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STRENGTHEN THE CONSTRUCTION WITH COMPOSITE MATERIALS

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Abstract:* *The fiber obtained from alkali treatment was optimized to produce all cement compounds. Alkali-treated flax fibers are satisfactory fibers for insertion into the cement matrix. Mechanical and physical properties of treated and untreated linen fibers were studied. Flax fibers showed some improvement in mechanical and thermal performance compared to untreated compounds. These improvements are due to changes in fiber composition and chemical composition, resulting in an increase in the tactile surface and improved adhesion of the fiber surface, increasing the additional mechanical bonding position. Part of fiber size plays an important role in determining complex mechanical properties. The mechanical properties of the compound are greatly affected by fiber content. This work was accomplished by preparing three different parts of fiber cement compounds (ie 0.5, 1 and 1.5%). The results showed that the increase in fiber content had a significant positive effect on destructive ability, strength index, flexure strength and impact resistance. However, these improvements are always associated with a decrease in compressive resistance.

I. INTRODUCTION

The construction industry uses a variety of construction materials to build buildings. Architects and construction project managers use these materials and product categories to specify the materials and methods of construction materials. Many types of construction materials, such as cold-rolled steel frames, are considered traditional construction methods, such as block construction and modern methods of wood construction. There are several uses of many construction materials. Therefore, it is always a good idea to negotiate with the manufacturer to determine if the product is best suited to your needs. The construction materials are all materials used in the construction industry. Examples: solid, cement, mud, stone, total, plastic, asphalt. The basic materials used for civil engineering work are the following.

Fig 1.1: Typical Woods used construction material

Fig 1.2: Cement and concrete used construction material

Fig 1.3: Bitumen and bituminous materials

Fig 1.4:Structural clay and concrete units

Fig 1.5:Reinforcing and structural steels

1.1 Material Testing, Inspection & Quality Control Services

Engineers and scientists dealing with materials such as building materials and geological materials need to understand the characteristics and performance at the time of completion. It is necessary to conduct multiple types of laboratory tests in a controlled environment to ensure that the materials function as intended and obtain the strength and compressibility of the materials used as input parameters in the design process. DST has established a number of laboratories that are suitable for soil, rock, aggregate, concrete and asphalt research. In addition, DST is also equipped with a variety of on-site test equipment for quality control testing at various civil engineering construction sites.

1.1.1 Soil Testing

Classification tests
Grain Size Distribution Tests

Fig 1.6: Grain Size Distribution Tests

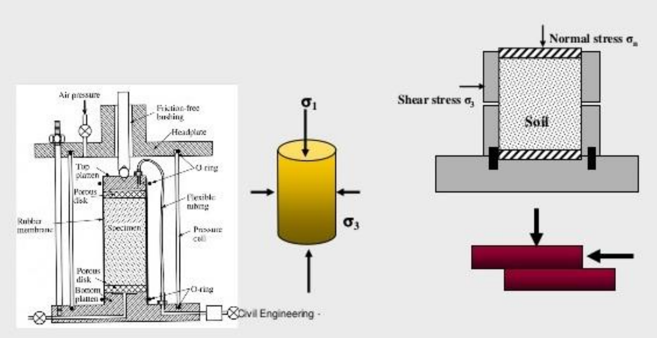


Fig1.7:Shear Strength Tests

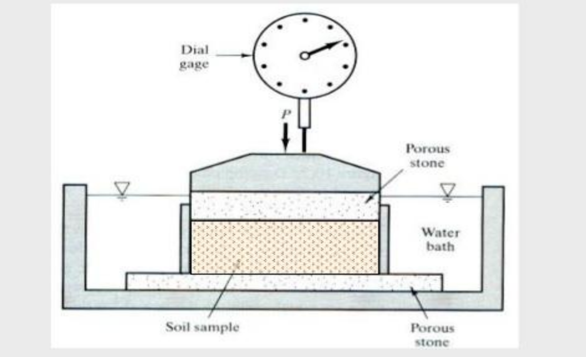


Fig1.8: Consolidation Tests

Fig1.9: compaction Test

- Rock Testing
- Point Load Test
- Uniaxial Compression Test
- Concrete Testing
- Aggregate Testing
- Asphalt testing

Inspection Services

- Subgrade inspection
- Platform installation check
- Earthwork Quality Control
- Pile Drive and Installation Inspection
- Road surface distress test
- Foundation damage investigation

II. LITERATURE SURVEY

In 2014, regarding the evaluation of the material/structural performance of yellow-light hybrid materials and recycled PET fiber reinforced concrete for environmental protection, Jing Jiuben, Jin Dam, Jin Shunhong, reduced carbon dioxide (CO2) emissions, and retained similar to ordinary cement concrete for production. The characteristics of the concrete, while minimizing the amount of concrete, have been developed and discovered by the world. Kodama is a kind of red clay that is widely distributed around the world. It is traditionally considered as an environmentally friendly construction material and has advantages in terms of health and cost. At present, due to its low strength, high shrinkage and cracking, ecliptic is not suitable as a modern building material. However, recent studies indicate that Kurodo can be used as an inorganic mixture to improve the strength of concrete. In addition, polyethylene terephthalate (PET) fibers recovered from PET bottle waste can be used to control shrinkage cracking of yellow concrete. Therefore, this study verified the performance of newly developed yellow concrete for short-term recovery of PET fibers. The results show that the yellow concrete has similar compressive strength, elastic modulus and pH characteristics as the ordinary cement concrete. However, the carbonization depth and creep strain characteristics of loess concrete are larger and smaller than ordinary concrete. According to the bending test, a reinforced concrete (RC) specimen using a loess mix (with or without PET fibers) has the same or better performance as a typical RC specimen. Under normal environmental conditions, the addition of PET fiber significantly improves the structural ductility of RC specimens. However, as previous studies have shown that durability can be reduced in severely corrosive environments such as seawater, it is necessary to carefully study the implementation of concrete in aggressive environments. The results of this survey indicate the possibility of using environmentally friendly yellow concrete to reinforce recycled PET fibers as a structural material for modern buildings. Professor Salem Hashimi, learned from the supervision of Dr. Abdul GhaniOlabiMalva Ali (B.Sc., M.钪.) In 2012, Professor Medhatt El Meselie gave his opinion on the development of environmentally friendly composite materials. In response to the increasing awareness of the world's environment, we have developed more sustainable building materials that take into account the environment. Recycling materials and construction agricultural waste are increasingly needed in the construction industry, and these materials are the most attractive because of their relatively low quality requirements, and the use of construction sites for a wide range of industrial uses.The main purpose of this paper is to evaluate the performance of linen/waste glass cement composites. Flax fibers are used to strengthen these two systems. The first system contained only ordinary Portland cement (OPC) as a binder, while part of the OPC in the second system was replaced with ground waste glass powder. By planning experiments, developing mathematical models and application center composite designs to optimize fiber parameters to select fiber parameters. In order to enhance these composites, nanoclay particles and colloidal nanoceria have added durability and long-term performance in the production of both systems. Removed from the fiber surface to improve the adhesion between the matrix and the fibers, and improve the long-term stability of the composite surface impurities to produce two systems of alkali-treated fibers. By designing experiments, developing mathematical models and applying the Box-Behnken method to optimize processing conditions to select alkaline processing conditions. Several fibers and complex characterization techniques were used in this study. This characterization aims to obtain information on surface morphology, fiber crystallinity, mineral composition, thermal stability, and mechanical properties of alkali-treated flax fibers and their composites. Therefore, X-ray diffraction (XRD), thermo gravimetry (TGA/TDA), scanning electron microscopy (SEM), stretching, and bending, the results of which were tested using toughness, fracture energy, and impact and compression properties.Sufficient evidence (up to 20% by cement weight) obtained in this study results in concrete and nano-silica (3% by weight of cement) or nanoclay (2.5% by weight of cement) waste Glass powder can be used in combination without any adverse effects. The presence of nanoparticles improves the mechanical and physical properties of waste glass cement systems and enables the development of high-performance cement composites. In addition, the use of nanoparticles and waste glass frits reduces the carbon dioxide footprint of the produced cement composites, which is also economically attractive. In short, the proposed new composite material has excellent performance, lower cost, better ecological and environmental benefits.Hassan Usman Katsina and Abbas Usman Kakale, 2016 Sustainable Development Environment: I studied red clay as a sustainable building material for the construction industry. They stated that building materials are considered to be the largest investment in any project and therefore have a major impact on the total cost of the project. Due to the high cost of this project, red earth needs to be added to most past and present projects. The purpose of this study was to determine the most important factors for the effective use of laterite as a sustainable building material for the construction industry. The study was conducted by a suitable civil engineering contractor located in Kano, Kaduna Province, in northern Nigeria. The survey results confirmed that economic factors are the most important sustainable building materials for the construction industry. Considering that an important economic factor has been established, the research results have a higher mean value based on statistical sampling, with an important mean of 4.25, and this study only considers the experts (researchers and Liu, 2010). The procedures used in this study were interview questions and self-administered questionnaires. Esin Kasapoglu studied polymer-based building materials: the impact of quality on durability in 2008. He said that the polymer is the main material of plastic. Monomers are "building blocks," polymers are finished plastics, and reactions are called polymerizations. In the production process, not only oily chemicals but also chlorine, hydrochloric acid, fluorine, nitrogen, oxygen, and sulfur are used. Almost all plastics contain additives such as plasticizers, pigments, stabilizers against solar radiation, preservatives and fragrances. Plastics are substances that contain natural or synthetic high-molecular organic materials that can be liquefied and cast into specific molds. Quality can be defined as the product's desired level of product effectiveness. The quality of a product or a complete building or other structure is its overall property. Quality allows you to perform a designated task or satisfactorily satisfy during the acceptance period. If the material quality is low, the material's durability will decrease. Plastic building materials are used for floors, roofs and walls. It is difficult and expensive to repair or replace them. The service life of plastics should be at least 50 years, equivalent to other materials in the building. Today's plastics are unlikely to meet these conditions.

In this article, we will redefine the meaning of quality from the perspective of polymer-based (plastic) building materials. Discussion of durable quality properties that give polymer-based materials longer service life. According to reports, the plastics industry had a lasting impact on R&D and durability.M.V. Seshagiri Rao, V. Srinivasa Radi, Men's Theological Seminary, P Wiener, P. Anusha, Bioengineering Concrete in 2013 - to study sustainable self-healing building materials. Their concrete structures degrade concrete that invades chemicals and water, which reduces the performance of the structure and requires maintenance in the form of expensive maintenance. Because cracks involve the transport of liquids and gases that may contain toxic substances, cracks in the concrete surface mainly reduce durability. The growth of micro-cracks is reinforced, not only the concrete itself is damaged, but also exposed to water, and CO 2 and chloride oxygen can also cause corrosion to increase. Therefore, microcracks are the main cause of structural failure. One way to avoid the maintenance and repair of expensive manuals is to incorporate autonomous healing mechanisms into concrete. One such alternative repair mechanism is currently under study, namely a new technology based on the application of bacterial biomineralization in concrete. Recently, the applicability of concrete calcification of calcite mineral-precipitated bacteria and the blockage of pores and cracks in concrete has been studied in particular. Studies have been conducted on the possibility of using certain bacteria as a sustainable self-healing agent embedded in concrete. . Concrete repairs and synthetic polymers such as the current epoxy process are used because it is harmful to the environment and the use of bioremediation technology in concrete has attracted attention. In this paper, people tried to apply the strength and durability of concrete to dormant but viable bacteria in the concrete matrix. Bon-Min Koo, Jang-Ho Jay Kim, Sung-Bae Kim and Sungho Mun studied on Material and Structural Performance Evaluations of Hwangtoh Admixtures and Recycled PET Fiber-Added Eco-Friendly Concrete for CO2 Emission Reduction. In 2014, they studied the evaluation of materials and structural properties to reduce the carbon dioxide emissions of green concrete added with yellow admixtures and recycled PET fibers. Their CO2 emission reduction (CO2) generates a friendly building material to the environment while minimizing the amount of cement used, the cement holds the type of traditional cement concrete that has developed and similar characteristics, and it is being studied around the world. Kodama is a kind of red clay that is widely distributed around the world. It is traditionally considered as an environmentally friendly construction material and has advantages in terms of health and cost. At present, due to its low strength, high shrinkage and cracking, ecliptic is not suitable as a modern building material. However, recent studies indicate that Kurodo can be used as an inorganic mixture to improve the strength of concrete. In addition, polyethylene terephthalate (PET) fibers recovered from PET bottle waste can be used to control shrinkage cracking of yellow concrete. Therefore, this study verified the performance of newly developed yellow concrete for short-term recovery of PET fibers. The results show that the yellow concrete has similar compressive strength, elastic modulus and pH characteristics as the ordinary cement concrete. However, the carbonization depth and creep strain characteristics of loess concrete are larger and smaller than ordinary concrete. According to the bending test, a reinforced concrete (RC) specimen using a loess mix (with or without PET fibers) has the same or better performance as a typical RC specimen. Under normal environmental conditions, the addition of PET fiber significantly improves the structural ductility of RC specimens. However, the previous research results, because they show the harsh environment, such as seawater, the specific implementation of a positive environmental endurance performance decline, you must carefully consider. The results of this survey indicate the possibility of using environmentally friendly yellow concrete to reinforce recycled PET fibers as a structural material for modern buildings. Paul Joseph and Svetlana Tretsiakova McNally studied sustainable non-metallic building materials in 2010. They said that buildings are the largest source of energy consumers and greenhouse gases in developed and developing countries. In continental Europe, only energy use in buildings accounts for 50% of CO2 emissions. Therefore, urgent changes are needed in energy conservation, emission control, material production and application, use of renewable resources, recycling and reuse of building materials. In addition, as environmental issues continue to increase, it is important to develop new environmental-conscious building materials and practices. This review reflects the major trends in non-metallic sustainable building materials that have occurred in the past decade.

III. PROPOSED WORK

SEM micrograph of fracture surface of flax cement composite after three point bending test

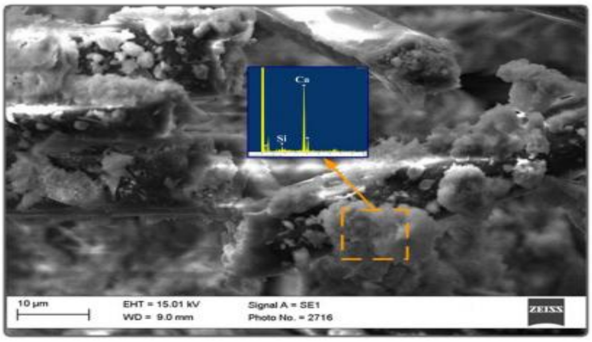
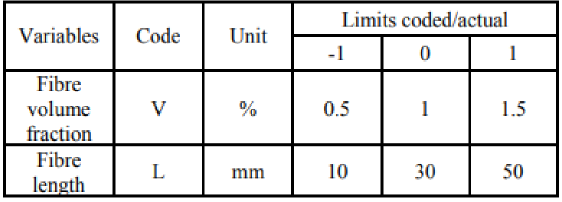


Fig3.1: surface of flax cement

3.1 Effect of Fibre parameters on the Mechanical Properties of Cement Composites

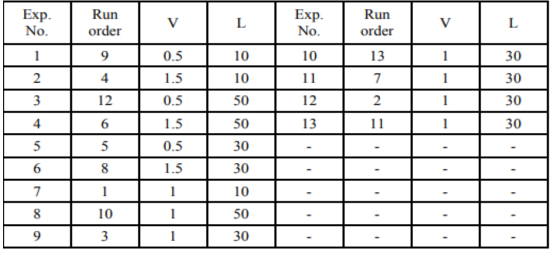
In this study, we designed an experiment based on two variable-center integrated designs. By changing one process variable to determine the working range of each variable, a batch of flax fiber cement composites was developed. If the volume fraction is 1.5% or more and the fiber length is 50 mm or more, damage will occur. Due to the low specific gravity of the flax fibres, the fibres float on top of the slurry, since the upper surface of the composite material is filled with accumulated fibres, no homogeneous mixture in the composite material is formed. Therefore, production of samples with a volume fraction exceeding 1.5% and a length exceeding 50 mm was stopped. Table 3.1 shows that fiber input parameters and experimental design levels indicate fiber input parameters and experimental design levels for the material. Experiment according to the design matrix shown in Table 3.3 to avoid systematic errors. (P), Fflex, Fracture Energy (F), Fimp, 8 A mathematical model to predict compressive strength (F command) and toughness indices I5, I10, and I20 were successfully developed. In order to determine and record these replies, we have performed the procedure described earlier in this chapter. Give an average of at least three measurements for each response.

Table 3.1: Process Variable and Experiment design levels



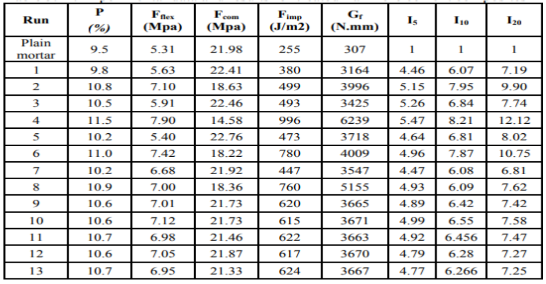
Variables	Code	Unit	Limits coded/actual		
			-1	0	1
Fibre volume fraction	V	%	0.5	1	1.5
Fibre length	L	mm	10	30	50

Table 3.2: Design Matrix in actual values



Exp. No.	Run order	V	L	Exp. No.	Run order	V	L
1	9	0.5	10	10	13	1	30
2	4	1.5	10	11	7	1	30
3	12	0.5	50	12	2	1	30
4	6	1.5	50	13	11	1	30
5	5	0.5	30	-	-	-	-
6	8	1.5	30	-	-	-	-
7	1	1	10	-	-	-	-
8	10	1	50	-	-	-	-
9	3	1	30	-	-	-	-

Table 3.3: Experiment data and result for treated flax fiber cement composites



Run	P (%)	F_{flex} (Mpa)	F_{com} (Mpa)	F_{imp} (J/m2)	G_f (N.mm)	I_5	I_{10}	I_{20}
Plain mortar	9.5	5.31	21.98	255	307	1	1	1
1	9.8	5.63	22.41	380	3164	4.46	6.07	7.19
2	10.8	7.10	18.63	499	3996	5.15	7.95	9.90
3	10.5	5.91	22.46	493	3425	5.26	6.84	7.74
4	11.5	7.90	14.58	996	6239	5.47	8.21	12.12
5	10.2	5.40	22.76	473	3718	4.64	6.81	8.02
6	11.0	7.42	18.22	780	4009	4.96	7.87	10.75
7	10.2	6.68	21.92	447	3547	4.47	6.08	6.81
8	10.9	7.00	18.36	760	5155	4.93	6.09	7.62
9	10.6	7.01	21.73	620	3665	4.89	6.42	7.42
10	10.6	7.12	21.73	615	3671	4.99	6.55	7.58
11	10.7	6.98	21.46	622	3663	4.92	6.456	7.47
12	10.6	7.05	21.87	617	3670	4.79	6.28	7.27
13	10.7	6.95	21.33	624	3667	4.77	6.266	7.25

As a result of analysis of the responses measured by the expert design program, the appropriate summary output showed that the linear model is statistically significant with respect to compressive strength, porosity and robustness I5, so it is used for further analysis did. For other responses the quadratic model is statistically recommended for further analysis because it has the maximum R2 and rate expected. We tested the significance test of the regression model and tested the importance for the lack of relevance test using the same statistical package for individual model coefficients and all responses. By specifying the gradient step method, parameters of obvious model can be automatically removed. The ANOVA table (Table 3.1 - 3.3) obtained for the reduced second order model shows the variance analysis of each response and shows the important model terms. The same table also shows other efficiency measurements "R2", R2 correction and R2 prediction. As can be seen from the tables from 3.1 to 3.3, most of the validity measure is close to 1, it is in a reasonable range, showing a sufficient model. Proper accuracy compares expected value range at design time with average prediction error. In both cases, the appropriate resolution value is greater than 4, indicating an appropriate model. In the case of the bending force model, analysis of variance shows that the main effect is the fiber size fraction (V), the fiber length (L) and the fractional second effect (V 2). The same tendency was observed in the I20 hardness index model. For the compression resistance model, the ANOVA analysis shows a linear relationship between the two main effects of the two teachers. Also, for the I5 hardness index and porosity model, the ANOVA analysis shows a linear relationship between the two main effects of the two teachers. In the case of the impact resistance model, the main effect of the fraction on fiber breakage (V), fiber length (L), the influence of the second L2 (fiber length) arrangement, and fractional break and fiber length (VL) It is a model condition. Finally, in the case of the fraction I 20 model and fracture toughness, the ANOVA analysis shows that the main size (F) of fiber size (V), fiber length (L), second fiber length effect (V2) and 2 volume and fiber length (VL) It shows that the effect is an important model term.

The final pilot form will be displayed from the perspective of the actual elements of the formula. 3.1 - 3.8:

$F_{flex=}$ 1.991+7.02V+0.015L-2.57V^2 (3.1)

F_{com}=25.56-3.72V-0.03L (3.2)

F_{imp}=311.24-21.67V-1.95L+9.6VL-0.064L^2(3.3)

G_f= 1699.62-3364.07V-4.8L+40.55VL-1471.61V^2 (3.4)

I_5=4.09-0.41v-0.013l (3.5)

I_{10}=8.55-6.44V+0.01L+3.94V^2 (3.6)

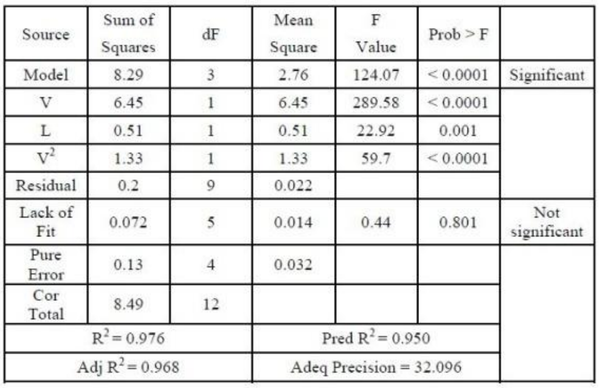
I_{20}=12.19-13.5V-0.012L+0.042VL+7.76V^2 (3.7)

P=9.16+0.93V+0.018L (3.8)

Where:

$F_{flex}$is flexual strength (MPa)
$F_{com}$is compressive strength (MPa)
$F_{imp}$is impact strength (j/m^2)
$G_f$is fracture energy (N.mm)
I_5,I_{10},$I_{20}$are toughness indices
P is porosity (%)
V is fibre volume fraction (%)
L is fibre length (mm)

Table 3.4: ANOVA analysis for the flexural strength model

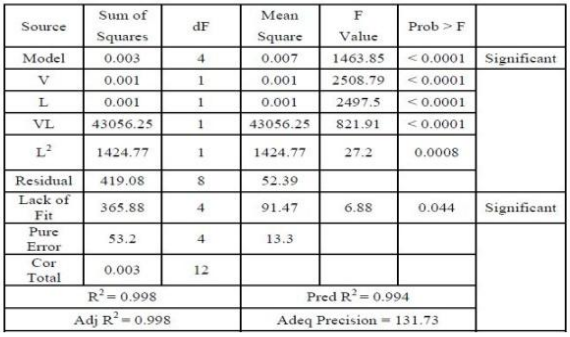


Source	Sum of Squares	dF	Mean Square	F Value	Prob > F	
Model	8.29	3	2.76	124.07	< 0.0001	Significant
V	6.45	1	6.45	289.58	< 0.0001	
L	0.51	1	0.51	22.92	0.001	
V^2	1.33	1	1.33	59.7	< 0.0001	
Residual	0.2	9	0.022			
Lack of Fit	0.072	5	0.014	0.44	0.801	Not significant
Pure Error	0.13	4	0.032			
Cor Total	8.49	12				
R^2 = 0.976			Pred R^2 = 0.950			
Adj R^2 = 0.968			Adeq Precision = 32.096			

Table 3.5: ANOVA analysis for the compressive strength model

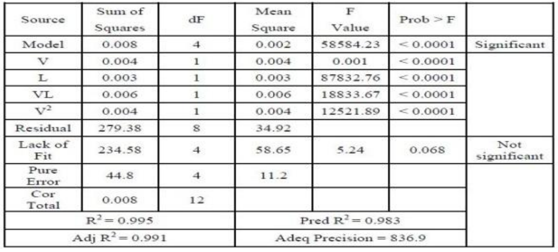
Source	Sum of Squares	dF	Mean Square	F Value	Prob > F	
Model	22.92	2	11.46	24.72	0.0001	Significant
V	20.76	1	20.76	44.78	< 0.0001	
L	2.16	1	2.16	4.66	0.0562	
Residual	4.64	10	0.46			
Lack of Fit	3.76	6	0.63	2.88	0.1625	Not significant
Pure Error	0.87	4	0.22			
Cor Total	27.55	12				
$R^2 = 0.832$			Pred $R^2 = 0.699$			
Adj $R^2 = 0.798$			Adeq Precision = 15.04			

Table 3.6: ANOVA analysis for the impact strength model



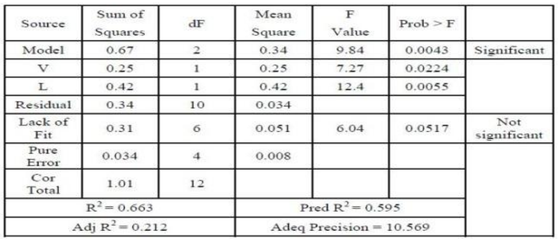
Source	Sum of Squares	dF	Mean Square	F Value	Prob > F	
Model	0.003	4	0.007	1463.85	< 0.0001	Significant
V	0.001	1	0.001	2508.79	< 0.0001	
L	0.001	1	0.001	2497.5	< 0.0001	
VL	43056.25	1	43056.25	821.91	< 0.0001	
L^2	1424.77	1	1424.77	27.2	0.0008	
Residual	419.08	8	52.39			
Lack of Fit	365.88	4	91.47	6.88	0.044	Significant
Pure Error	53.2	4	13.3			
Cor Total	0.003	12				
$R^2 = 0.998$			Pred $R^2 = 0.994$			
Adj $R^2 = 0.998$			Adeq Precision = 131.73			

Table 3.7: ANOVA analysis for the fraction energy model



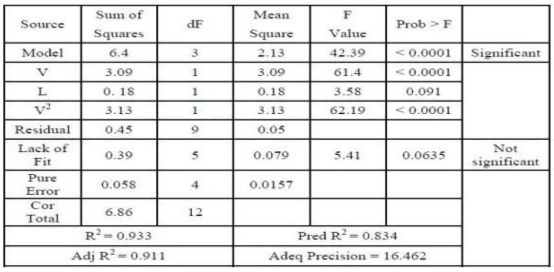
Source	Sum of Squares	dF	Mean Square	F Value	Prob > F	
Model	0.008	4	0.002	58584.23	< 0.0001	Significant
V	0.004	1	0.004	0.001	< 0.0001	
L	0.003	1	0.003	87832.76	< 0.0001	
VL	0.006	1	0.006	18833.67	< 0.0001	
V^2	0.004	1	0.004	12521.89	< 0.0001	
Residual	279.38	8	34.92			
Lack of Fit	234.58	4	58.65	5.24	0.068	Not significant
Pure Error	44.8	4	11.2			
Cor Total	0.008	12				
$R^2 = 0.995$			Pred $R^2 = 0.983$			
Adj $R^2 = 0.991$			Adeq Precision = 836.9			

Table 3.8: ANOVA analysis for the toughness index I5 model



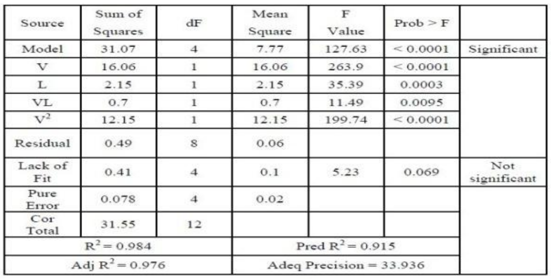
Source	Sum of Squares	dF	Mean Square	F Value	Prob > F	
Model	0.67	2	0.34	9.84	0.0043	Significant
V	0.25	1	0.25	7.27	0.0224	
L	0.42	1	0.42	12.4	0.0055	
Residual	0.34	10	0.034			
Lack of Fit	0.31	6	0.051	6.04	0.0517	Not significant
Pure Error	0.034	4	0.008			
Cor Total	1.01	12				
$R^2 = 0.663$			Pred $R^2 = 0.595$			
Adj $R^2 = 0.212$			Adeq Precision = 10.569			

Table 3.9: ANOVA analysis for the toughness index I10 model



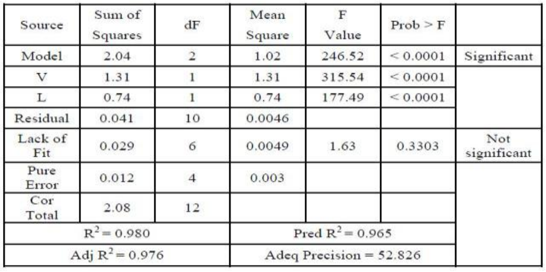
Source	Sum of Squares	dF	Mean Square	F Value	Prob > F	
Model	6.4	3	2.13	42.39	< 0.0001	Significant
V	3.09	1	3.09	61.4	< 0.0001	
L	0. 18	1	0.18	3.58	0.091	
V^2	3.13	1	3.13	62.19	< 0.0001	
Residual	0.45	9	0.05			
Lack of Fit	0.39	5	0.079	5.41	0.0635	Not significant
Pure Error	0.058	4	0.0157			
Cor Total	6.86	12				
$R^2 = 0.933$			Pred $R^2 = 0.834$			
Adj $R^2 = 0.911$			Adeq Precision = 16.462			

Table 3.10: ANOVA analysis for the toughness index I20 model



Source	Sum of Squares	dF	Mean Square	F Value	Prob > F	
Model	31.07	4	7.77	127.63	< 0.0001	Significant
V	16.06	1	16.06	263.9	< 0.0001	
L	2.15	1	2.15	35.39	0.0003	
VL	0.7	1	0.7	11.49	0.0095	
V^2	12.15	1	12.15	199.74	< 0.0001	
Residual	0.49	8	0.06			
Lack of Fit	0.41	4	0.1	5.23	0.069	Not significant
Pure Error	0.078	4	0.02			
Cor Total	31.55	12				
$R^2 = 0.984$			Pred $R^2 = 0.915$			
Adj $R^2 = 0.976$			Adeq Precision = 33.936			

Table 3.11: ANOVA analysis for the porosity model



Source	Sum of Squares	dF	Mean Square	F Value	Prob > F	
Model	2.04	2	1.02	246.52	< 0.0001	Significant
V	1.31	1	1.31	315.54	< 0.0001	
L	0.74	1	0.74	177.49	< 0.0001	
Residual	0.041	10	0.0046			
Lack of Fit	0.029	6	0.0049	1.63	0.3303	Not significant
Pure Error	0.012	4	0.003			
Cor Total	2.08	12				
$R^2 = 0.980$			Pred $R^2 = 0.965$			
Adj $R^2 = 0.976$			Adeq Precision = 52.826			

IV. CONCLUSION

Fiber length plays an important role in the mechanical performance of fiber cement compounds. If the fiber length is sufficiently long (length >30 mm), more breakage is required to draw the fiber into the matrix, and the compound can be made more rigid and strong. This work was done by manufacturing cement compounds of three different lengths (i.e. 10, 30, 50 mm). The results showed that the reduction in hardness of the compound, the bending strength and the impact strength were observed, as compared with the long fibers (30, 50 mm), using short fibers (10 mm) as strength.

For example, at 1% by volume fraction the short fibre composites showed around 10-15% decrease in fracture energy and impact strength and around 20-22% decrease in flexural strength compared to composites containing the same amount of the longer fibre. The mathematical models for the fracture energy, toughness indices, porosity, flexural, impact and compressive strength of flax fibre cement composites were obtained by using central composite design using two fibre parameters (fibre length and volume fraction). The results indicate that within the limits of fibre parameters used in this study the proposed models predict the above properties adequately.

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