Development of hybrid composites using treated natural biofibers and nanoparticles for structural applications

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Abstract: Tiger grass which is inculcated in reinforcements with combining with Polypropylene(PP) emulsed as a resin scorted by individual combination with verity of different nano particles resulting with a composite materials incorporated in real structural applications. Adherence between the nanofillers with bonding matrix was enhanced with combination of alkalization & KMnO₄ treating methods to enhance or cultivate on biofibre surface. Three different types of nanofillers with different percentage combination were made separately. Certain mechanical testing was encapsulated under 3 point bending and tensile stress loading to obtain mechanical properties such as deflection due to loading and obtaining tensile strength of respective sample beams. The bioreinforced composite was also tested by Thermo Gravimetric Analysis (TGA) to understand the methodology for degradation with rising temperature. For this reason, there must be microscopically test taken up like scanning electron microscope (SEM) was carried out. Based on the obtained results, when the chemically induced biofibres amalgamated along nanofillers with certain percentage, displayed striking better mechanical properties than the biofibres which were untreated. Among the results, out of 3 different nanofiller combined with treated natural fibers, h-Bn with 0.3% of weight of fibres treated with consulted percent composition near to 5% NaOH along with 0.6% of KMnO₄ gave acceptable mechanical testing properties as compared to other graphite, graphene platelets and nontreated bio-fibre composites.

Keywords: Tiger grass, Potassium permanganate (KMnO₄) treatment, Sodium hydroxide (NaOH) treatment, Polypropylene (PP), Graphene, Graphene platelets, h-Bn, TGA, SEM

1. INTRODUCTION

Biofibers are slowly and steadily replacing the synthetic based fiber in today's world. Recently, researchers bringing a focus towards antimicrobial aspects, resistance to flame and water to address mechanical properties [1]. There were studies highlighted on vegetable fibers and kitchen based waste peels of onion, potato and carrot for their mechanical properties [2]. Perhaps, there are many biofibers relating fruit peels were also studied for its strength properties such as lemon and sweet lime peels in epoxy resin [3]. Surfactants are playing pivotal role in enhancing the material properties of biofibers which were discussed in several articles. Moreover, the main vital role of uses of biocomposites is its economical as it grows naturally. Some of the researches are taken up with jute fibres and combination of cotton and coir composite for sports equipment and other light weight structural applications [4]. With day to day increasing of universal population, complications related to ecology are giving more problems in society. Studies have been additionally performed on blending of manmade fibres with biofibres along with the mixture of polymer matrix for marine application and
military structures.[5] Hence, the compatibility issues have been detected from plant extracted aggregates along with some traditional method binders, which resulted to formulate a bio-composite giving less mechanical properties and these bio-composites can’t be utilized for practical structural applications. Air voids can be reduced in order to addition of some prior nano particles which helps in enhancement of the properties of the bio composites in terms of mechanical and fatigue applications. Some researchers also inculcated with some phosphate salts with combination of magnesia to enhance the properties and reduce air voids [6].

Certain advantages catch up when natural fibres over synthetic fibres. The main thing is these are easily available and taking about cost, there are huge number natural fibres which are low cost along with positive reaction towards environment like recyclability, biodegradability and renewability. Some of prior applications of natural fibres incorporated with polymer matrices are automobile body panels, interiors, building and storage panels, storage devices, false ceilings and partition boards. Another areas nowadays the much usage of bio composites is the aerospace industries where the aircraft wings and wind turbine blades are steadily dragging the limits based on size and introducing advanced materials with engineering design and fabrication techniques[8].The main descriptive objective about this current research work gives enhancement with polymer matrix composites reinforced with biofibre tigergrass along with chemical treatment with NaOH plus KMnO4 and addition of different nanofillers study their practically suitable for structural applications.

Boron Nitride is refractory compound of Boron and Nitrogen that exists in many crystalline forms. h-BN is synthesized by ambient pressure chemical vapour Deposition on the poly Nitrogen. [9] It is a novel material which is highly resistant to chemical and heat. For moderate high temperature applications like varying between 150-200°C, the incorporation of polymer matrices are increasing starily[10].Notable attention and methods of research have been prioritised on the usage of polymer matrix as thermal applications solutions due to lesser in density with ease of fabricating capability along with large range of practical applications [11].

Graphene is associate degree chemical element of carbon within the variety of one layer of atoms during a 2D polygon lattice during which one of atom tries to forms every vertex. Graphene features a special set describing about properties that set it except alternative allotropes from carbon. It conducts heat and electricity terribly expeditiously and is almost clear.[12] Graphene additionally shows an oversized and nonlinear magnetic force,[13] even larger than C, and may be levitated by Nd-Fe-B magnets.

Exfoliated black lead nano-platelets (xGnP) square measure new styles of nanoparticles made up of black lead. These nanoparticles encompass tiny stacks of graphene that square measure one to fifteen nanometers thick, with diameters starting from sub-micrometre to one hundred micrometres. The thrombocyte form, however, offers xGnP edges that square measure easier to change with chemicals for increased dispersion in polymers.[14]

2. MATERIALS AND METHOD ADOPTED:

PP epoxy composites are developed along with biofibres & nanoparticles materials considered as reinforcements. There were different materials used in process of preparation of natural bio-fibrecomposites constituting tigergrass fibre, Sodium hydroxide (NaOH) with Potassium permanganate (KMnO4), h-Bn, graphene, graphene platelets, distilled water, PH paper, epoxy polymer and Acetic acid. Table1 show the chemical individual composition of tigergrass that influences the characteristic of bio-composites that are developed. Figure one shows the tiger grass fibre. Fibers that having length of 2000 millimeter long was shredded to 5mm through a machine called fibre chopping machine. The word that checks specimens utilized in the current study. This section discusses the materials used and therefore the procedure enforced within the development of
the various Nano-composites and therefore the testing of those Nano-composites as per ASTM standards. The properties of the all nano particles utilized in this current case square measure described in table 2, table 3 and table 4; the h-Bnare having commercial grade giving a purity of bigger than or up to ninety nine.9%.

**Table 1. Composition of different chemicals in Tiger grass fibres**

| Pectin   | Cellulose | Waxes and oils | Hemicelluloses | Lignin |
|----------|-----------|----------------|----------------|--------|
| 0.87%    | 58.3%     | 2.5%           | 17.48%         | 23.3%  |

![Figure 1. Tigergrass fibre](image)

**Table 2. Properties of h-BN powder used for study**

| Specifications        | Dimensions         |
|-----------------------|--------------------|
| Diameter              | 60 (nm)            |
| Purity                | 99.9 (%)           |
| Density               | 2.29 (g/cm3)       |
| Molecular Weight      | 2482.5 (gms/mol)   |
| Young’s Modulus       | 3500 (GPa)         |
| Melting point         | 2527 (°C)          |

**Table 3. Properties of graphene powder used for study**

| Specifications        | Dimension’s         |
|-----------------------|---------------------|
| Diameter              | 50 (nm)             |
| Purity                | >99.9 (%)           |
| Density               | 2.26 (g/cm3)        |
| Molecular Weight      | 2043.82 (gms/mol)   |
| Young’s Modulus       | 2400 (GPa)          |
| Melting point         | 4156.85 (°C)        |

**Table 4. Properties of the graphene platelets used for study**

| Description           | Dimensions         |
|-----------------------|--------------------|
| Thickness             | 6-8 (nm)           |
| Purity                | >99.9 (%)          |
| Density               | 2.3 (g/cm3)        |
| Molecular Weight      | 1201.56 (gms/mol)  |
| Young’s Modulus       | 3500 (GPa)         |
| Melting point         | >4100 (°C)         |
3. PREPARATION OF SPECIMENS

3.1. Surface treatment:
This section keenly elucidates the methodology taken on chemical treatment of tigergrass fibres used as bio fillers in the polymer composites.

3.2. Alkaline treatment (NaOH):
Sodium hydroxide (NaOH) which is used to improve the strength of the alkali fibre application. Alkali treatment is performed by weight of fibers with respect to single concentration levels i.e. 5%. During 2 hours the fibers were immersed in sodium hydroxide solution and then washed with 2 percent acetic acid along with distilled water until the pH value exceeds 7. Then soaked fibers were dried for 24 hours in hot air oven keeping temperature at 60 °C help to extract moisture. Composites were prepared by adding 20% of fiber to the resin weight used. As control beams, reinforced composites were prepared for checking the efficiency of treatment method on composites which were nontreated biofibre. For different composition considered 5 specimens is prepared. Universal testing machine (UTM) conducted traction testing.

3.3. Chemical treatment with Potassium permanganate (KMnO4)
In this test, Potassium permanganate (KMnO4) is used in different amounts called as surfactant. Optimum results have been given among the prior alkali-treated nano specimen S2. The S2 was further being soaked for 3 minutes in acetone along with KMnO4 solution, which was dried at 60°C for 24 hours in a hot air oven to extract its moisture. All nano-specimens were being prepared to maintain fiber concentration at 20 per cent by resin weight. Nano-Specimen was being prepared from varying fiber weight concentration levels of KMnO4 viz., 0.3% cent. For this same composition six specimens were prepared and average readings from results obtained of course plotted for the test analysis. Traction testing was done from Universal testing machine (UTM).[12]

3.4. Experimental methods
Fillers used in preparation of composites were being chopped by fibre-cutting machine into 2-3 millimeters in thickness. Fibers melted in furnace along with polypropylene, and resulting blended completely mixture was applied to the mould machine for injection. Subsequent injection procedure is conducted at 220°C, with a pressure of 1.5 MPa for 12-15 minutes. The mould has been removed from mould machine for injection and made to cool at room temperature. For all the composites produced, the fraction of volume of fibers was kept fixed at 20 per cent. Tensile test was carried out in compliance with ASTM criteria D3039. In a Universal testing machine (UTM) with a capacity of 750 kgf load at crosshead speed upto 3 mm / min room temperature, the natural bio fiber-reinforced composites strengthened with treated and nontreated fibres were subjected towards tensile loading.

| Sample No. | Specimen Reference | Constituents | Percentage of nanofillers by weight of fibres |
|------------|--------------------|--------------|--------------------------------------------|
| 1          | UF                 | epoxy + non treated biofibres | Nil                                        |
| 2          | NS01               | epoxy+ treated biofibres+graphene (0.2%) | 0.2% graphene                              |
| 3          | NS02               | epoxy+ treated biofibres+graphene (0.3%) | 0.3% graphene                              |
| 4          | NS03               | epoxy + treated biofibres+graphene platelets (0.3%) | 0.3% platlates                             |
| 5          | NS07               | epoxy+ treated biofibres+hBN (0.3%) | 0.3% h-Bn                                  |
Table 5 illustrates the different composition involved in the manufacturing of the sample. The sample 1 is untreated bio fibres which are mixed in polymer epoxy. The second sample is the treated biofibres are mixed with 0.2% weight of biofibres of nanoepoxy i.e. Graphene. The third sample is the treated biofibres are mixed with 0.3% weight of biofibres of nanoparticles i.e. Graphene. The fourth sample is the treated biofibres are mixed with 0.3% weight of biofibres of nanaoparticles i.e. Graphene nanoplatelets. The fifth sample is the treated biofibres are mixed with 0.3% weight of biofibres of nanaoparticles i.e. h-Bn.

3.5. Experimental set up
3.5.1. Three-point Bending test
This test allows the determination of the optimal percentage of nanofillers and tigergrass for reinforcement in three-point loading tests based on epoxy beams. This check guarantees an optimal amount per weight of nanofillers. Therefore flexural activity regarding bio-reinforced polyepoxy beams is studied. Reinforced beams subjected to flexural testing (3point loading) to assess mechanical properties as standards for resistance deflection etc. The performance of the reinforced beams was compared with the unmodified beams to check the reinforcement’s effectiveness for structural applications.[13]

| Sl. No. | Title                                      | Description           |
|--------|--------------------------------------------|-----------------------|
|        | Size of the Specimens                     | 40mm x 12mm x 3 mm    |
|        | Epoxy resin                                | L-12                  |
|        | Percentage of h-BN, graphene, graphene platelets | 0.2%, 0.3%             |

Table 6 shows the specimen characteristics used for flexural testing as per ASTM (D2344). The specimen’s total bending load shown in figure 2. From the table 8 it follows that various polymer matrix nanoparticles show different types of composite brittleness. The explanation for this could be that they form some coarse and irregular pattern when distributed into the base polymer matrix. Such irregular patterns become the root of the Nano Composite’s distortion or shear yield. The mechanical properties of the Nano-composite material were tested by mechanical fracture research. Specimen size of 40mm x 12mm x 3mm is tested as shown in figure 1. (a) using a hydraulic closed loop testing machine. To evaluate the average values obtained from flexural strength to polymer specimens, ASTM D2344 M was followed for experimental precision. Table 7 displays the equipment taken for the 3 point load test is described Figure 1. (b) technical details of the test apparatus.

Figure 1. (a) Sample for three point load set-up  Figure 1. (b) Equipment used for 3 point bending
Table 7. Technical details of bending test apparatus

| Sl. No. | Facilities for tests | Specifications | Test conducted |
|---------|----------------------|----------------|----------------|
| 1.      | Load frame testing machine | Capacity-10 kN, Least count =0.01kN, Displacement=0.01mm, FSR= ±1count, Accuracy = ± 0.1% Operating condition= 10 to 45oC, Power supply=230V,50Hz, AC mains Strain rate = 0.05mm/min | Three-point test on beams |
| 2.      | LVDTs and Displacement indicating units | Least count= 0.01mm, Range = ± 25mm Linearity and accuracy= ± 1digit Operating temp=10 to 50oC Range-0 to 1999 micro-strains Nominal strain= 50µm/m Input resistance >1000 Ω Output Resistance= 1000 Ω Gauge factor= 1.5 to 5 Zero-point deviation = 5% |
| 3.      | Strain measuring system | Range-0 to 1999 micro-strains Nominal strain= 50µm/m Input resistance >1000 Ω Output Resistance= 1000 Ω Gauge factor= 1.5 to 5 Zero-point deviation = 5% |

3.5.2. Results of 3 point bending test

Table 8. Result of three-point bending test

| Sl. No. | Specimen | Ultimate load (kN) | Max. Deflection (mm) | Max. Flexural stress (N/mm2) |
|---------|----------|--------------------|----------------------|-------------------------------|
| 1       | UF       | 3.9                | 1.4                  | 29.4                          |
| 2       | NS01     | 2.07               | 1.67                 | 18.8                          |
| 3       | NS02     | 3.09               | 1.45                 | 29.4                          |
| 4       | NS03     | 4.99               | 1.37                 | 47.5                          |
| 5       | NS07     | 1.3                | 1.35                 | 12.4                          |

The results obtained after 3 point bending test are displayed in table 4. The graphical interpretation of obtained results is in figure 2. The bar graph representation and load vs deflection of 3 point bending test is shown in figure 3. In the above table, the prior description of each sample constituting different results when they are prior subjected to 3 point loading.
Figure 2. The Ultimate bending load of the specimen in 3 point bending.

As the bending test results are plotted in a graphical manner. In figure 2, the verity of characterization is observed. Taking about the first specimen i.e the untreated fibre, the ultimate load reached up to 10N. whereas, the max deflection is 1.4mm furthermore giving the ultimate stress as 29.4N/mm². Similarly, graphene with treated biofibres having the weight percentage 0.3 of the biofibres gave the similar ultimate stress as of untreated fibers in terms of bending load. The leading one amongst all the samples is the graphenenanoplatlets having the weight percentage of 0.3 in through with treated biofibre giving the remarkable ultimate stress as 47.5 N/mm². However, its max deflection is 1.37mm which comparatively less but its higher than specimen constituted with h-Bn nanoparticles. It gave the lowest ultimate stress in terms of bending compared to the other specimens. At last, the positive results shown in terms of 3 point bending flexural strength bangs the top position by grapheme nanoplatlets with effective ultimate stress in terms of bending.

3.6. Tensile Test

This test assists in determining the optimal percentage of nanoparticles for strengthening epoxy beams which will result in increased ductility of the changed beams. This classification compares optimum percentage from nanofillers by weight percent of tigergrass and epoxy which delivers maximum structural efficiency regarding of load bearing power. It examines the tensile nature of the bio-reinforced epoxy beams. Modified beams under tensile loads have been studied to analyze mechanical properties as, strength parameters, etc. Tensile effects of the changed beams were measured against unmodified beams in order to determine the adjustments sustained for strengthening. It then compared the results obtained with unmodified beams. Table 6 shows the specimen properties used for the tensile processing. Table 11 displays the results of the specimen used for the study. The specimen Ultimate Load is shown in figure 3.

The optimal percentage of nanoplatlets per wt of h-Bn, graphene, and graphene. Percentage from epoxy resin required for reinforce plain polyepoxy specimens, that defines structural efficiency with terms of maximum load carrying prior capacity, has been evaluated. Hence tensile activity of re-inforced nanoparticles in the bio epoxy beams was studied. For the composite, tensile test was performed to determine the strength deflection criteria. Comparison was made of experimental results of the composite materials with tidy beams. Table 9 displays the Micro Universal Testing Machine design used to perform the tensile tests.
Table 9. Technical details of tensile test apparatus

| Sl. No. | Facilities for tests | Specification | Test conducted |
|---------|----------------------|---------------|----------------|
| 1       | Max cap=10kN,       | Least count =0.2kgf, (1.9613N) | Direct tension test on flat shape specimen |
|         | Least Count of elongation scale =1mm |                  |                |
|         | Micro UTM            | Grip separation=25mm-750mm |                |
|         | Straining Rate=100 mm/min |                  |                |
|         | Accuracy = +/- 0.005% |                  |                |

The specimen characterization required for the tensile test is shown in table 6. The size of the specimen is as per the ASTM standards which help to get the results in systematic form. The use of epoxy resin is given by the code of conduct is L-12 and the different percentages are specially constituted in the table 10.

Table 10. Specimen Characteristics for Tensile test as per ASTM (D3039)

| Sl. No. | Title | Description |
|---------|-------|-------------|
|         | Size of the Specimens | 230mm x 25mm x 3 mm |
|         | Epoxy resins           | L-12 |
|         | Percentage of h-BN, graphene, graphene platelets | 0.2%,0.3% |

![Figure 3. (a) tensile specimen (b) Tensile test apparatus](image)

The above figure 3(a) is the specimen taken for the tensile test. The dimension of the specimen is as per the ASTM standards. Figure 3(b) is the tensile test apparatus where the significant testing is done based upon the loading which will be acting in terms of tensile. Hence, different types of the specimen are loaded in the UTM in order to get the tensile test results. After receiving the results the further process is to be taken in terms of modification if required or deletion of some properties for prior update to receive positive results.

3.7. Results of tensile test for different specimens

Table 11. Result of tensile test

| Sl. No. | Samples | Ultimate load (kN) | Ultimate Tensile strength (N/mm²) |
|---------|---------|--------------------|----------------------------------|
| 1       | UF      | 0.369              | 12.3                             |
| 2       | NS01    | 0.423              | 14.1                             |
| 3       | NS02    | 0.179              | 5.97                             |
| 4       | NS03    | 0.367              | 12.2                             |
| 5       | NS07    | 0.562              | 18.7                             |
Figure 4. The Ultimate load of the different samples in Tensile test

The figure 4 describes the tensile test results are plotted in a graphical manner, the verity of characterization is observed. Taking about the first specimen i.e the untreated fibre, the ultimate load reached up to 0.3690kN. whereas, the ultimate stress obtained as 12.3N/mm². Similarly, graphene with treated biofibres having the weight percentage 0.3 of the biofibres gave the similar ultimate stress as of untreated fibers in terms of tensile load. The leading one amongst all the samples is the h-Bn having the weight percentage of 0.3 in through with treated biofibre giving the remarkable ultimate stress as 18.7 N/mm². However, its ultimate load is also higher than the all giving 0.56kN which comparatively high. NS02 gave the lowest ultimate stress in terms of tensile compared to the other specimens. At last, the positive results had shown in terms of tensile strength bangs the top position by h-Bn with effective ultimate stress in terms of tensile loading.

Figure 5: The Stress-Strain curve of the different samples in Tensile test

Figure 5 shows the ideal stress strain curve of five different specimens. As observed in the above graph, the results showing the positivity in the h-Bn and graphene in terms of strength and yield strength. The grapheme nanoplatelets at first overtaken the UF in terms of yield strength and then in some mid ranges of strain percentages, it went down as compared to UF and at last its highest point of strain is higher as compared with graphene nanoplatelets. At last the h-Bn and graphene showed good properties as compared to other specimens in terms of stress and strain.
4. MICRO-CHARACTERISTIC STUDY

4.1 Scanning Electron Microscopic Analysis (SEM)

Figure 6 (i to iv) displays SEM photographs of epoxy bio composites with different composition of nano particles incorporated in the matrix. From Figure 6 (a) and (b) to get 0.3 weight percentage of h-Bn which is reinforced in polymer matrix along with biofibres. It can be seen that the reason of scarcity phenomenon of reinforced nanoparticles, the prior distribution of biofibres and nanoparticles across the polymer matrix is observed. (ii) For 0.3 weight percentage of h-Bn having different magnification that is reinforced in polymer matrix. (iii) For 0.3 weight percentage of h-Bn 5 micrometer magnification that is reinforced in polymer matrix.

4.2 Thermo Gravimetric Analysis

The thermo Gravimetric Analysis (TGA) was performed in air atmosphere with temperature rise of 20 degree Celsius per minute to conclude the thermal stability of graphene and respectively h-BN reinforced bio Composites. The figure 7(a) elucidates the TGA curve of h-Bn composition and figure 6 elucidates the TGA curve of graphene composition. The 5% degradation temperature (T\textsubscript{d5%}) of around 341.37 degree Celsius for the h-Bn composition for 0.3 wt. % of epoxy and weight of bio fibres. Polymer degradation temperature in the composite is around 403.650C which is greater than that graphene which is by around 20%. The remaining degradation temperature reaches upto 645.61 degree Celsius of the remaining apart from the degraded material.
Figure 7 (a) indicates the graph of TGA results of h-Bn with biofibers. Hence, at last the remaining material weight is 0.1024g which is almost 0 grams in h-Bn reinforced bio nanocomposite. The T_d5% of graphene is around 3410C. For the weight of 0.3% of biofibres composite around 401.090C for graphene reinforced composites. During the ending of this temperature, maximum degradation has taken place up to 90.67% of the total sample size taken up for testing. The residual was about 10% at temperature of 589.50 degree Celsius for polymer composite material where as 2.236% nano particles of graphene nano composite was remaining at temperature around 697.88 degree Celsius. Figure 7(b) helps to describe the T_d5% of non biofibre with polymer is around 3380C. The residual was about 10% at temperature of 590 degree Celsius for polymer composite material where as 2.236% nano particles of graphene nano composite was remaining at temperature around 697.88 degree Celsius. The combined graph of biofibres in h-Bn, graphene and without biofibre composite gives the significant difference among the three in terms of degradation temperature, impulsive weight loss. Figure 8 describes the combined results of thermo gravimetric analysis.

Figure 8. combined results of thermo gravimetric analysis.
5. CAE ANALYSIS

CAE Analysis is considered as most important for simulation in order to receive virtual results for any type of modification eradiated for the requirements. In fact, it will be of positive interest to apply new level of system design towards the approach to CAE designing with operation which helps to extend of the sample towards applicability and can be used within the cheap power system. Along with this, custom design means that the new CAE techniques will helps to deliver non similar performance which are required for variety of applications in optimum value of cost with higher operational flexible conditions.

5.1 Static structural Tensile test analysis

The specimen undertaken for CAE analysis was Graphene nanoplatlets. The reason of choosing this sample signifies the amount of nanoparticle dispersed in polymer matrix along with tigergrass was calculated optimum as per the preparation of sample. Preparation of other samples was undergoing but, the main problem raised was the proper dispersion of nano particles in matrix. Comparatively, grapheme nanoplatlets gave proper structural specifications as per the real prepared sample. Figure 9 shows the specimen for tensile test.

5.2 Preparation of specimen for simulation

5.2.1 3D Modelling

Same amount of loading was applied as done in physical tensile test in UTM. Significantly the CAE results obtained were quite similar to the real results. The main motivation of the CAE analysis is to check and compare the real time results and the simulated results which can be further researched. The future research undertaken can be designed and modified the virtual model in CAE according to the requirements like change in percentage of the nanospecimen composition, polymer matrix change in composition etc. figure 12 shows the normal stress ranges for the specimen when subjected for loading.

Figure 10 illustrates the mesh pattern assigned to the specimen in order to achieve proper and authentic results from the simulation. The type of mesh is coarse adjustment in order to setup the meshing cell to be distributed equally across the specimen. Hence, two faces constitute fixed support and other two faces constitute pull force of 500N. It’s a common application where the specimen is subjected to tensile loading which experiences the deformation and sometimes fracture at certain point.
5.3 Results obtained after simulation

5.3.1 Normal stress

Figure 11 illustrates obtained from the results the max normal stress reached to 11.929 MPa and the minimum stress went up to the negation form. The simulated picture describes the max stress has been taken up at the center portion of the specimen where the max amount of portion is in loading. However, there is medium level of the loading at the neck of the specimen so the miniature action of the tensile forces is less at necks. Table describes about the comparison of normal stress btn simulated and UTM results.

| Sl. No | Samples                | Normal stress (MPa) | Normal stress (MPa) |
|-------|------------------------|---------------------|---------------------|
|       |                        | UTM                 | simulated           |
| 1     | Graphene nanoplatlets  | 12.1                | 11.929              |

6. CONCLUSIONS

- Research on Development of hybrid composites using treated natural biofibers and nanoparticles for Structural applications is gaining prominences which are essential to substitute critical structural components in automobile structures, aircraft structures, and space craft structures. The present work is an attempt in this direction to develop Polymers reinforced with Biofibres and h-BN for structural applications.
- It can be inferred from the above experimental results that in-house polymer beams reinforced with h-BNs and tigergrass samples showed optimal results for mechanical properties as opposed for plain beams.
- Compared with other nano specimens like graphene and graphenenanoplatlets, h-Bn showed a better properties in terms of tensile strength and some applications with fluxeral load.
- This existence was discovered till 0.3 wt. Percentage of h-BN composition in the Epoxy Matrix but with an agglomeration of h-BN particles above 0.3 wt. Nano Composite material tensile resistance of 0.3 wt. The percentage h-BN of other nanospecimens such as graphene and graphenenanoplatlets was found to be greater than the tensile strength of 49.25 percent.
- Hence this Polymer Nano Composite material can be used for applications at higher temperature at around 3500C. This reduces the weight of the component and increases the strength. Thus this composite will be a substitute to the presently used ceramic composites.
- Further work in current research area includes the development of hybridnano-composites using combination of nano and micro-materials that helps to tackle both micro ornano-level aspects and could improve the composite material's ductility.
REFERENCES

[1]. Arun Y. Patil, N. R. Banapurmath, Jayachandra S.Y., B.B. Kotturshettar, Ashok S Shettar, G. D. Basavaraj, R. Keshavamurthy, T. M. YunusKhan, ShridharMathd, Experimental and simulation studies on waste vegetable peels as bio-composite fillers for light duty applications, Arabian Journal of Engineering Science, Springer-Nature publications, IF:1.518,03 June, 2019. https://doi.org/10.1007/s13369-019-03951-2.

[2]. Arun Y Patil, Umbrajkar Hrishikesh N Basavaraj G D, Krishnaraja G Kodancha, Gireesha R Chalageri, Influence of Bio-degradable Natural Fiber Embedded in Polymer Matrix, Elsevier, Materials Today Proceedings, Volume 5, 7532–7540, May 2018.

[3]. Shankar A. Hallad, N.R. Banapurmath, Vishal Patil, Vivek S Ajarekar, Arun Y. Patil, Malatesh T. Godi, Ashok S. Shettar, Graphene Reinforced Natural FiberNanocomposites for Structural Applications, IOP Conf. Series: Materials Science and Engineering, IOP Publishing, 376 (2018) 012072 doi:10.1088/1757-899X/376/1/012072.

[4]. Shahinur, S., &Hasan, M. (2019). Jute/Coir/Banana Fiber Reinforced Bio-Composites: Critical Review of Design, Fabrication, Properties and Applications. Reference Module in Materials Science and Materials Engineering. doi:10.1016/b978-0-12-803581-8.10987-7

[5]. Anidha, S., Latha, N., &Muthukkumar, M. (2019). Reinforcement of Aramid fiber with bagasse epoxy bio-degradable composite: investigations on mechanical properties and surface morphology. Journal of Materials Research and Technology. doi:10.1016/j.jmrt.2019.05.008

[6]. Ahmad, M. R., Chen, B., Haque, M. A., & Ali Shah, S. F. (2019). Development of a sustainable and innovanthygrothermal bio-composite featuring the enhanced mechanical properties. Journal of Cleaner Production. doi:10.1016/j.jclepro.2019.05.002

[7]. Karthi, N., Kumaresan, K., Sathish, S., Gokulkumar, S., Prabhu, L., &Vigneshkumar, N. (2020). An overview: Natural fiber reinforced hybrid composites, chemical treatments and application areas. Materials Today: Proceedings. doi:10.1016/j.matpr.2020.01.011

[8]. Sharma, D., Mohanty, S., & Das, A. K. (2019). Surface modification of titanium alloy using hBN powder mixed dielectric through micro-electro discharge machining. Surface and Coatings Technology, 125157. doi:10.1016/j.surfcoat.2019.125157

[9]. Momeni, F., Mehrafrooz, B., Montazeri, A., &Rajabpour, A. (2020). MD-based design of bilayer graphene-hBNheterostructures: An insight into enhanced thermal transport. International Journal of Heat and Mass Transfer, 150, 119282. doi:10.1016/j.ijheatmasstransfer.2019.119282

[10]. Madhukar, P., Selvaraj, N., Rao, C. S. P., &Veeresh Kumar, G. B. (2020). Fabrication and characterization two step stir casting with ultrasonic assisted novel AA7150-hBN nanocomposites. Journal of Alloys and Compounds, 815, 152464. doi:10.1016/j.jallcom.2019.152464

[11]. Tian, J., Wu, S., Yin, X., & Wu, W. (2019). Novel preparation of hydrophilic graphene/graphene oxide nanosheets for supercapacitor electrode. Applied Surface Science, 143696. doi:10.1016/j.apsusc.2019.143696

[12]. Morse, J. R., Zugell, D. A., Matis, B. R., Willauer, H. D., Balow, R. B., & Baldwin, J. W. (2019). Macroscale evaluation and testing of chemically hydrogenated graphene for hydrogen storage applications. International Journal of Hydrogen Energy. doi:10.1016/j.ijhydene.2019.11.098

[13]. Mondal, S., &Khaustgir, D. (2017). Elastomer reinforcement by graphenenanoplatelets and synergistic improvements of electrical and mechanical properties of composites by hybrid nano fillers of graphene-carbon black &graphene-MWCNT. Composites Part A: Applied Science and Manufacturing, 102, 154–165. doi:10.1016/j.compositesa.2017.08.003

[14]. Loukil, M., Hassine, W. B., Limam, O., &Kotronis, P. (2019). Experimental determination of GFRC tensile parameters from three-point bending tests using an analytical damage model. Construction and Building Materials, 223, 477–490. doi:10.1016/j.conbuildmat.2019.07.005