skew angle) on the tensile properties of the TPCL for different industrial applications without having to produce and

test several prototypes was achieved by numerical modelling by the use of FEA. Validations of model was done by comparison of experimental and modelling results. The information gained through this can be used to provide, an estimate of desirable properties for a product, required in specific application without actual production of that product.

For serving a specific purpose for an application, it exhibits desirable properties in terms of ease of combination with other materials. Many required properties like tensile strength, flexural strength, impact strength, damage resistance strength, cost effectiveness, corrosion resistance and temperature were considered to prepare a material selection chart to suggest applications from a broad range of areas, illustrating typical textile polymer composite laminate produced in this work in each area by using a material selection chart table.