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Investigations on Tensile and Flexural Behaviours of Fly Ash / Coir Reinforced Polymer Matrix Composites

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HIGHLIGHTS

- Influence of Fly ash and Coir Fibre in mechanical performance of Polymer composite
- Polymers exhibits varying performance in tensile and flexural loading
- A threshold fly ash proportion has been limited to 5- 10%.
- Increasing fibre length shows improvement in strength whereas short fibre are good enough for modulus.

Abstract: Natural fibre reinforced polymer composites are often a better substitute to man-made fibre reinforced polymer composites because of their wide availability, economical, recyclability and biodegradability. In this paper, natural fibre reinforced polymer composites are made using coir/ fly ash as reinforcements. Influences of polymer types, natural fibre (coir) length and wt. % of fly ash on tensile and flexural behaviors are investigated. General purpose resin, Vinyl ester and Isophthalic resin are the different polymers used in making samples. The samples are prepared according to Taguchi Design of Experiments using L9 orthogonal array. To explore the significance of participating factors such as polymer type, natural fibre (coir) length and wt. % of fly ash on the tensile and flexural behaviors, ANOVA is implemented. Regression equations reveal that the type of polymer influences tensile and flexural behaviors more than that of natural fibre (coir) length and wt. % of fly ash.

Keywords: Fly ash; Coir fibre; Polymer composites; General-purpose resin; Vinyl ester; Isophthalic resin.

INTRODUCTION –

Nowadays, the most important environmental concern is non-degradable plastic waste. An increase in utilization of plastics made from synthetic materials increases plastic waste globally. The disposal of waste plastic becomes a great problem and it is necessary to contribute a major part of scientific research through specific materials of ecofriendly nature. Hence, the attention of researchers is focused towards the development of such materials and one of those kinds is natural fibre reinforced composites.

Significant numbers of research papers on natural fibre composites were found in the literature and few are taken here for discussion to know their abilities in replacing conventional non-eco-friendly materials. Kumar and coauthors [1] reviewed the mechanical property of sisal/glass fibre reinforced polymer composites. Authors mentioned that, the hybridization of sisal fibre with glass fibre in polymer composites improves the specific mechanical properties of the structure.

Coir is the natural fibre extracted from the coconut outer shell. It possesses high weather resistance due to higher lignin content and less water absorption compared to other fibres due to lower cellulose content. Bansal and coauthors [2] have studied the effect of bamboo fibre addition with jute and coir fibre reinforced polymeric composite respectively. During the experiment analysis, it was observed that the impact and hardness properties of bamboo-coir epoxy polymer composite exhibits better results. The significance of coir in mechanical properties of hybrid polyester with triple filler (coir, rice husk and egg shell) was studied and reported that 40% Coir, 48 % epoxy and 12 % husk and egg shell exhibits higher mechanical strength. In this work, though coir wt. % is constant, the effect of filler addition (12%) was found to be significant in enhancing composite strength [3].

It is worth to know about the fibre surface qualities and hydrophilic nature of coir as presented in the article by Adeniyi and coauthors [4]. These drawbacks were addressed by chemical and physical treatments, which improve matrix wettability and subsequently making it suitable for structural application. They reported that, tensile property of 20-30 wt. % coir reinforced polypropylene is marginally similar, which shows the range of fibre loading for measurable changes. In addition to hydrophilic nature, coir has some amount of wax, lignin, oil and other impurities posing challenges in using structural application. These are addressed by pre-treatment of fibres in the $Ca(OH)_2$ solution for 24 hrs, then washed and cured before using for specimen preparation[5].

Coming to fibre physical characteristics such as coir fibre length, diameter and orientation are playing significant role in attaining mechanical properties. Proper fibre treatment and orientation were exhibiting better strength and lower hardness than random orientation [6]. In the work done by Kumar S and coauthors [7], the fibre loading and treatment seems to have a contradictory effect on mechanical properties. On investigating the outcome, fracture toughness and hardness were found to be appreciable; however, tensile and flexural properties were not as expected. This sort of research insisted on proper selection of fibre sizing chemicals to achieve overall better performance.

The work done by Fahim and coauthors [8] is in a way to address the issue raised by Kumar and coauthors [7]. The effect of fibre length and chemicals used for fibre treatment was taken in their work [8]. Rice straw reinforced Low-density polyethylene (LDPE) composite was used with varying fibre wt. %, length and fibre treating chemicals. In the work, an appreciable rise in flexural and tensile properties was observed in phosphoric acid treated rice straw of 4mm length with 5% loading. This sort of outcome insisted on the selection of optimum factors for better performances.

As mentioned by many in the above paragraphs, reinforcing fibres (natural / synthetic) were wieldy used as reinforcement members to develop composite materials. Nevertheless, the prevailing limitation is the pore formation offering subsequent scope for filler additives to exploit their full load carrying capacity. Nair and coauthors [9] reviewed the effect of coal ash fillers on the mechanical properties of uni-directional E-Glass / epoxy composite. It was observed that fillers dispersed composites have higher strength because of effective load distribution and by preventing concentration at any specific location. [10]. The mechanical properties of fly ash dispersed epoxy composite is found to be affected by volume % and preparation temperature [11]. It was reported in the work done by Kang and coauthors [11] that the compressive properties increase with increase in fly ash volume % whereas tensile strength drops. However, for specific volume % of fly ash, preparation temperature found to have inverse effect on tensile strength. In the work done by Obed D’Souza and coauthors [12], they analyzed the wt. % effect of fly ash on flexural, tensile and wear behaviours of composites and reported that wt. % is in the same chronological order i.e., 9, 6, 3. Mohan Kumar and coauthors [13] investigated the mechanical properties of fly ash dispersed GFRP composite and reported that lower wt. % (2%) has better performance.

Purohit and coauthors [14] made polymer composite with fly ash to study impact, tensile and flexural strengths. It was shown that maximum strength is obtained at 4% fly ash. Singla and Chawla [15] investigated the mechanical properties of fly ash / epoxy composite and observed the increase in compressive strength. The interface adhesion properties of fly ash were assessed by using fly ash in Polyurethane (PU) core GFRP and CFRP skin- sandwich composites [16] by testing shear and flexural properties. Fly ash coating in PU core contributes to 39% and 5-10% rise in shear modulus and bending strength respectively in GFRP and CFRP skin sandwich composites. Chaowasakoo and coauthors [17] studied the effect of fly ash on tensile and flexural properties of epoxy composites with thermal and microwave curing. It was reported that, the modulus has increasing trend on fly ash addition whereas the strength shows a declining trend. However, curing time is also a contributing factor on their properties as well.

The fly ash as a particle is very fine and has smooth surface, which hurdles its ability to stick with plastics [18] and hence it is preferred to mix with other elements for better results. Sunkara and coauthors [19] made polymer composite with nano-fly ash and found an increase in these properties with 1% addition of nano-fly ash and decrease in strength at 2 and 3 wt. % of nano filler in matrix. Chen and coauthors [20] explored the mechanical properties of fly ash cenospheres (FAC) / epoxy composite. As mentioned by many researchers, increasing the weight fraction of FACs, the impact and flexural strengths and the flexural modulus of composite increases and reached the highest values when the weight fraction of FACs is at 15 wt%. Alomayri and coauthors [21] investigated the mechanical performances of fly ash-based geo polymer composites considering the effects of glass - micro fibre addition in composite.

Nanoclay is one of the members used to accommodate fly ash in epoxy composites to attain mechanical and electrical properties [18]. Mere addition of 3% nanoclay with 40% fly ash in epoxy composite brought significant rise in mechanical and drop in electrical properties. Though the addition of fly ash is contributing to rise the modulus and strength, its contribution to wear and corrosion is on other way round [22 and 23]. Energy dissipation measured in terms of damping is also another area of interest when considering material behaviour. In the work done by Babu and coauthors [24], the influence of fly ash on damping properties of glass fibre epoxy composites was studied and found to have better damping at 5% fly ash reinforced glass fibre composites. Apart from strength, fly ash contributed significant resistance to wear. Pattanaik and coauthors [25] investigated dry sliding wear behavior of epoxy fly ash composite following Taguchi design of experiment approach. The Taguchi orthogonal array gives the most precise result with least possible number of experiments.

Saradava and coauthors [26] studied the effect of red mud filler in coir fibre reinforced polymer composites.. They reported that by utilizing the red mud, improvement is observed in their mechanical properties. In another work, Mechanical behavior coir fibre reinforced orthophthalic polyester resin composites with fillers like bone and sea shell powder (SSP) was investigated [27]. However, the fillers of identical size (100 µm) were used, their responses to the tensile, flexural, impact and compressive were not same. Bone particle contributes to higher impact and compression properties whereas SSP supports tensile and flexural loads.

It is very useful in any investigation to study the effect of participating test factors in achieving desired output. To do so, some of the statistical routes [25 and 28] were taken by many researchers. In the work done by Kumar and coauthors [29], they used Taguchi method to see the effect of sliding velocity, fibre size, sliding distance and normal load on wear resistance of natural fibre composites. It was observed that the selected factors are contributing in varied proportions and their significance on wear is in the same order as mentioned in the phrase above. In work done by Devadiga and coauthors [30], they analyzed the combined effect of MWCNT and fly ash in wear resistance of aluminum Nano composites by implementing Taguchi technique. They observed that 0.25 and 8 wt. % of MWCNT and fly ash respectively as the optimum wt. % for better wear performance of the proposed composite.

Several papers reported in the literature are mostly based on epoxy polymer composite and only few have tried with different polymers suing same reinforcement. An endeavor is made in this work to make composite with different polymers such as General-purpose resin, Vinyl ester and Isophthalic resin with coir as reinforcement. The chosen coir fibre is ecofriendly and available in plenty. To overcome the fibre induced pores and enhance fibre matrix adhesion, fly ash is used as a filler material considered in this work. Moreover, Taguchi L9 array, a design of experiments (DOE) approach is used to make different combinations of samples considering different polymers used, fibre length and wt. % of fly ash. After testing, analysis of variance (ANOVA) is performed to highlight the influences of type of polymer, fibre length and wt. % of fly ash on tensile and flexural behaviors of the synthesized composite materials.

METHODOLOGY

The thermosetting polymers such as General-purpose resin, Vinyl Ester and Isophthalic resin are used as matrix material procured from local supplier. The coir fibers obtained from the local farming yard were cut into pieces by scissors to a size which is least possible (0.5 cm). The cut fibers are further chopped into fine ones using a mechanical crusher. Then, the crushed fibers are sieved to classify their sizes (1, 500, 1000µm). Fly ash is taken from the nearby power plant and dried in oven to remove environmental moisture.

The primary function of the matrix is to transfer stresses to the reinforcing fibres (hold fibres together) and protect the fibres from mechanical and/or environmental damages. The coir fibre is used as the reinforcing material in different sizes such as 1, 0.5 and 0.001 mm. Fly ash is used as the filler material with different wt. % such as 5, 10 and 15. The reinforcing fibers and fly ash of fixed percentage were dispersed in the resin and poured into the mould and cured for a maximum duration of 24 hrs at RT.

Design of Experiments

To reduce the number of sample preparation, design of experiments (DOE) concept is followed. Nine combinations of samples are fabricated as suggested by Taguchi's L9 array [29], a DOE technique. This technique customs special set of arrays called orthogonal array and used to reduce the number of samples. Three input parameters such as type of polymer, fibre length and wt. % of fly ash are considered in different sample preparations. Table 1 illustrates the different combinations of samples to be prepared according to Taguchi's L9 array. In type of synthetic resin, General-purpose resin, Vinyl Ester and Isophthalic resin are designated as 1, 2 and 3 respectively. It was fixed to maintain 32% V_f for all specimens in this study.

Table 1. Taguchi DOE L9 array showing different combinations of specimen.

Specimen Number	Wt. % of fly ash	Coir fibre length (mm)	Type of synthetic resin
1	5	1	1
2	5	0.5	2
3	5	0.001	3
4	10	1	2
5	10	0.5	3
6	10	0.001	1
7	15	1	3
8	15	0.5	1
9	15	0.001	2

Using hand layup technique, samples are prepared. Samples meant for Tensile and flexural tests are prepared according to ASTM D3039 and ASTM D7264 respectively. Figure1 shows few of the prepared samples which are subjected to tensile and flexural testing.

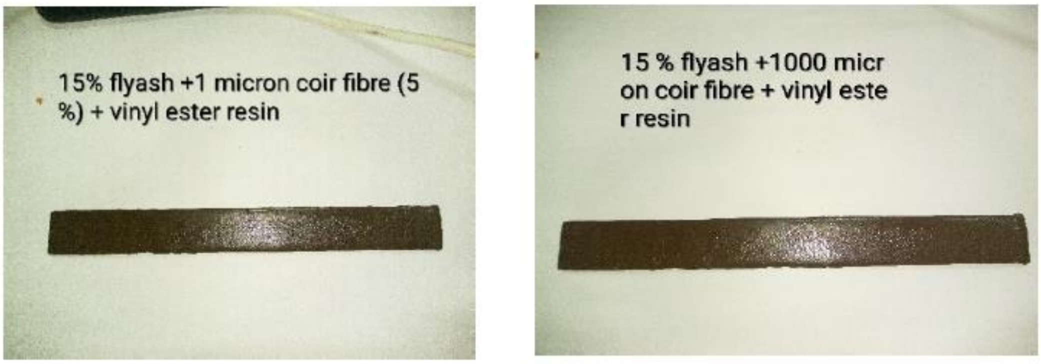


Figure 1. Illustration of prepared samples meant for tensile and flexural tests.

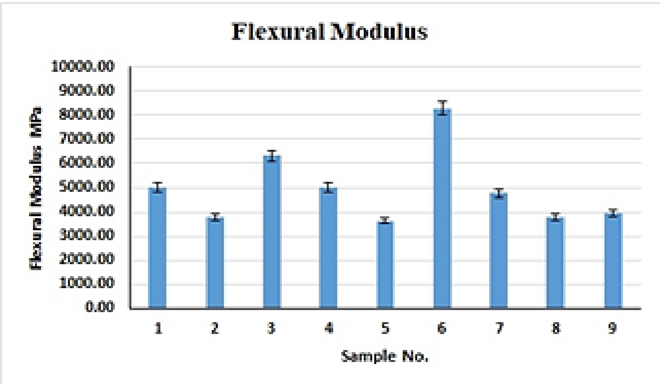
RESULTS AND DISCUSSIONS

Tensile test results

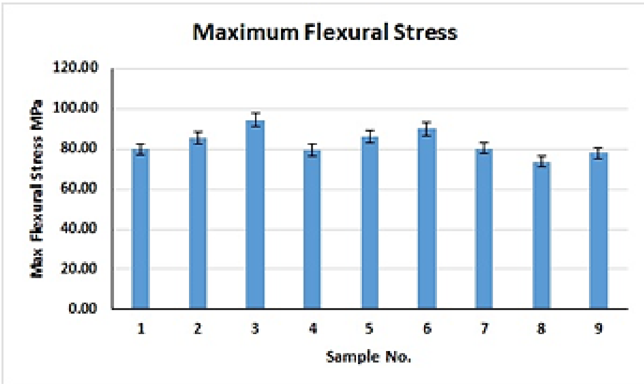
All the fabricated specimens are undergone tensile test and the results are tabulated in Table 2. Each value in the Table 2 is the mean of three experimental results conducted for each combination of factors as given in Table. 1. Wt. % of fly ash, coir fibre length and type of polymer are named as A, B and C in the Table 2. Table 2 presents tested tensile results of the composites namely yield stress, ultimate tensile stress (UTS) and Young's modulus (E). Figure 2 c, d, e gives the variations of tensile properties. After recording tensile test results, Analysis of Variance (ANOVA) is carried out to determine the level of influences of different input parameters such as wt. % of fly ash, coir fibre length and type of polymer on tensile properties. MINITAB software is used to carry out ANOVA. ANOVA results are recorded in the form of main effects plot, contour plot and regression equation [31].

Table 2. Tensile test results

Wt. % of fly ash (A)	Coir fibre length (mm) (B)	Type of polymer (C)	Yield Stress (MPa)	Ultimate tensile stress (MPa)	Young's Modulus (MPa)
5	1	1	7.744	30	2241
5	0.5	2	5.12	21	1928
5	0.001	3	5.4	22	2660
10	1	2	6.1	23	2126
10	0.5	3	4.12	15	1838
10	0.001	1	10.4	36	1978
15	1	3	5.45	20	2400
15	0.5	1	5.46	22	1625
15	0.001	2	9.6	34	2630



(a)



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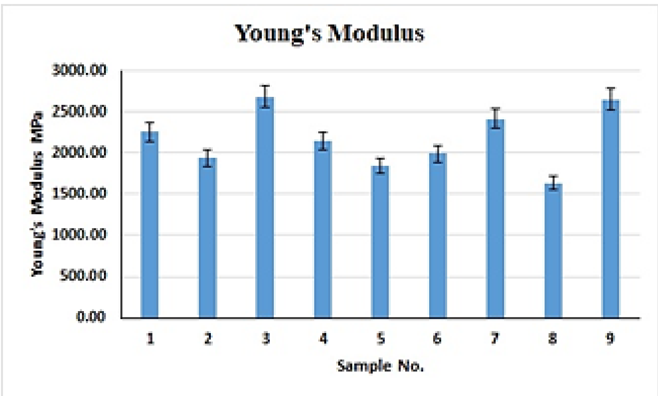

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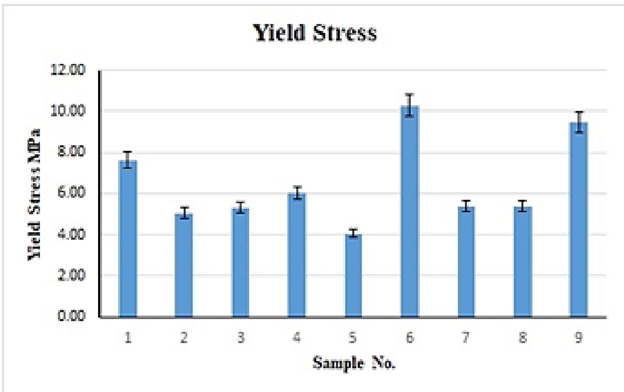

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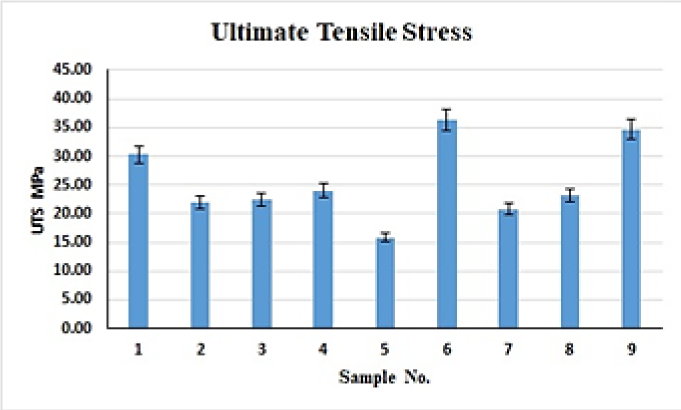


(e)

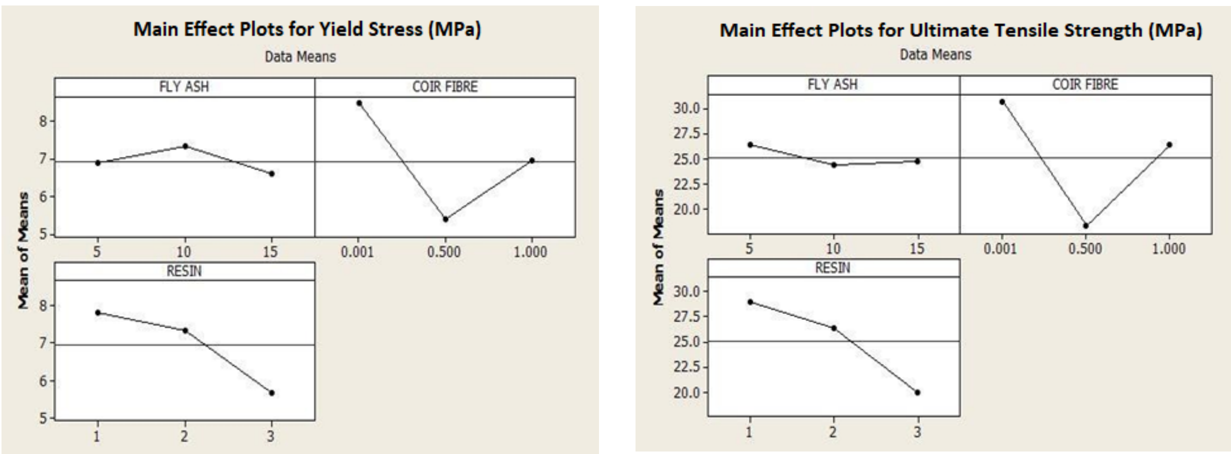
Figure 2. a) Flexural Modulus b) Flexural Stress c) Youngs Modulus d) Yield Stress and e) Ultimate Tensile stress.

Figure 3 (a,b, c). depict the main effects plot for yield stress, UTS and Young's modulus respectively. For UTS and Young's modulus, 5 wt. % of fly ash exhibits maximum values whereas for yield stress, it is 10 wt. %. In all three responses i.e. yield stress, UTS and Young's modulus, use of coir fibre length of 0.001 mm gives maximum response values. For yield stress and UTS, use of polymer type 1 i.e. general purpose resin furnishes maximum value whereas for Young's modulus, it is polymer type 3 i.e. Isophthalic resin.

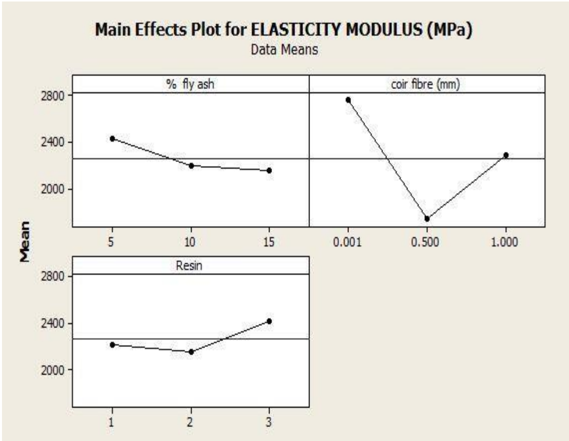
Figure 4 (a, b, c) portray the contour plots for yield stress, UTS and Young's modulus respectively. These plots explain the interaction between fly ash and type of polymer. To get maximum yield stress and UTS, fly ash should be 10 wt. % and 15 wt. % for general purpose resin and vinyl ester respectively whereas isophthalic resin interaction with fly ash is insignificant. To get maximum Young's modulus, fly ash should be 10 wt. %, 15 wt. % and 5 (or 15) wt. % for general purpose resin, vinyl ester and isophthalic resin respectively.

Figure 5 (a, b, c) expose the contour plots for yield stress, UTS and Young's modulus respectively. These plots elucidate the interaction between coir fibre and type of polymer. From Figure 5 a, it is evident that there is no significant interaction between coir and isophthalic resin for yield stress. There is significant interaction in case of UTS and Young's modulus for isophthalic resin and coir fibre length should be smaller in size (0.001 mm) to get maximum. To get maximum yield stress, UTS and Young's modulus, coir fibre length (0.001 mm) should be smaller in size for general purpose resin and vinyl ester.

Figure 5 (d, e, f) represent the contour plots for yield stress, UTS and Young's modulus respectively. These plots reveal the interaction between coir fibre size and fly ash. From these figures, it is palpable that the combination of small size coir fibre (0.001) and around 10 wt. % of fly ash offers maximum yield stress, UTS and Young's modulus.



(a) (b)



(c)

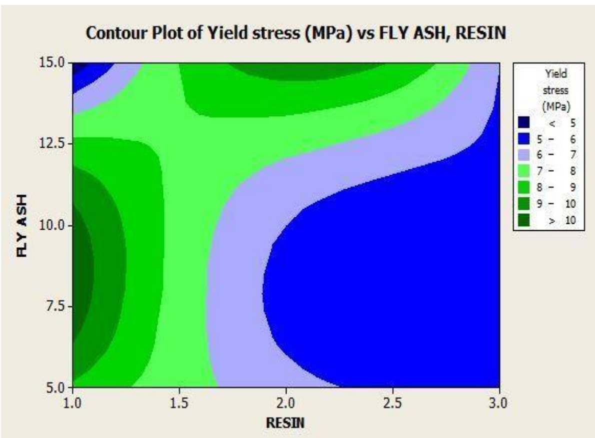
Figure 3. Main Effect Plots of a) Yield Stress, b) UTS and c) Young’s Modulus.

Regression equation is also obtained using ANOVA. The below given equations 1, 2 and 3 are the Regression equation obtained from ANOVA for the current study. The level of influence of each input parameter on yield stress, UTS and Young’s modulus can be well understood from that. The level of influence of fly ash is not significant comparing with that of coir fibre length and type of polymer. From the regression equations 1-3, one can understand that coir fibre of smaller in size (0.001 mm) has more influence than the other sizes. Also it is evident from the regression equations that general purpose resin has more influence on yield stress and UTS when compared with vinyl ester and isophthalic resin. However, in the case of Young’s modulus, isophthalic resin has more influence than the other resins. Table 3 compares values of yield stress, UTS and Young’s modulus obtained from experiments and regression equation. Except few samples, error is less than 5 % which shows the veracity of the regression equations.

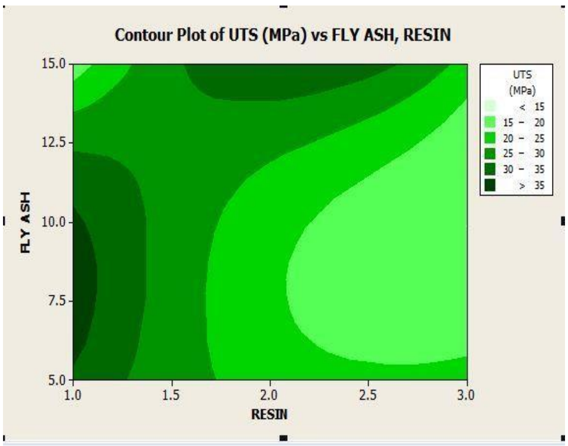
Yield stress (MPa) = 10.1 - 0.027 (Fly ash) - 1.53 (Coir fibre) - 1.07 (Type of polymer) (1)

UTS (MPa) = 37.9 - 0.167(Fly ash) - 4.33 (Coir fibre) - 4.50 (Type of polymer) (2)

Young’s Modulus (MPa) = 2571- 27.8 (fly ash) – 470 (Coir fibre) + 102 (Type of polymer) (3)



(a)



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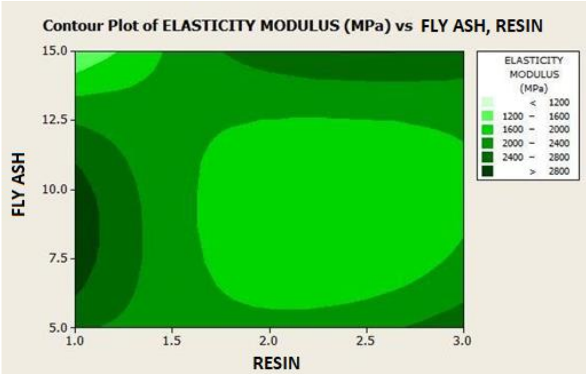
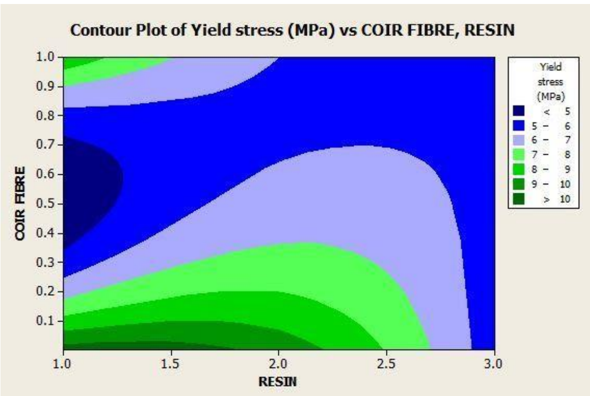


(c)

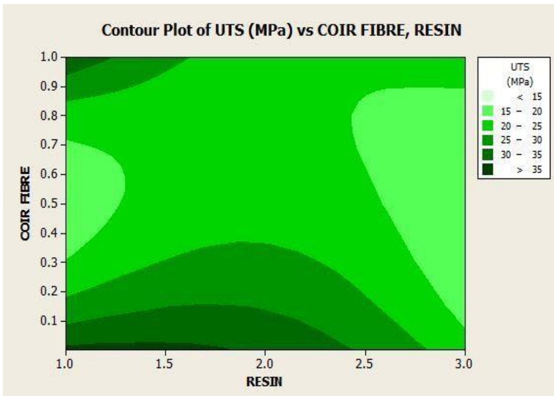
Figure 4. Contour Plots of a) Yield stress Vs fly ash, type of polymer, b) UTS Vs fly ash, type of polymer and c) Young's modulus Vs fly ash, type of polymer.

Table 3. Error between experimental regression model values.

Sample No	Yield stress (MPa)			Ultimate Tensile Stress (MPa)			Young's Modulus (MPa)		
	Experiment	Regression Equation	Error %	Experiment	Regression Equation	Error %	Experiment	Regression Equation	Error %
1	7.744	7.473	3.499	30	28.903	3.6566	2241	2193	2.14
2	5.12	4.873	4.824	21	20.073	4.414	1928	1843	4.40
3	5.4	4.983	7.72	22	21.43	2.59	2660	2538	4.58
4	6.1	6.376	4.524	23	24.02	4.434	2126	2285	7.52
5	4.12	3.886	5.67	15	15.006	0.04	1838	1935.4	5.29
6	10.4	10.12	2.69	36	34.3	4.7	1978	1836	7.17
7	5.45	5.2	4.58	20	19.369	3.155	2400	2379	0.875
8	5.46	5.889	7.87	22	23.839	8.35	1625	1669	2.70
9	9.6	9.12	5	34	32.809	3.50	2630	2506	4.71



(a)



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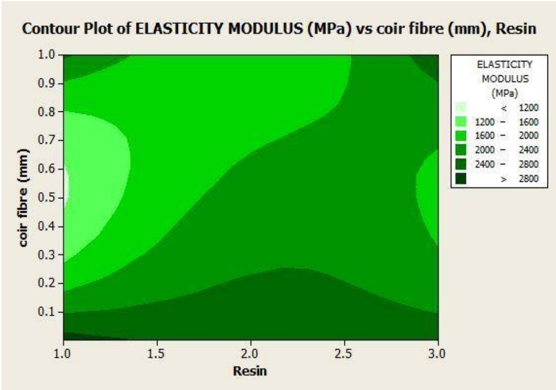

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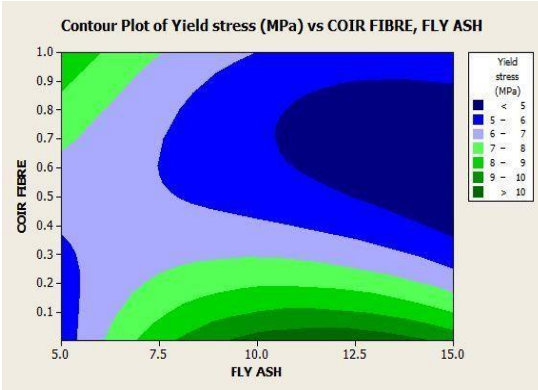

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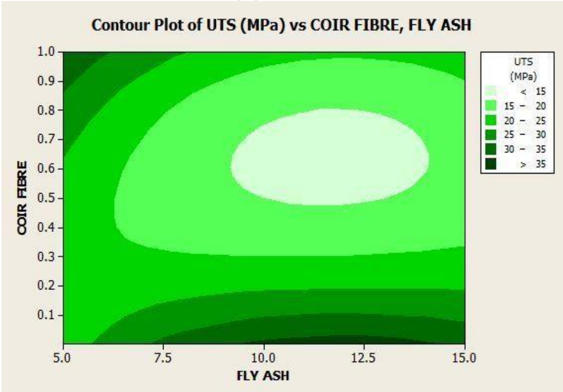

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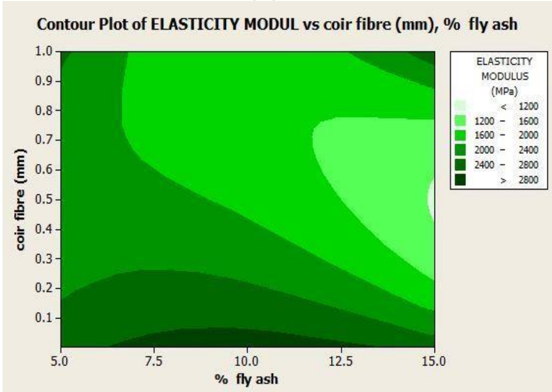


(f)

Figure 5. Contour Plots of: a) Yield stress Vs coir fibre, type of polymer, b) Contour plot – UTS Vs coir fibre, type of polymer, c) Young's modulus Vs coir fibre, type of polymer, d) Yield stress Vs coir fibre, fly ash, e) UTS Vs coir fibre, fly ash and f) Young's modulus Vs coir fibre, fly ash.

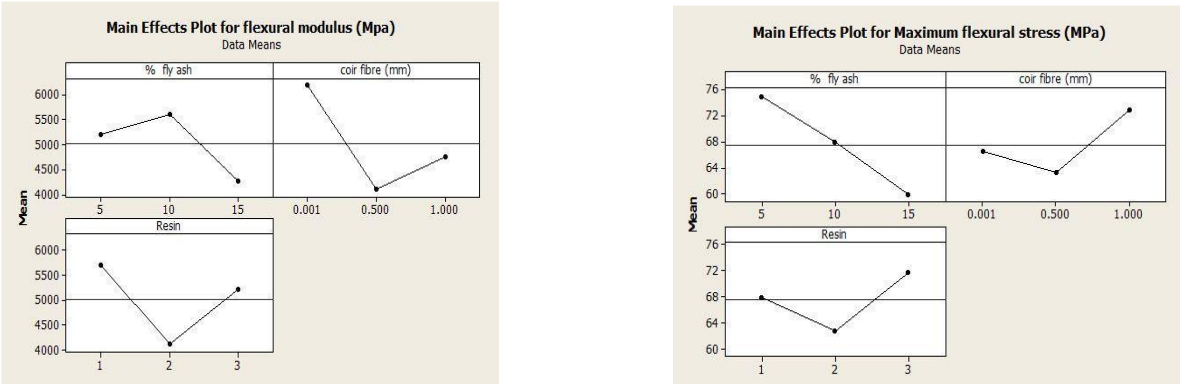
Flexural test results

Samples as per Table 1 are tested using INSTRON machine to investigate its flexural behavior and the results are tabulated in table 4. Wt. % of fly ash, coir fibre length and type of polymer are assigned as A, B and C in the Table 4. Table 4 and Figure 2 a, b presents flexural modulus and maximum flexural stress.

Table 4. Flexural Test Results.

Wt. % of fly ash (A)	Coir fibre length (mm) (B)	Type of polymer (C)	Flexural Modulus (MPa)	Maximum Flexural Stress (MPa)
5	1	1	5016.84	80.24
5	0.5	2	3809.55	85.56
5	0.001	3	6326.46	94.68
10	1	2	5015.04	79.85
10	0.5	3	3649.9	86.64
10	0.001	1	8321.67	90.16
15	1	3	4780.2	80.75
15	0.5	1	3787.33	73.87
15	0.001	2	3944.43	78.15

After tabulating flexural test results, Analysis of Variance (ANOVA) is used to establish the level of influences of various input parameters such as wt. % of fly ash, coir fibre length and type of polymer on flexural modulus and maximum flexural stress. MINITAB software is utilized to carry out ANOVA. ANOVA results are presented in the form of main effects plot, contour plot and regression equation.



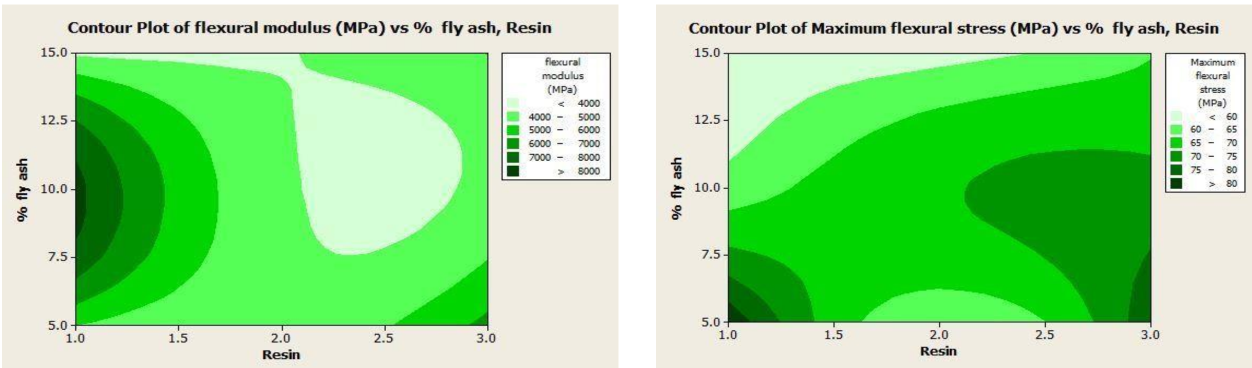
(a) (b)

Figure 6. Main effects plot of a) Flexural Modulus and b) Flexural Stress.

Figure 6 (a, b) illustrate the main effects plot for flexural modulus and maximum flexural stress respectively. 10 wt. % and 5 wt. % of fly ash offer high flexural modulus and high (maximum) flexural stress respectively. In case of coir fibre length, small size fibres exhibit high flexural modulus where as large size fibres exhibit high (maximum) flexural stress. Among the polymers, vinyl ester offers less flexural modulus as well as less (maximum) flexural stress. General-purpose resin and isophthalic resin offer high flexural modulus and high (maximum) flexural stress respectively.

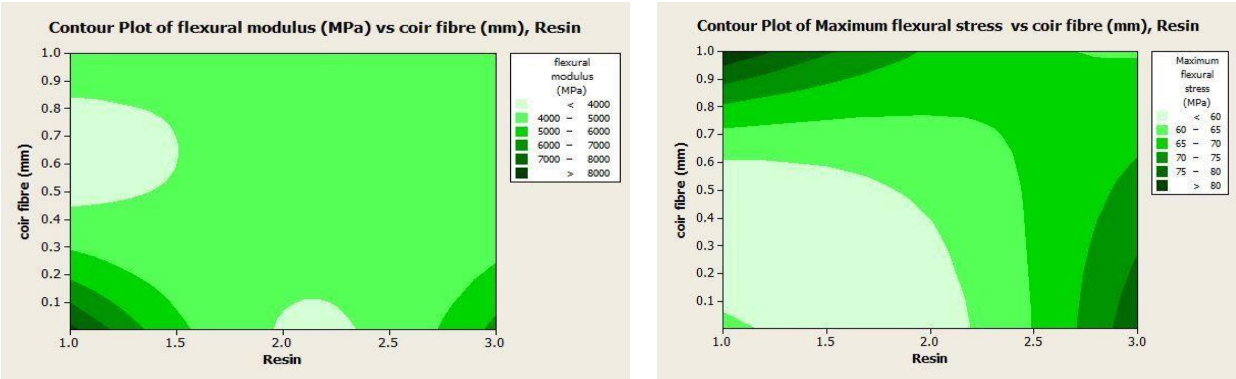
Figure 7 (a, b) represent the contour plots for flexural modulus and maximum flexural stress respectively. These plots elucidate the interaction between fly ash and type of polymer. To get maximum flexural modulus and maximum (maximum) flexural stress, fly ash should be 10 wt. % and 5 wt. % respectively for general purpose resin. Considering the interaction between vinyl ester and fly ash, maximum values of both responses cannot be reached. In case of isophthalic resin, fly ash should be 5 wt. % to get maximum values of both responses.

Figure 8 (a, b) depict the contour plots for flexural modulus and maximum flexural stress respectively. These plots explain the interaction between coir fibre and type of polymer. In case of flexural modulus, smaller coir fibre size offers high flexural modulus for general-purpose resin and isophthalic resin. For vinyl ester, medium flexural modulus is obtained for long coir fibre. To obtain maximum flexural stress for general-purpose resin and vinyl ester, long coir fibre is preferred whereas smaller size coir fibre provides the same for isophthalic resin



(a) (b)

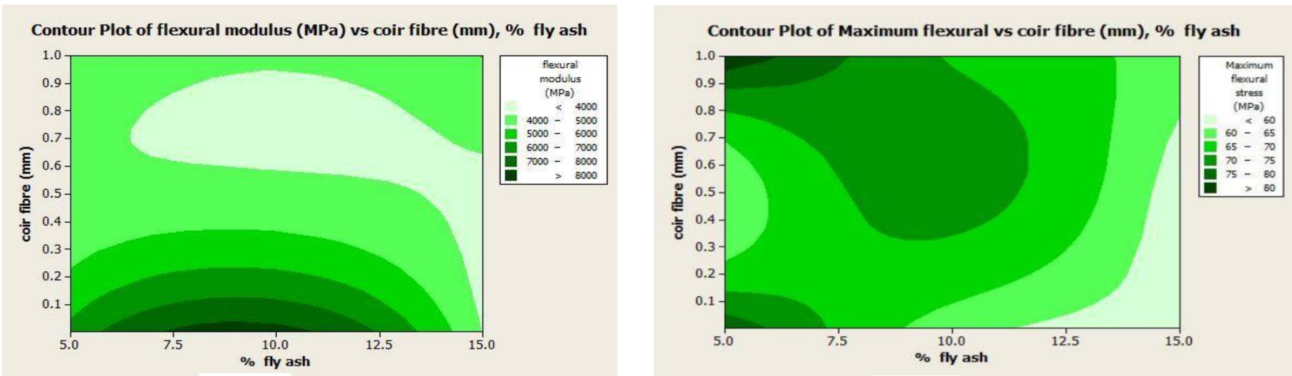
Figure 7. Contour plots of: a) Flexural modulus Vs fly ash, type of polymer and b) Maximum flexural stress Vs fly ash, type of polymer.



(a) (b)

Figure 8. Contour plots of: a) Flexural modulus Vs coir fibre, type of polymer and b) Maximum flexural stress Vs coir fibre, type of polymer.

Figure 9 (a, b) correspond to the contour plots for flexural modulus and maximum flexural stress respectively. These plots reveal the interaction between coir fibre size and fly ash. From the Figure 9 a, it is palpable that the combination of small size coir fibre (0.001) and around 10 wt. % of fly ash offers maximum flexural modulus. In case of maximum flexural stress, it is long coir fibre size and 5 wt. % of fly ash combination presents high (maximum) flexural stress.



(a) (b)

Figure 9. Contour plots of: a) Flexural modulus Vs coir fibre, % fly ash and b) Maximum flexural stress Vs coir fibre, % fly ash.

Equations 4 and 5, obtained using ANOVA, represent the regression equation for flexural modulus and maximum flexural stress respectively. The influence of fly ash on flexural property is not significant when compared with that of coir fibre length and type of polymer. From the regression equations 4 and 5, it is evident that small coir fibre size composite offers more flexural modulus where as large one offers high (maximum) flexural stress. Also, it is evident from the regression equations that general purpose resin has more influence on flexural modulus when compared with vinyl ester and isophthalic resin. But, in the case of maximum flexural stress, isophthalic resin has more influence than the other resins. Table 5 compares values of flexural modulus and maximum flexural stress found from experiments and regression equation. Except few samples, error is less than 5 % which shows the genuineness of the regression equations.

$$\text{Flexural modulus (MPa)} = 7172 - 94\ (\text{Fly ash}) - 1455\ (\text{Coir fibre}) - 246\ (\text{Type of polymer}) \tag{4}$$

$$\text{Maximum flexural stress (MPa)} = 75.5 - 1.50\ (\text{Fly ash}) + 6.45\ (\text{Coir fibre}) + 1.93\ (\text{Type of polymer}) \tag{5}$$

Table 5. Showing error between experimental regression model values.

Sample No	Yield stress (MPa)			Ultimate Tensile Stress (MPa)		
	Experiment	Regression Equation	Error %	Experiment	Regression Equation	Error %
1	5016.84	5377	7.019	80.24	76.38	4.81
2	3809.55	3676	3.49	85.56	90.76	6.077
3	6326.46	6122.5	3.22	94.68	99.14	4.71
4	5015.04	5037	0.43	79.85	82.81	3.70
5	3649.9	3336	8.57	86.64	91.19	5.25
6	8321.67	8068.2	3.04	90.16	93.78	4.01
7	4780.2	4679	2.11	80.75	83.24	3.08
8	3787.33	3734	1.39	73.87	79.38	7.4
9	3944.43	3659	7.22	78.15	81.31	4.04

CONCLUSION

Coir fibre reinforced polymer (General-purpose resin, Vinyl ester and Isophthalic resin) composites dispersed with fly ash filler are fabricated for the examination. Experimental and statistical tests are carried out to unearth the effect of factors such as type of polymer, natural fibre (coir) length and wt. % of fly ash on tensile and flexural behaviors. Taguchi's L9 array is used to fix specific combination of participating factors through DoE. After conducting tensile and flexural tests, the influences of factors on tensile and flexural behaviors are investigated using ANOVA. The regression equations, main effects plot and contour plots expose the influences of factors on the desired outcome. The following conclusions are drawn from the results:

1. 'Type of Polymer', and coir fibre length have higher influence on tensile and flexural behaviors of the composites than 'wt. % of fly ash'.

2. General-purpose resin offers higher tensile properties than the other two resins whereas, Isopthalic resin favours flexural behaviour in the proposed composites. This reveals the importance of polymer on the desired outcome.

3. A threshold in fly ash wt. % is observed on tensile and flexural properties, i.e, 5% and 10% respectively.

4. Length of reinforcing fibres is found to vary for upper bound properties. Small size coir fibre (0.001 mm) yields improved tensile behaviors and flexural modulus. However, long coir fibres are for higher flexural stress.

5. The obtained regression equations are found to be in good correlation with the experimental values that is ascertained by minimum error percentage.

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