Role of Textile Reinforced Composite Material in Preventive Forensic

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Abstract

Textile material is not confined to just the apparel purpose but it also has its application in various sectors viz. Construction sector, Automobile sector, Aerospace field and many more. In the aerospace industry, the body of the fighter jets, aircrafts, rockets etc. was earlier made up of metal/steel alloy which was replaced by the aluminum metal which reduced the weight of the aircraft body. Further using the Carbon fibre textile reinforced composite material the weight of the body was reduced up to 30-40% which helped the payload capacity of the aircrafts. Also in automobile sector to reduce the weight of the vehicle, reduce the CO_2 emissions the carbon or glass fibre composite material is used. My paper will help the reader to know the advancement in the recent using textile reinforced material in aerospace field, automobile and construction sector to prevent the accidents. The recent textile reinforced composite material used in aerospace has drawback of delamination which leads to fatal accidents when they are not repaired or noticed. In automobile sector the textile composite material reduces the weight of the vehicle by almost 60%. Using such textile reinforced composite materials also prevents the damage to the occupants in case of crash due to special structure of the composite material. In the construction sector, the accidents occurring due to failure of bridge or fatal accidents lead to severe damages. So on using textile reinforced composite material the bridge can be repaired in short span of time and life of the bridge can be increased by 10-20 years.

I. Introduction

The world is moving towards the era of combinations of resins and reinforcement. Such products are known as the Composite material. These are the solid materials combined with more than two different materials having its own property and giving the superior quality product in its application area. Earlier metal, steel, aluminum etc. spare parts were used having drawback in its application field related to damage propagation, weight of the material and various others. So to overcome this, composite material have come into existence made up of Textile material core having low density, high tensile strength and creating its application in aerospace, marine, automobile construction and medical field.[9] Fiber-reinforced polymer composite materials are most preferred materials for construction of aircrafts, space crafts, cargo ships, automotive body, civil engineering and many other fields. The composite materials used in aerospace, marine or automobile industries are in the form of laminated composite structures. These laminated composite structures are made up of unidirectional layers used in high-end applications because of their greater in plane stiffness and strength. Their probable properties are realized only if the composite structure is loaded chiefly in the plane of the reinforcement. If a composite structure is subjected to loading along different directions, the location of primary structural failure would be at the fiber / resin interface. So, the development of fiber reinforced textile composites which possess significant fibrous interconnectivity between adjacent planes of fibers to increase the relatively weak fiber / resin interface. This interconnectivity would enrich the damage tolerance of composite structures. The fibers like carbon, glass, aramid fibres – Kevlar, Nomex and many other man-made fibers are used for fiber reinforced composites.

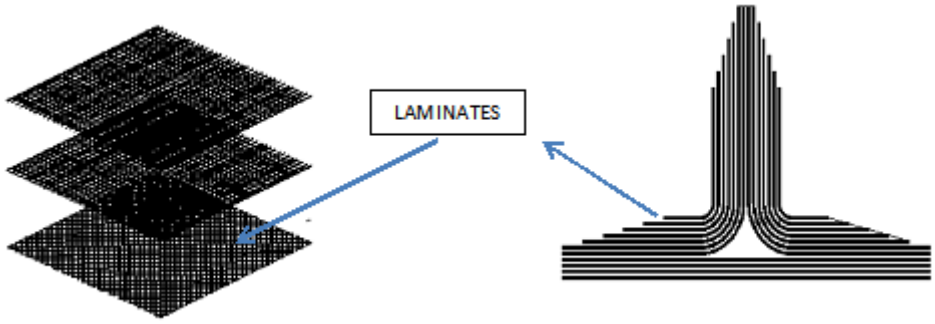

Fig. 1 Laminates

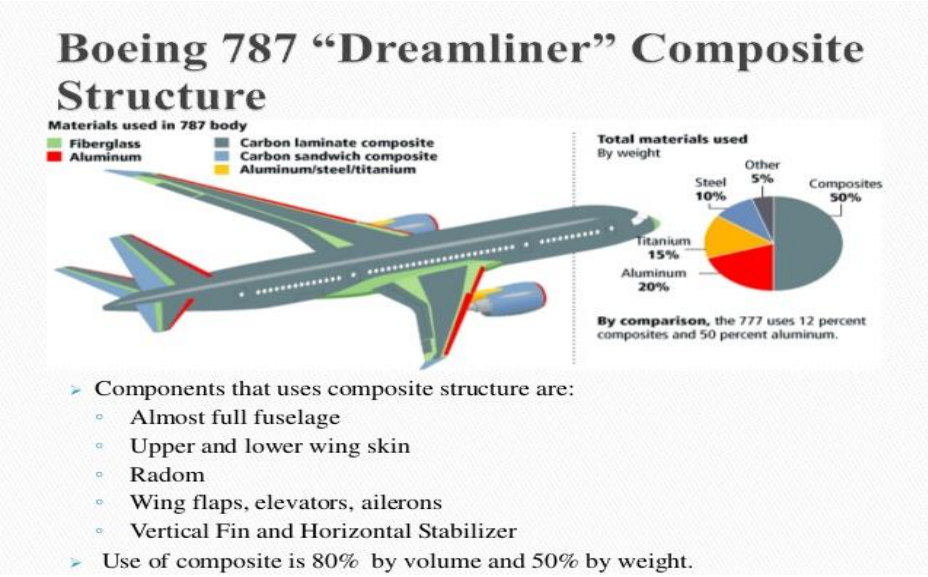

Fig 2. Composite percentages in Boeing structure

II. Preventive Forensics For Accident In Aerospace Application

The use of laminated composite material in aerospace structure has been largely considered due to its advantages like – [1]

1. Light weight material due to its high stiffness and specific strength.
2. Fatigue resistance.
3. Corrosion resistance.
4. Maintains dimensional stability and alignment stability in space environment.
5. Can be easily molded into various complex shapes.

But the use of laminated composite has some inherent weakness like Laminated composite have weak interfaces resulting in poor resistance to out-of- plane tensile loads.

1. Delamination - Vulnerability to impact-damage and strong chances of internal damage going unnoticed.

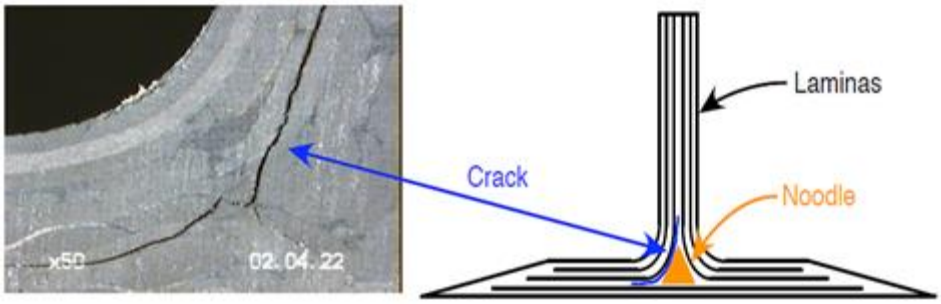

Fig. 3 Laminate Composites – Delamination

2. Manufacturing Defect and variability in material properties by Human error. [8]

The main cause for air craft failure is the internal damage to the laminated due to propagation of the cracks in laminates. Also, the discontinuous plies to create thickness changes and sharp bends required in stiffening members is of particular concern to the proneness displayed for damage due to impact to the aerospace structure. This not only reduces the tensile strength of the structure but also damages the material internally which is not visible and leads to accidents and huge damage.[7] Some instances of tool dropping while repairing, hail stones, runaway debris and impacts & jolts while handling leads to hidden internal damage in composites mainly delamination. Aircraft accidents occurring due to faulty maintenance of the aircraft due to tool dropping incidence (4) or damage propagation internally, fractured crankcase bolt on the composite, failure of rotor blade, delamination of wing, failure of landing gear and in flight bird strike is due to the weakness of laminated composite.

Thus, to prevent such damages and accidents to air craft structures, a new composite has been developed known as **3 Dimensional woven composite structure** [4,6]. In this woven structure the fibers are woven in 3 Dimension such that these structures have strength in both in plane strength and out of plane strength. These structures can be woven in various form like angle interlocked 3D woven structure, warp interlocked structure, orthogonally interlocked structure and Noobed structure. The benefits of using the 3D woven fabric as the pre form of composite material is [5,6]

1) No chances of delamination- the structure is woven with layers together producing 3D fabric preform for composite and no discontinuous plies are
2) Strength increases due to better fibre and resin interaction.
3) Light weight.
4) Higher strength- regain of composite strength due to no propagation of cracks.
5) Can be molded in any required shapes.
6) Higher fatigue strength then laminated composites.


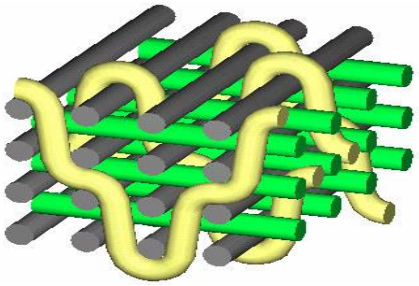

Fig. 4 3-Dimensionally woven Near Net Preform **Fig. 5** 3-Dimensional weaving – Angle interlocked method **[5]**


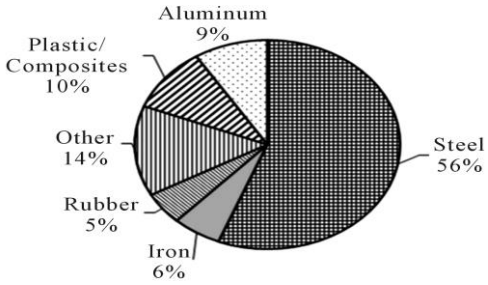

Fig. 6 – Metal: 335kg Carbon: 285kg Weight Saving – 15% **Fig. 7** Material Distribution in standard vehicle

III. Preventive Forensic For Accidents in Automobiles

The application of composites material in automotive design is no longer new area. With the extra ordinary vehicle designs, composites are also used to reduce the vehicle weight and reduce the carbon dioxide emissions. Composites are lighter, safer and hence make automobile fuel efficient. [2] The composite uses high performance fibers like carbon, glass, Kevlar etc. Carbon is widely used and weighs about one-fifth as much of steel, and is better in terms of both strength and stiffness. Composites do not corrode like steel or aluminum, and hence they increase the vehicle efficiency and fuel economy by approximately reducing the vehicle weight by 60% and drop in fuel consumption up to 24%. [2]. To manufacture crash worthiness and damage tolerant vehicle sandwich composite is used in body structure. Crash worthiness refers to ability to protect the occupants in case of crash. The sandwich composite is used in automotive flooring and roofing applications. During the automobile crash the sandwich composite being broken into tiny pieces where the crash occurs and everything else remains intact. Composites in automobiles exceed the safety requirements in case of crash they are designed to absorb significantly more energy than the traditional metallic metals when crushed.

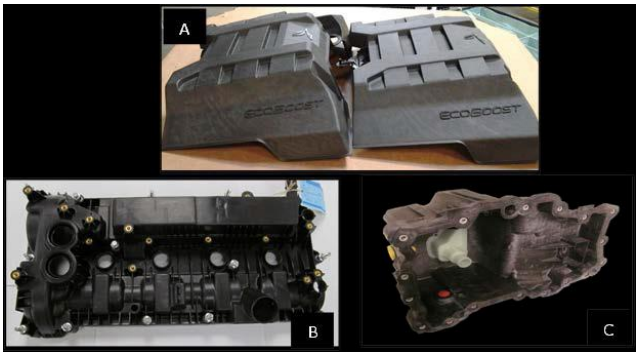

Fig. 8 Prototypes of engine cover (A), cam cover (B), and oil pan (C) developed by CBBP, University of Toronto, Canada

IV. Preventive Forensics for Accidents in Civil Engineering

Repair and Retrofitting of Existing Bridge Structures

Repairing and retro fitting of the existing bridge structures using externally bonded fiber reinforced composites is one of the applications in civil engineering. [3] This technique is fast, simple and very effective. Fibre reinforced composites can be used in sheets form or strip form depending upon their type of application for strengthening and retrofitting of the bridge. Externally bonded Fibre Reinforced Plastic composites have the ability for increasing both flexural and shear capacity of concrete elements, including girders, beams and slabs. Various methods are available for using externally FRP Reinforcement like adhesive bonding, hand lay-up or wet lay-up and resin infusion. Fibre Reinforced Plastics (FRP) composites can be used in retrofitting of reinforced concrete bridges in the form of wrapped column. FRP composite does not give any traffic disruption. [3]

Fig. 9 Application of Carbon Fibre Column Wrap and completed Carbon Fibre Wrap **[3]; Fig.10** Application of Carbon Fibre Column Wrap and completed Carbon Fibre Wrap **[3]**

All-Composite Bridge Structures

Composite bridge structures are understood as bridges with superstructures constructed of Fiber Reinforced Polymeric (FRP) materials. The substructure elements usually consist of traditional reinforcing materials. In these structures differences are apparent between traditional bridge concepts with simple material replacement and first steps towards new material-adapted concepts.

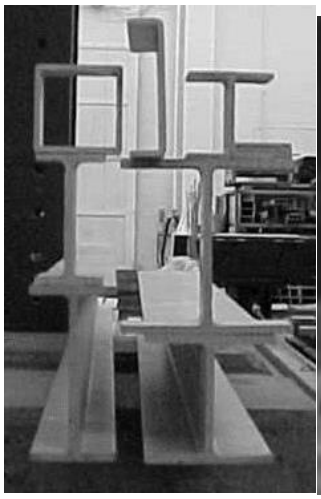

Fig. 11 Fibre reinforced Polymers Shapes **Fig. 12** Cellular Panel Bridge Deck

V. Conclusion

With the development of composite material, textile fibre play a very vital role in its high end application. High performance fibres like Glass, Carbon, Kevlar, Nomex etc have been used on a very large scale in Aerospace, Automobiles, Civil Engineering and various other sectors.

Using composite materials, the weight is reduced 30-40%, which improves the efficiency of the product. Advancement of the textile fibres reinforced composite also help in preventing the major accident and also prevent the loss of economy and sometimes lives.

In case of Aerospace sector, laminated composites can be replaced by 3 Dimensional Woven composite structure. The laminated composite has the disadvantage of delamination and crack propagation on development of catastrophic crack, thus reducing the strength and its performance.

In case of Automobile, composite materials are highly preferred due to its light weight and higher strength. Now, as it's weight is reduced, vehicle efficiency increases and fuel economy is improved as composite weight gets reduced up to 60%.

In case of Civil structures, the bridge gets damaged after certain years of usage. So to repair these bridges, rather than completely destroying Fibre Reinforced Plastic(FRP), composites can be used to repair and retrofit the Civil structure, which further increases the life span by 20 to 30 years.

Hence, it can be concluded that using the textile FRP in fore mentioned sectors, the chances or occurrence of the accident can be prevented. Thus, durability and efficiency of the product is improved.

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