*DEFLECTION TEST OF SIMPLY SUPPORTED BEAM ON BUS BODY COMPOSITES**

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Abstract-

Composites are the most important materials in modern automotive field.In bns body applications composites and its mechanical behavior has its significant role in the manufacturing.In the present work,the composites were prepared with hand layup technique using chopped strand mat powdered type glass fibre with polymers.The polymers namely polyester resin and epoxy resin are compared as polymer reinforced fibre matrix.Sandwich laminate panels were prepared and studied the deflection test of simply supported beam.

Keywords-*Chopped strand matt powdered type glass fibres,Epoxy resin,Polyester resin,Hand layuptechnique,Sandwich laminate panels,Deflection test of simply supported beam.*

1.INTRODUCTION

Reducing weight while increasing or maintaining strength of products is getting to be highly important research issue in this modern world. Composite materials are one of the material families which are attracting researchers and being solutions of such issue[1]. The composite material has the superior properties compared to its constituent materials. The strength of a composite structure depends on its constituent fiber and matrix material. The laminated composite beams are in use for various components in engineering applications. These beams are subjected to different environments and loads[2]. Despite the potential benefits of lighter weight and durability resulting from corrosionresistance, advanced composites are not recognized as a material of choice in the near termfor automotive applications. Significant changes on a broad spectrum would be required to make advanced composites attractive for widespread commercial. However there are opportunities for advanced composites in specific components in the commercial automotive sector. In specialty vehicles of several types, produced in small numbers advanced composite materials have an opportunity to demonstrate their performance benefits, apart from the requirements of the competitive marketplace. The composite industry
worldwide is investing in process improvements for the molding of polymer composites using forms of conventional E-glass in mid-level performance resins,both thermoplastic and thermoset[3]. A major benefit of composites materials is that the variations allowed in fibre type,

fibre format, fibre length, orientation, stacking sequence and resin type can provide potentially many materials tailored to individual applications[4-5]. The anisotropy of composite materials demands larger properties with acceptable accuracy for identifying new materials. The ability to predict the engineering properties for the different fibres and well characterised constituent properties increases in Continuous aligned type[6]. The use of polymer matrix composite has been in the use with various fibres, as it can be easily manufactured, and also has the advantage of having properties which are equivalent and even more than expectations, to the traditional materials by strength and usage[7].Fiber reinforced plastic (FRP) composite materials have been increasingly used in the fields of structural engineering applications over the past few decades[8]. FRP is one of the widely used composite materials in the world. It consists of one or more discontinuous phases embedded in a continuous phase.Generally, matrix is used as continuous phase. The matrix is light in weight and its specific gravity ranges between 1.2 and 1.5. Reinforcement or reinforcing materials (Fibers) are used as discontinuous phase. These are comparably very stronger and harder than the matrix. More over they have high load carrying capacity, high modulus and stiffness, and high strength. Glass fibers are the most common fibers of all reinforcing fibers due to its Low cost,High chemical resistance,Excellent insulating properties[9]. The use of polymer in fiber reinforced composite materials is growing day by day in all types of engineering structures such as aerospace, automotive, aircraft, chemical, constructions etc because of their tailorable properties. Fibre glass composites produced today is also used for boat hulls, surfboards, sporting goods, swimming pool linings, building panels and car bodies. Fiber-reinforced composite materials consist of high strength and high modulus fibers in a matrix material. Over 95% of the fibers used in reinforced plastics are glass fibers, as they are inexpensive, easy to manufacture and possess high stiffness with respect to the plastics with which they are reinforced. E-Glass has been used extensively in polymer matrix composites, commonly termed "fiberglass[10].A few of the benefits of FRP for use in infrastructure compared to conventional materials are high strength to weight ratios, high corrosion resistance, lightweight, electromagnetic transparency, and excellent fatigue performance and excellent long-term durability[11]. In the form of FRP, the fibers and polymer resins still have their own physical and chemical properties. The fibers provide strength and stiffness, and resins provide shape and protect the fibers from damage. These properties include a high strength-to-weight ratio, high corrosion resistance, tailoring of the material to specific applications and ease of installation[12]. FRP composite properties are directional, meaning that the best mechanical properties are in the direction of the fiber placement[13]. The Glass Fibre is a processed form of glass, which in turn is composed of a number of oxides, such assilica compounds with raw materials, such as limestone, boric acid,fluorspar, and clay.Different proportions of each element gives different type of glass fibers (E, C, R, S, andT). Each type has different properties and uses. E-glass is the most commonly used dueto its good mechanical properties and relatively low cost[14]. The resultant high load-bearing capacity, invisible reinforcement, easy installation, easy

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 UGC CARE Listed (Group -I) Journal Volume 11,Iss 12, 2022

design, and the economical factor are all determining the reinforcement method and the choice of reinforcement material[15]. Few research works on the mono-symmetric profiles were carried-out[16]. However, the glass fiber is preferred due to its transparent property and the reminiscent of thick coat of lacquer[17]. Glass fibre reinforced plastics(GFRP) reinforced beams has proven its character to be safe,good in integrity and residual resistance capacity and very high in performance,strength,fragile behavior,accuracy,serviceability and esteemed global nature behavior depends on proportion of reinforcement[18]. GF is the most commonly used reinforcement in constructions due to its properties.It has a high strength, low weight, and resistance to the environmental effects,ability to form different shapes, low maintenance, and good durability[19]. GFRP can be moulded to various shapes because of potentially resist to environmental conditions and low maintanence cost. Glass fibres has high strength [20].Mechanical properties of mono directional fiber reinforced composite have been extensively studied[21]. The use of continuous fibre composites favoured for low volume, whereas chopped fibres in sheet or bulk moulding compounds have strongly entered the high volume production markets[22]. In the recent decades the application of laminated composites are finding increasing in Transportation vehicles due to their Low thermal expansion, low corrosion resistance, high strength to weight and stiffness to weight ratios. The majority of engineering composites materials in demanding applications consists of continuous fibers of glass reinforcement in thermosetting epoxy polymer[23].Most composite structures are built up into useful sections by stacking plies of fibre . Since the orientation of the fibres can be varied, the properties of the laminate are not consistent through the thickness of the part, and are considered highly anisotropic in all 3 planes. The purpose of a core in a composite laminate is therefore to increase the laminate's stiffness by effectively 'thickening' it with a low-density core material[24]. Now a day's laminated composite beams are preferred for various engineering applications on priority. These beams are subjected to different environments and loads during their operation.Composite beams with ± (0˚-0˚-0˚) orientation is found to have highest value of natural frequency[25]. A unidirectional or one-dimensional fiber arrangement is anisotropic. This fiber orientation results in a maximum strength. These properties are measured in the longitudinal direction of the fibers.The heterogeneous nature of fiber/polymer composite materials provides mechanisms for high energy absorption on a micro-scale comparable to the metallic yielding process.E-glass comprises approximately 80 to 90 percent of the glass fiber commercial production. The nomenclature "ECR-glass" is used for boron-free modified E-glass compositions. This formulation offers improved resistance to corrosion by most acids. Laminates are made by stacking a number of thin layers (laminate) of fibers and matrix and consolidating them into the desired thickness.Epoxy resins are used in advanced applications including aircraft, aerospace, and defense, as well as many of the first generation reinforced composite. Thermosetting polymers are almost always processed in a low viscosity, liquid state. Therefore, it is possible to obtain good fiber wet-out without resorting to high temperature or pressure. Today ,

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 UGC CARE Listed (Group -I) Journal Volume 11,Iss 12, 2022

thermosetting matrix polymers have been the materials of choice for the great majority of composite applications.In common commercial composite products, the polymer matrix is normally the major ingredient of the composite[26]. The unsaturated thermosetting polyester is widely used, offering a good balance of vibration properties at moderate or ambient temperatures, and also at relatively low cost[27].Bending develops in structures such as plates or shells due to a variety of loading situations in service[28].High degree of bending exhibited by a specimen seems to have more accuracy seen in deflections[29].

2.METHODOLOGY

This is a manual approach in which layers of fabric and resin are successively applied onto a mould. This method is perhaps the simplest, oldest and least complicated. In recent years, the advances in manufacturing technology have resulted in some improvement in this manual process. Today, the hand lay-up has become automated in several applications. The hand lay-up technique is the oldest, simplest, and most commonly used method for the manufacture of both small and large reinforced products[10].FRP composite are highly reliant on the matrix material[30].The FRP composite is a material composed of fiber reinforcement bonded to a matrix with distinct interfaces between them[31]. The FRP composites that are typically being utilized tend to be the more cost-effective lassfiber, and resin combinations[11].The mechanical properties such as high strength and stiffness, high strain avoids FRP brittle failure. The adhesive properties includes good bonding of fibers and matrix to distribute the loads equally and efficiently. The resistance to environmental degradation of matrix should have a good resistance to protect the fiber from the environmental agents and aggressive substances[32].Gfrp composites behaves linearly as a continuous fibre,instead of discontinuous fibre natures such as non-linear , small crack in resin,fiber debonding. It is highly influenced by matrix strength and fibre matrix bonding strength[14].

A. Preparation of composite-hand layup method

The composites are prepared by hand layup method. The wax,gelcoat applied on a uniform surface. Chopped matt glass fibres (30%)are prepared in proper size and placed above the wax and gelcoat applied surface. The Polymer (Resin) are applied on the fibre through brush and the surface evenly rolled by roller. The proportion given as follows, General purpose Resin Proportions: 97% of gp resin,2% ofcobaltoctoate hardener,1%accelerator with wax, gelcoat, pva.Epoxy proportions:90% of ly556 epoxy resin,10%hy 951 hardener After the curing of composites, test specimen is prepared as per the specifications.

In a thermoset polymer also called resin, the molecules are chemically joined together by cross-links. Therefore these polymers cannot be reused once cross-links are formed on curing. They

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UGC CARE Listed (Group -I) Journal Volume 11,Iss 12, 2022

are used in continuous or long fiber-reinforced composites mainly because of the ease of processing due to their low viscosity[9]. Epoxy specimen has more complete bond whereas bonds with the polyester resin were weaker. Bonding of the epoxy resin was superior to that of the polyester resin[33]. The performance of any composite depends on the materials of which the composite is made, the arrangement of the primary load-bearing portion of the composite (reinforcing fibers), and the interaction between the materials (fibers and matrix). Thermosetting matrix polymers are low molecular-weight liquids with very low viscosities. The polymer matrix is converted to a solid by using free radicals to effect cross linking and "curing. Epoxy resins are available in a range of viscosities, and will work with a number of curing agents or hardeners. The nature ofepoxy allows it to be manipulated into a partially-cured or advanced cure state commonly known as a "prepreg." If the prepreg also contains the reinforcing fibers, the resulting as lamina can be positioned on a mold at room temperature.Large parts fabricated with epoxy resin exhibit good mold shape and dimensions of the molded part. Epoxy resins can be formulated to achieve very high mechanical properties and long term durability and suitability for any given application.. There is no styrene or other monomer released during molding.No volatile monomers are emitted during curing and processing, Low shrinkage during cure, Excellent resistance to chemicals and solvents, Good adhesion to a number of fillers, fibers, and substrates.The matrix gives form and protection from the external environment to the fibers. It maintains the position of the fibers. Under loading, the matrix resin deforms and distributes the stress to the higher modulus fiber constituents. The matrix should have an elongation at break greater than that of the fiber. It should not shrink excessively during curing. Fiber composites are able to withstand higher stresses than can their constituent materials because the matrix and fibers interact to redistribute the stresses of external loads. The stresses are distributed internally within the composite structure depends on the nature and efficiency of the bonding.Many different combinations of fiber and resin can be used in the manufacture of FRP. This is an advantage because it allows modification and enhancement of properties for a particular application. Significant research could be undertaken in this area to determine optimum fiber/resin combinations for development of FRP characteristics such as strength, modulus, and durability[26]. The material properties and cure rates can be formulated to meet the required performance. Epoxies are generally found in marine, automotive, electrical and appliance applications. The high viscosity in epoxy resins limits it use to certain processes such as molding, filament winding, and hand lay-up[13].

ISSN PRINT 2319 1775 Online 2320 7876

 UGC CARE Listed (Group -I) Journal Volume 11,Iss 12, 2022

B. Sub methodology-photos of specimens

Fig. 1.*Deflection test of simply supported beam*

Fig. 2.*Deflection test of simply supported beam showing the specimens of general Purpose resin (Polyester)and epoxy resin*

ISSN PRINT 2319 1775 Online 2320 7876

 UGC CARE Listed (Group -I) Journal Volume 11,Iss 12, 2022

3.RESULTS&DISCUSSIONS

A. *Deflection test of simply supported beam showing procedure*

Description:

Distance between the knife edge support are measured. The deflectometer and hanger are fixed and corresponding distance a and b are noted . Load is applied on the hanger and corresponding deflectometer reading is noted and cycle is repeated for different readings.The specimen size tested as (1524mm×50mm×3mm).

Formula:

Young's modulus $=\frac{Wab}{6\delta Il}(L^2-a^2-b^2)$ N/mm²

Where,

I =Moment of inertia in 'mm'

b =Distance between the deflection and support 'mm'

δ =Deflection in 'mm'

a =Distance between the load hanger and support'mm'

W =Load applied in 'N'

L =Effective span of beam in 'mm'

B =Breath of beam in 'mm'

D =Depth of beam

ISSN PRINT 2319 1775 Online 2320 7876

 UGC CARE Listed (Group -I) Journal Volume 11,Iss 12, 2022

B. Deflection test of simply supported beam

showing tabulations

TABLE 1.General Purpose Resin(Polyester Resin)

Load at A

S.No	Mass in g	Weight in N	Loading deflection (mm)	Unloading deflection (mm)	Mean deflection at center δ (mm)	Young's modulus (E) (N/mm^2)
1	100	0.981	0.03	0.00	0.015	276.75×10^6
2	150	1.4715	1.81	3.42	2.615	2.381×10^6
3	200	1.962	2.21	4.71	3.46	2.399×10^6
4	250	2.4525	3.5	6.21	4.855	2.137×10^6
5	300	2.943	6.21	6.21	6.21	2.005×10^6

Load at B

S.No	Mass in g	Weight in N	Loading deflection (mm)	Unloading deflection (mm)	Mean deflection at center δ (mm)	Young's modulus (E) (N/mm^2)
1	100	0.981	0.2	0.75	0.475	8.73×10^6
2	150	1.4715	0.22	2.78	1.5	4.15×10^6
3	200	1.962	1.22	4.20	2.71	3.06×10^6
4	250	2.4525	2.46	4.20	3.33	3.116×10^6
5	300	2.943	4.20	4.20	4.20	2.965×10^6

The young's modulus of general purpose resin(Polyester resin) material is E =3.43X10^6 N/mm^2

TABLE 2.Epoxy Resin

Load at A

S.No	Mass in g	Weight in N	Loading deflection (mm)	Unloading deflection (mm)	Mean deflection at center δ (mm)	Young's modulus (E) (N/mm^2)
1	100	0.981	0.12	0.30	0.21	19.76×10^6
2	150	1.4715	0.5	1.20	0.85	7.325×10^6
3	200	1.962	1.25	2	1.625	5.109×10^6
4	250	2.4525	1.47	2.05	1.78	5.896×10^6
5	300	2.943	2.05	2.05	2.05	6.075×10^6

Load at B

s.no	Mass in g	Weight in N	Loading deflection (mm)	Unloading deflection (mm)	Mean deflection at center δ (mm)	Young's modulus (E) (N/mm^2)
1	100	0.981	0.08	1.87	0.975	4.257×10^6
2	150	1.4715	0.58	2.08	1.33	4.681×10^6
3	200	1.962	1.06	2.46	1.76	4.717×10^6
4	250	2.4525	1.9	2.52	2.21	4.696×10^6
5	300	2.943	2.52	2.52	2.52	4.942×10^6

The young's modulus of Epoxy resin material is E =6.74X10^6 N/mm^2

C. Deflection test of simply supported beam showing graphs

Fig. 3.*Deflection test of simply supported beam of load A for general purpose resin(Polyester) and epoxy resin*

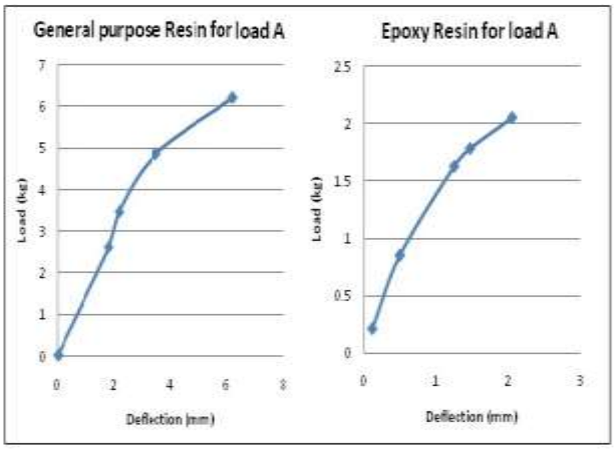
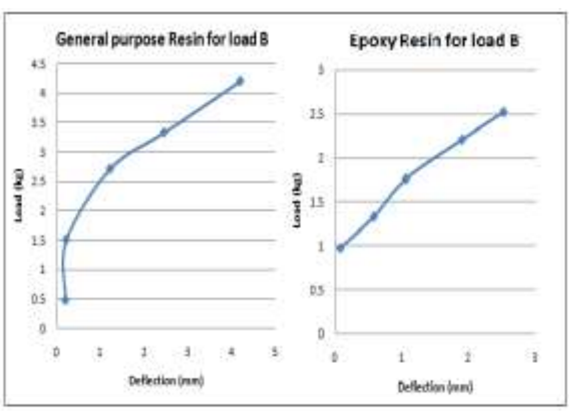


Fig. 4.*Deflection test of simply supported beam of load B for general purpose resin(Polyester) and epoxy resin*



The arrangement consists of a standard test of specimen size as (1524mm×50mm×3mm) that is (lengthxbreadthxthickness)of composite beam panels prepared for general purpose resin and epoxy resin with chopped strand mat glass fibres.The beam is placed over two vertical supports as simply supported and at centre of the beam holds the weight hanger which is added by increasing the weights such as 100g,150g,200g,250g,300g.At the mean time the dial gauge pointer points the beam and notes the load and unload readings for both the load A and load B for general purpose resin and epoxy resin. From this the deflection and young's modulus values obtained for general purpose resin and epoxy resin. The typical test set-up configuration and instrumentation to measure critical load is the simply supported beam . To prevent beams from sudden falling , the beams were restrained laterally at the support by using safety vertical rods fixed at the bottom support. In contrast, it was also found that the obtained maximum deflection at the mid-span section increased when the span of beam increases. Beam deflection is a deflection due to bending deformation[34]. The GFRP beams which is simply supported at their ends A and B, has its spans length L loaded by a vertical point W applied at mid-span. A dial gauge is used to measure the deflection.Beam is loaded and unloaded for the deflection to be measured. The beam which shows deflection exhibits high degree of linearity and repeatability[35]. The beam predicts the strength and deflections for generic beam shapes, such as, solid, box and channels.Mixed loading for bending were experimentally checked by a wide range of beam loading tests. The material properties of laminate can be found under different loading situations.For rectangular panels and sandwich panels the loading conditions considered as point which is used to predict the strength and deflections .The material properties becomes increasing importance as the deflection increases.Increase in young's modulus results in decrease in the failure load.The mechanical property of any of the composite material depends upon its constituent material (i.e. fiber and resin). In general beams, only the bending phenomenon is pre-dominant.It is found out that with increase in thickness also increases for all end conditions. Also it is found out that the beams with fixed-fixed boundary condition have highest rigidity. Increase in width of the beam, the supporting area of the beam also increases which provides enough strength to carry the additional mass for fixed length[25]. Large deflection depends on the geometry of the cross-section, the material properties, and the loading conditions[36]. Laminate plate theory describes the deformation of a laminate under external loading based on the properties of the fibre, matrix and the % of each in each axis of loading. The total deformation at a point of load application in a direction perpendicular to fibre direction is the sum of the deflections in the fibre and the matrix. Use of Youngs and Shear moduli, which are bulk properties of the raw material simple properties of composite materials can be estimated based on the contribution of each part of the composite[24].The loading capacity and energy absorption are dependent on many parameters[37]. From the above graph and tabulation of load A for general purpose resin it shows that weight in grams increases from 100grams,150grams,200grams,250grams,300grams.For that the loading increases gradually as 0.03mm,1.81mm,2.21mm,3.5mm,6.21mm.The unloading values shows gradual increase as 3.42mm,4.71mm,6.21mm,6.21mm.The mean deflection at centre occurred as not an spontaneous increase of values as 0.015mm,2.615mm,3.46mm,4.855mm,6.21mm.The young's modulus value obtained for N/mm^2 as 2.381x10^6,2.399x10^6,2.137x10^6,2.005x10^6 as decreased

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gradually. Thermoplastics have low stiffness and strength.Thermosets are highly brittle,rigid,thermally and dimensionally stable in their resistances such as electrical,chemical and solvent[14].From the above graph and tabulation of load B for general purpose resin it shows that weight in grams increases from 100grams,150grams,200grams,250grams,300grams.For that the loading increases gradually as 0.2mm,0.22mm,1.22mm,2.46mm,4.20mm.The unloading values shows gradual increase as 0.75mm,2.78mm,4.20mm,4.20mm,4.20mm.The mean deflection at centre occurred as not an spontaneous increase of values as 0.475mm,1.5mm,2.71mm,3.33mm,4.20mm.The young's modulus value obtained for N/mm^2 as 8.73x10^6,4.15x10^6,3.06x10^6,3.116x10^6,2.965 x10^6 as decreased gradually. Although thermoplastics have the added advantage of recycling possibilities, thermosets are targeted to obtain much improved mechanical properties as compared to thermoplastics in the resulting composites[7].The young's modulus(E) of general purpose resin material is 3.43X10^6 N/mm^2. Glass fibres with epoxy resin shows the maximum deflection under repeated loads keep on increasing[38].From the above graph and tabulation of load A for epoxy resin it shows that weight in grams increases from 100grams,150grams,200grams,250grams,300grams.For that the loading increases suddenly as 0.12mm,0.5mm,1.25mm,1.47mm,2.05mm.The unloading values shows peak increase as 0.30mm,1.20mm,2mm,2.05mm,2.05mm.The mean deflection at centre occurred as an spontaneous increase of values as 0.21mm,0.85mm,1.625mm,1.78mm,2.05mm.The young's modulus value obtained for N/mm^2 as 19.76x10^6,7.325x10^6,5.109x10^6,5.896x10^6,6.075x10^6 as increased at high rate. In epoxy resin glass transition temperature, thermal stability as well as chemical resistance are improved. Good adherence to metal and glass fibers because of Curing agents and modifiers are available, Absence of volatile matters during curing, Low shrinkage during curing, Excellent resistance to chemicals and solvents. Polyester resin has high shrinkage,strength and modulus are lesser than epoxy[9]. From the above graph and tabulation of load B for epoxy resin it shows that weight in grams increases from 100grams,150grams,200grams,250grams,300grams.For that the loading increases suddenly as 0.08mm,0.58mm,1.06mm,1.9mm,2.52mm.The unloading values shows peak increase as 1.87mm,2.08mm,2.46mm,2.52mm,2.52mm.The mean deflection at centre occurred as an spontaneous increase of values as 0.975mm,1.33mm,1.76mm,2.21mm,2.52mm.The young's modulus value obtained for N/mm^2 as 4.257x10^6,4.681x10^6,4.717x10^6,4.696x10^6,4.942x10^6 as increased at high rate. Performance of the composite depends upon the materials of which the composite , the arrangement of the primary load-bearing reinforcing fiber portion of the composite, and the interaction between these materials.Different sections of the beam should be used to obtain a better estimate of deflection values. FRP causes large deflections at load levels depends on the fraction of ultimate load carrying capacity.Thermosetting polymers in continuous fibers will usually be stiffer and stronger. Thermosetting polymers exhibitgreatly increased high-temperature and load-bearing performance.At high loading rates, or in the case of short

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 UGC CARE Listed (Group -I) Journal Volume 11,Iss 12, 2022

durations of loading, the polymeric solid behaves in a rigid, brittle manner. At low loading rates, or long durations of loading, the same materials may behave in a ductile manner and exhibit improved toughness values. Thermosetting matrix polymers provide good thermal stability and chemical resistance. They also exhibit reduced creep and stress relaxation in comparison to thermoplastic polymers. The matrix resin must have significant levels of fibers within it at all important load-bearing locations. Reinforcing fibers must be fully wetted by the polymer matrix to insure effective coupling and load transfer. Thermoset polymers of major commercial utility either have suitably low viscosity, or this can be easily managed with the processing methods utilized.Commercial uses of thermoplastic matrix polymers hasbeen slow. A major obstacle is that thermoplastic matrix polymers are much more viscous and are difficult to combine with continuous fibers in a viable production operation[26].The young's modulus(E) of Epoxy resin material is 6.74X10^6 N/mm². E-glass fiber and epoxy resin with catalyst addition as matrix for the composite material showed that the glass fiber reinforcing the laboratory composite resins have greater effect[39]. The Maximum value of deflection is with epoxy resin, minimum value of deflection is with polyester resin. Specimen's reinforced with epoxy resin always shows better properties as compared to the Specimen reinforced with polyester resin[23].

4.CONCLUSIONS

Composites are prepared by using hand layup technique. Chopped strand matt powdered type glass fibre and polymers namely epoxy resin and polyester resin used for the preparation of composites in bus body applications. From the mechanical studies, Deflection test on simply supported beam concludes that the epoxy resin has high young's modulus (6.74×10^6 N/mm²) than general purpose resin (3.43×10^6 N/mm²).

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