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A Review on Comparative Study of Polymer Matrix Composites and Metal Matrix Composites

Amandeep Kaur [1], Dr. Harpal Singh [2]
[1]*M.Tech Student,* [2] *Professor, Department of Civil Engineering, Guru Nanak Dev Engineering College, Ludhiana, India*

Abstract: ***In recent years, various considerable works performed for strengthening of the structural members such as beams, slabs and columns with the composite material. Large number of strengthening techniques have been carried out in the previous years but the most popular is external bonding of hybrid composite material laminates. Now- a- days RC beams are wrapping with Polymers such as Glass Fibres and Carbon Fibres are more popularly used .This paper presents a brief overview of physical and mechanical properties of Metal Matrix Composites. The engineering properties such as tensile strength, stiffness, modulus of elasticity etc. of MMC (Metal Matrix Composites) have been compared with the PMC (Polymer Matrix Composites). Comparative evaluation of composites shows that MMC also gain attention in the world of composites and possess better engineering properties for strengthening of the structural members. Hence MMC becomes new trends in composite material.***
Keywords: Composite Material, Hybrid, MMC, PMC, Strengthening

I. INTRODUCTION

Composite material is composed of two or more materials having non identical properties and variations from the individual material. In terms of strength, stiffness and heat resistance, composite materials possess better physical and mechanical properties than the individual material. Composite materials have been used because they are strong as well as light weight. Composite materials generally consist of a bulk material called the matrix and a filler or reinforcement material of some type such as fibres, whiskers, particulates, or fabrics. It is a two phased material in which the matrix phase is typically soft phase in terms of physical and mechanical properties such as ductility, thermal conductivity, on the other hand reinforcement is considered as hard phase with high strength and high stiffness which mainly carries the applied load to the composite. Reinforcement is embedded and surrounded by matrix phase and matrix phase protect it from environment and handling .Matrix is generally an intermediate to fully utilize the strength of the reinforcement and to transfer the loads from external forces to reinforcement as shown in Fig 1.

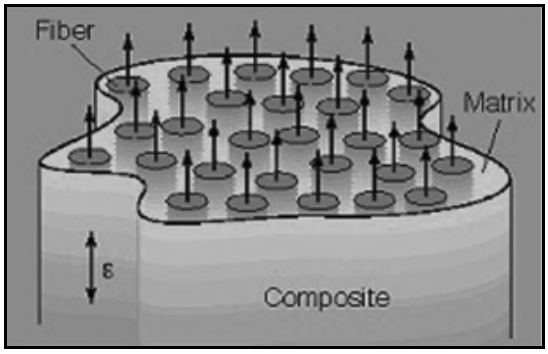


Fig. 1 Structure of Composites

So basically composite material is depicted as advanced composites when two or more phased material is combined together in which one of them is stronger and stiffer and serve as the basis of primary load carrying phase and the other one is weak link. The performance of composite material depends upon their physical, mechanical and chemical properties, also on size, distribution and interface of the components.

Now-a-days various composites have been used for strengthening of different structural elements .FRP system become popular to increase load caring capacity, flexural and shear capacity of beams. RC beam usually wrapped with the polymer composites such as Glass Fibre Reinforced Polymer, Carbon Fibre Reinforced Polymer, Basalt Fibre Reinforced Polymer, Aramid Fibre Reinforced Polymer etc. With the recent advancement of composites, development of Metal matrix composites have been used in various fields of engineering due to their superior properties.

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II. POLYMER MATRIX COMPOSITES

These are also known as plastic composites and non-metallic material which can be moulded into any shape. Fibres are used as reinforcement medium in polymer matrix composites. Resins are used in polymer matrix composites (PMC) which is stronger than conventional materials. The FRP system consists of resins for bonding, applied coatings on concrete substrate to protect constituents. The fibre phase involved glass fibres, carbon, aramid, basalt and the matrix phase involves epoxy, polyester, vinyl ester resins which are bonded at interface. The acceptance of FRP sheets has increased manifold due to high strength/self-weight ratio, high corrosion resistance, resistance to ultra violet radiation and oxidation, more durability, ease of installation, construction and design flexibility. The thin profile of FRP sheets makes them desirable to improve aesthetics like shielding of pipe. FRP composite have been widely adopted in the design construction phase of civil engineering. Civil engineers tremendously used the FRP material for increasing the strength of various structural elements such as beams, columns, slabs and bridges are completely carried out by the new construction practices. The technique for wrapping the damaged elements with composite material greatly enhanced the strength and also to prevent from collapse or buckling of the reinforcement. Along with civil engineers, FRP composites have also take place in the field of architecture. Now a days architects have been greatly make use of FRP composites in non-structural elements such as partitions, cladding, roofing, flooring etc.

A. Glass Fibre Reinforced Polymer

Fiberglass is essentially a composite comprising of glass strands, which may be continuous or discontinuous, contained inside a matrix of polymers, this kind of composite is formed in the major amounts. Fibre thicknesses normally range between 3 and 20 m. Glass is commonly used as a fibre reinforcement material due to the so many reasons such that it can be effectively drawn into high quality filaments from liquid state. Also it is easily accessible and fabricated using wide variety of composite techniques. It creates a composite of high specific strength when it is combined with the strong fibre and plastic matrix. The properties involved in GFRP such as high stiffness to weight ratio, better insulating properties, greater resistance to corrosion and chemical attack also the modulus of elasticity is about one third of the reinforcing steel. The main advantage of GFRP is relatively inexpensive material along with superior properties as on the other side, GFRP material have lower strength, low thermal and acid resistance, and low interfacial properties as compared to the CFRP material. In FRP sheets, resins are used as an alternative to conventional materials. FRP system encompasses resins, fibres which are bonded to form laminate and also coatings to protect material constituents present. GFRP's have been widely used in automobile parts, pipes, pressure vessels, structural elements, manufacturing boats and marine structures etc.

B. Carbon Fibre Reinforced Polymer

Carbon is a popular fibre material that is the most utilising reinforcement surrounded in the matrix to develop advanced polymer-matrix composites. It contains carbon fibres which makes the whole composite strong and light weight that means no fibre glass is there. The material holding high modulus of elasticity as compare to all fibres and equal to that of the steel. The main advantage of CFRP possess good physical and mechanical properties that built up the composite more usable and reliable. These CFRP sheets are low density material, having low coefficient of thermal expansion with high corrosion resistance, high tensile strength can extent up to 7 Gpa, high chemical inertness. But these sheets are relatively expensive as compare to the GFRP also at room temperature, carbon fibres are not influenced by dampness or any kind of acids, bases and solvents. These carbon fibre sheets have high electrical conductivity or failure occurs in a brittle manner. These are widely adopted in the industrial and structural applications such as in pumps, drive shafts and load bearing elements.

III.METAL MATRIX COMPOSITES

There is another class of composites known as Metal Matrix Composites which recently gaining attention in the family of composites. The research began in 1950's and due to the continuous growth of the material, the research on this material is still continues. The research is carried out in different aspects of engineering and now-a-days becoming most popular research in material science. MMC's are combination of two phase of material, the first phase is matrix which is purely bases on the metals such as Titanium, Aluminium, Magnesium etc. and the rest of the phase consists of reinforcement which is based on dispersed ceramics that are formed as pure compounds of metals such as boron, alumina, silicon carbide, nitrides etc. The development of MMC totally depends upon the selection of the properties of both the phases i.e. on reinforcement and matrix. A large number of organisations and companies of United States and Canada are involved such as Advanced Composites Material Corporation, Aluminium Company of Canada, General Dynamics Corporation, American Refractory Corporation etc. Also Japan came in 1980's to take place in large application of automotive parts and various manufacturers of MMC material as shown in Table 1.

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Table 1: Manufacturers Of MMC

Manufacturer	MMC system	Characteristics of applied MMC	Product
Toyota	Aluminium + Alumina oxide	Light weight, wear resistance at high temperature	Pistons
Honda	Aluminium+ Silicon Carbide	Reduced weight, improved strength, wear resistance.	Engine Block
Audi	Aluminium + Silicon carbide	high strength and stiffness, high running temperature	Brake rotor, Caliper
Mitubish	Aluminium+ Silicon Carbide	Light weight, Low friction	Shock Cylinder

The research carried on development of MMC material slowly spread in various other countries such as Denmark, Australia, Korea, and China etc. over worldwide also become trending in India now. For better designing of material, the attributes such as structure, size, shape and volume of the constituents of the material are very necessary. In India there are large amount of waste products of agriculture such as paddy husk which is utilized and converted into good quality of reinforcement in MMC material. So many organizations in India working on the MMC material are involved such as Natural physical laboratory in New Delhi, Indian Institute of technology in Bombay, National Aeronautical laboratory in Bangalore etc. as shown in Table 2.

Table 2: List Of Organizations

Name of Organization	Location
National Physical Laboratory, CSIR	New Delhi
Indian Institute of Technology	New Delhi
Hindustan Aeronautics	Bangalore
Regional Research Laboratory	Bhopal
Defense Metallurgical Research Laboratory	Hyderabad
Indian Institute of Technology	Kanpur
Indian Institute of Technology	Bombay

A. Current Assessment on MMC

MMC's development also shown the approximate same progress and at the stage of PMC's from the previous 15 years. Due to their improved properties, MMC provides better specific strength and stiffness at high temperatures as compare to the PMC's. But at present, MMC involves expensive and complex manufacturing methods. In general, high cost is one of the primary barriers to large scale use of composite materials. Now a days, the widely used metal is Aluminium and reinforcement is silicon carbide as shown in Fig 2.

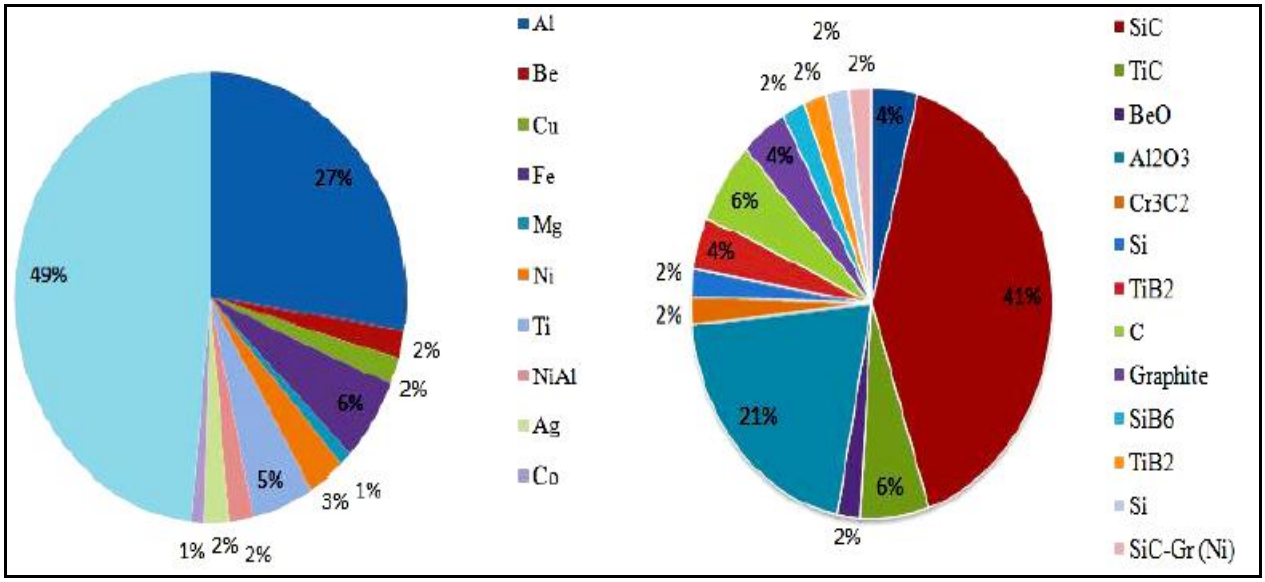


Fig. 2 Usage Volume of Metals and Reinforcement

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IV. COMPARATIVE EVALUATION OF PMC AND MMC

Metal matrix composites are isotropic material have many advantages over the monolithic metals such as better wear resistance, elevated temperatures, better fatigue resistance, greater strength to density ratios, lower coefficient of thermal expansion, greater stiffness to density ratios. MMC's also have advantages over polymer matrix composite such as more transverse strength and stiffness, better radiation resistance and conduciveness, no moisture absorption but it is suffer with disadvantages also such as higher costs newer technologies, limited service experience, more complex fabrication methods The general key characteristics of MMC as compare to the uniaxial plastics are such that they are more efficient in plate buckling, combined loads of tension, compression or shear, also in transverse and off- axis loads. On the other hand PMC's are highly anisotropic material in which strength and stiffness are highly parallel to the fibres but it is low perpendicular to the fibres. They have stress strain curves generally linear to failure. PMC's have higher tensile strength and stiffness. They are more adaptable to design changes and can be easily repaired also they are more advanced in the state of art. The general key characteristics of PMC are such that they are more efficient in uniaxial tensile loads and bending also give less deflections and more resistant to dynamic loads. Plastic composites are advance in the fabrication technology and also lower in fabrication cost and raw material.
Comparison of engineering properties between MMC and PMC as shown in Table 3.

Table 3: Engineering Properties

Property	MMC	PMC
Strength axial (Mpa)	620-1240	820-1680
Stiffness (Gpa) axial	130-450	61-224
Specific Strength (axial)	250-390	630-670
Specific Gravity	2.5-3.2	1.3-2.5
Elastic Modulus (Gpa)	419.4	221.7
Transverse strength (Mpa)	30-170	11-56
Transverse stiffness (Gpa)	34-173	3-12
Maximum use temp (C)	300	260
Plane strain fracture toughness (Mpa)	-----	-----

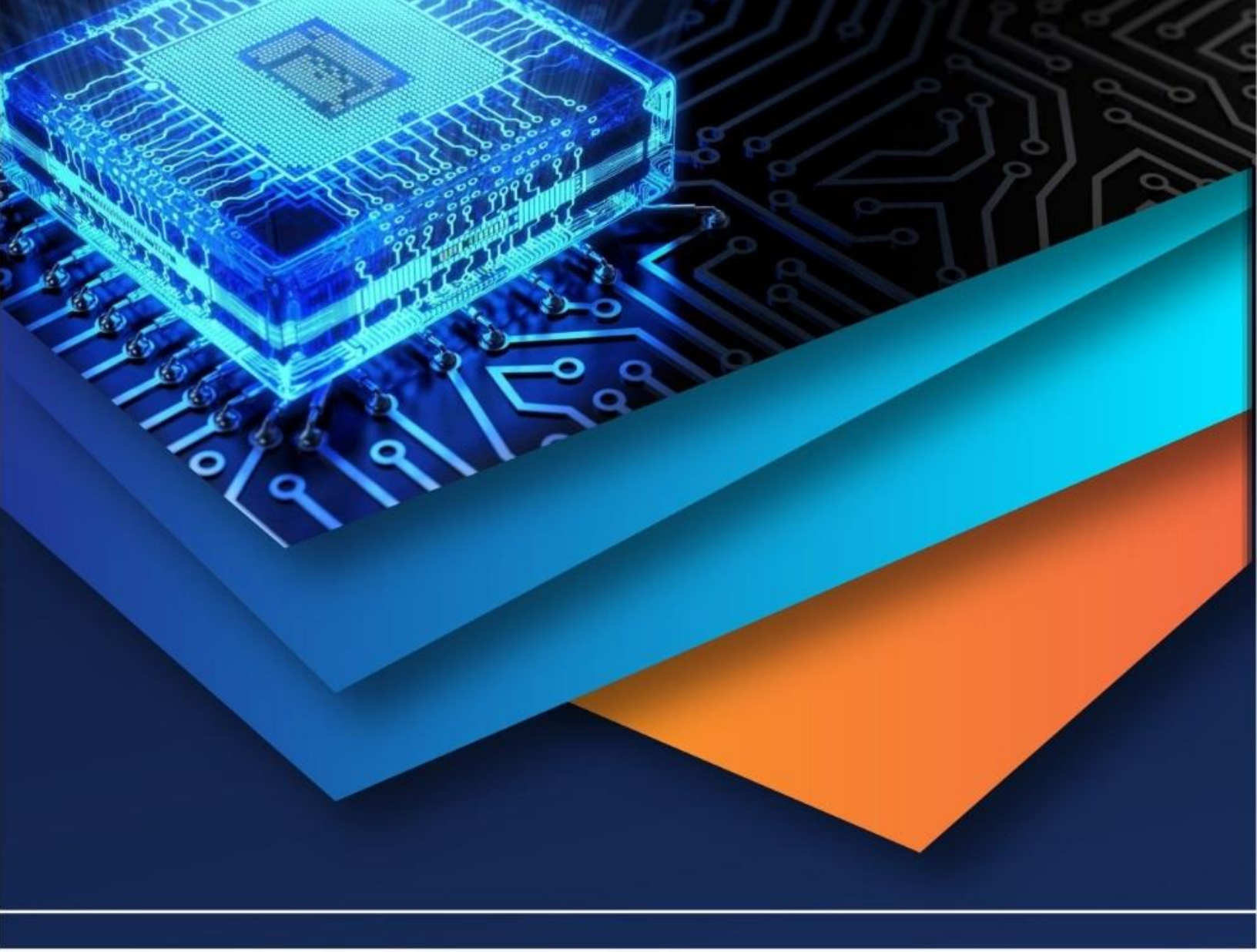
V. CONCLUSION

An effort has been made to study the different class of composites for strengthening of different structural elements. Using of Polymer Matrix Composites is old technique of strengthening proven to be viable and incredible development in concrete technology. Later on the advance development of newly composite materials i.e. Metal Matrix Composites also possess better engineering properties and start gaining popularity in the worldwide. It can also be used in the structural applications for strengthening of RC members and used as a reinforcing material. It is concluded that both metals and polymer matrix composites are affected by matrix and reinforcement properties, their form and the arrangement, reinforcement volume and matrix interface properties.

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