Project ID -780

Competitive Research Grant

Sub-Project Completion Report

on

Design and Development of Jute-Cotton Reinforced Polymer Composite for Rural Poultry Housing

Project Duration

November 2017 to September 2018

Textile Physics Division
Bangladesh Jute Research Institute
Manik Mia Avenue
Dhaka-1207

Submitted to
Project Implementation Unit-BARC, NATP-2
Bangladesh Agricultural Research Council
Farmgate, Dhaka-1215

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Project Implementation Unit
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Bangladesh Agricultural Research Council (BARC)
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ACRONYMS

Full name of Abbreviations and Acronyms used in the report

MEKPO	:	Methyl Ethyl Ketone Per Oxide
CNSL	:	Cashew Nut Shell Liquid
BJRI	:	Bangladesh Jute Research Institute
PSO	:	Principal Scientific Officer
BARC	:	Bangladesh Agriculture Research Council
GSM	:	Gram Per Square Meter
lb	:	Libra (Pound in weight)
TPI	:	Twist per Inch
ISO	:	International Standard Organization
TGA	:	Thermogravimetic Analyzer
J	:	Joule
mm	:	millimeter
gm	:	gram
m	:	meter
Sec	:	Second
CRG	:	Competitive Research Grant
Kg	:	Kilogram
wt%	:	Weight Percentage
KN/m^2	:	Kilo-Newton per meter square
K	:	Thermal Conductivity
w/v	:	Weight per Volume
h	:	Hour
$W/m/^oC$	:	Watt per meter per Degree Celsius
J/Kg/K	:	Joule per Kilogram per Kelvin
m_1	:	Weight of the dry sample at initial time
m_t	:	Weight of the sample at time (t)
M_t (%)	:	Percentage of weight gain
W	:	Power in Watt
Ne	:	English Cotton Count

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Executive Summary

Diversified jute products are becoming more and more valuable to the consumer today. Among these home textiles, high performance geo-textiles, composites are more prominent. The combination of natural fibres is suitable to produce composites for lightweight structural applications. Composites are made of reinforcing and matrix materials. For the selection of proper reinforcing material, different types of jute-cotton union fabric were purchased from local market. Purchased fabric is of different design, fabric density (gm/m^2) and blend ratio (like 50% jute+50% cotton, 60% jute+40% cotton and 70% jute +30% cotton etc.). Fabric weave, GSM and physical and mechanical properties were determined at different laboratories of BJRI. Generally, two types of matrix, namely thermosetting and thermoplastics are used in composites fabrication. Thermosetting matrix (polyester) was chosen for this particular experiment. The matrix material was prepared with the mixture of polyester resin and methyl ethyl ketone per oxide (MEKPO) in various proportions. The MEKPO was chosen to enhance the hardness of composites. In this experiment, the best proportion of 1, 1.5, and 2 wt% MEKPO was chosen to mix with polyester resin. Inclusions of Nano cellulose impart excellent heat and electrical resistance property on the produced composites. An evaluation was carried out at different percentages like 2%, 4%, and 6% of nano-cellulose application. After selection of different types of reinforcing and matrix materials, composites were fabricated according to experimental design. Composites samples of 3 mm and 4 mm of thickness were prepared by using jute cotton fabric adding different wt% of nano clay/cellulose. Jute composites were fabricated varying the sample thickness of 3 mm and 4 mm, MEKPO (methyl ethyl ketone per oxide) wt%, and Nano-cellulose wt%. The best weight proportion of MEKPO (methyl ethyl ketone peroxide), nano-cellulose and the optimum thickness of the composites were 1.5%, 6% and 3 mm respectively. It was found that 60% jute and 40% cotton blended union fabrics are suitable reinforcement for composites fabrication having composite thickness of 3 mm. The thermal conductivity decreases with the increase of fibre content. It is because of hollow portion of reinforced fibres contains the air. The thermal conductivity of the air is 0.26 (w/.m-k) at 25^0C . It has excellent heat insulation effect. The volume percentage of air increases with the increase of fibre content. The thermal conductivity of the composites with fibre content (60% jute + 40% cotton), was found 0.106 [w/m/^{o}C].

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. **Title of the CRG sub-project:** Design and Development of Jute-Cotton Reinforced Polymer Composite for Rural Poultry Housing

2. **Implementing organization:** Textile Physics Division, Bangladesh Jute Research Institute, Dhaka-1207

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4. **Sub-project budget (Tk):**
4.1 Total : 27,79,280.00
4.2 Revised (if any) : Not applicable

5. **Duration of the sub-project:**
5.1 Start date (based on LoA signed) :07 November 2017
5.2 End date :30 September 2018

Justification of undertaking the sub-project: Jute fibre is bio-degradable, recyclable and thus environment friendly. It is the second most important vegetable fibres after cotton, in terms of usages, global consumption, production and availability. It has high tensile strength, low extensibility and ensures better breathability of fabrics. On heating to high temperature, jute fibres char and burn without melting like cotton. Ignition temperature of jute is about $193^{O}C$. The high specific heat value (1360 $JKg^{-1}K^{-1}$) results good thermal insulation of jute. Diversified jute products are becoming more and more valuable to the consumer today. Among these, home textiles, high performance geo-textiles, composites are prominent. The combination of natural fibres is suitable to produce composites for lightweight structural applications. Roofing is one of the most important and difficult problem in housing. In most developing countries and in many industrialized countries, natural materials are used for roofing in rural areas. An interesting solution to the roofing problem seems to be thin sheets made of plant fibre concrete. A corrugated roof sheet is probably one of the most interesting forms even if other forms can be produced. Apart from roofing materials, plant fibre concrete can be used for the production of sun screens, thin blocks, small beams, and other products. The research proved that it is also possible load-bearing structures with bio fibres reinforced composites. There are many poultry farms in Bangladesh. During the month of March to June, temperature raises up to 40^0 C. This temperature cannot be sustained by the chicken. As a result, lots of chicks are died. If roofing of poultry firms is made by jute-cotton fibre reinforced composite, the temperature will be reduced. So, different designed composites should be studied. Considering all this facts, the project proposal of "**Design and Development of Jute-Cotton Reinforced Polymer Composite for Rural Poultry Housing"** has been taken to study this problem.

6. **Sub-project goal:** To produce strong and more heat protected hybrid composite
7. **Sub-project objective (s):**
   - **i.** To increase diversified usages of jute fibres
   - **ii.** To produce jute-cotton reinforced polymer corrugated sheet for rural poultry housing
   - **iii.** To reduce inner temperature of poultry house

8. **Implementing location (s):**

   Textile Physics Division, Bangladesh Jute Research Institute, Manik Mia Avenue, Dhaka-1207

9. **Methodology in brief:**

(A) Material Design (Selection of Proper Reinforcing and Matrix Material):

Reinforcing Material:

i) **Jute Fibre**:

Fibres that is used in composite, increases stiffness and strength. As the jute fibre is abundantly available natural fibre and shows good tensile strength ranging from 20000-25000 KN/m^2, it is chosen as reinforcing material. Natural fibre reinforced composites have a good potential as a substitute for wood-based material in many applications. The development of environment-friendly green materials is because of natural fibre's biodegradability, light weight, low cost, high specific strength compared to glass and carbon, recycling and renewing natural sources. Composites, the wonder material with light-weight, high strength-to-weight ratio and stiffness properties have come a long way in replacing the conventional materials like metals, woods etc. Fibre parameters like treatment of fibres, duration of treatment, weight of fibres used are considered for the analysis of the effect of parameters exhibited on tensile strength.

ii) **Cotton Fibre:**

Incorporation of cotton is likely to increase the impact resistance of these structures that makes such composites suitable for many more applications. Among all natural cellulosic fibers, cotton is well known for its excellent absorbency, comfort properties, and natural feel. In addition, biodegradable nature of cotton is an important quality that makes it an attractive and strong candidate in a situation, where waste disposal is becoming a major concern.

For the selection of proper reinforcing material, different types of jute-cotton fabric were produced at BJRI. Produced fabrics were of different design, fabric density (g/m^2) and blend ratio (like as 50% jute+50% cotton, 60% jute+40% cotton and 70% jute +30% cotton etc.).

(iii) Matrix Material: Generally two types of matrix, namely thermosetting and thermoplastic matrix are used in composites. Polyester resin is chosen for experimentation as it is cost competitive. The matrix material were prepared with the mixture of polyester resin and cashew nut shell liquid (CNSL) in various proportions. The CNSL is chosen to enhance the biodegradation and recycling of composites. As the increase in CNSL resin increases plasticity of the material. The best proportion of 5, 10 and 15 % is chosen to mix with polyester resin. Matrix material like polyester resin was purchased from local market. Different percentage of the above resin were applied in the different reinforcing material.

(B) Collection of raw materials: Jute-Cotton blended fabric, Matrix Material etc.

(i) Jute-Cotton Blended fabric: Jute-Cotton blended fabric were purchased from local market.

(ii) Matrix Material: Matrix Material were purchased from local market.

(C) Determination of Fabric Properties:
Fabric weave, fabric density (gm/m^2) and different physical and mechanical properties were determined in different laboratories of BJRI, (As shown in Table 3).

(D) Optimization of Hardener (catalyst):
Composites hardening compound were added at different percentages like as 1%, 1.5%, and 2% to increase hardness as well as to achieve rapid drying ability of the composites. An evaluation of the prepared composites was executed at the stated hardener application percentages.

(E) Optimization of Nano-Cellulose/ Nano-Clay:
Inclusions of nano cellulose impart excellent heat and electrical resistance property on the produced composites. An evaluation was executed at different percentages like as 2%, 4%, and 6% of nano-cellulose application.

(F) Experimental Design (Fabrication of composite):
After collection of different types of reinforcing and matrix materials, composite were fabricated according to experimental design. The parameters of reinforcement fibre are the major influential factors in determining the tensile strength of the composite. Similarly, the recycling capability of composites rests predominantly on the percentage of concentrations of Cashew Nut Shell Liquid (CNSL) in matrix. The experiment was planned and was conducted with various values of reinforcement parameters. The details of the fiber and the reinforcement parameters and their values are given in Table-1.

Table 1: Details of fibre and resin used for composite preparation

a. Classification of reinforcement fiber factors			
Reinforcement parameters	**Parameter /Values**		
Fibre weight % (Jute + Cotton)	50% Jute+ 50% Cotton	60% Jute + 40% Cotton	70% Jute+ 30% Cotton
Alkali treatment of jute fibre	5 % NaOH Solution	10% NaOH Solution	15% NaOH Solution
Duration of treatment at room temperature (30^{o}C)	24 hours	12 hours	06 hours
b. Classification of Matrix Resin Factors			
Resin Parameter	**Parameter/Values**		
wt% of Cashew Nut Shell Liquid (CNSL) in Polyester resin	5	10	15
Nano-Cellulose/ Nano-Clay	2 %	4%	6%
Hardener (catalyst)	1	1.5	2

G. Composite fabrication: Composite samples of 3 mm and 4 mm thickness were prepared by using jute-cotton blended reinforcing material adding different wt% of nano clay.

Composite corrugated sheet manufacturing process:
At first jute-cotton blended fabrics were cut into predetermined length and width. Milot-paper was also cut according to fabric length and width. Polyester resin was poured on the milot paper. Then jute-cotton blended fabrics were placed on the milot paper and resin was pulled by a roller. Then another piece of jute-cotton blended fabric was placed. By this way all layers are completed. At the end, one milot paper sheet was placed on top of the composite. Finally, for curing and releasing the bubbles from the fabricated composite samples, certain weight was placed over the sample for 24 hours.

Table 2: Reinforcing and Matrix Material Optimization

Ratio	Ratio	Comments/Remarks
Fabric : Resin	1:1	Incomplete Saturation
Fabric : Resin	1:2	Incomplete Saturation
Fabric : Resin	1:3	Partial Saturation
Fabric : Resin	1:4	Complete Saturation

Polyester resin was taken four times of the fibre material 1% (w/v) Methyl Ethyl Ketone per Oxide was taken for hardening of composite.

Different types of composite varying reinforcing material and thickness were prepared such as.

Composite Material-1: 50% jute fabric+ 50% cotton blended fabric reinforced polyester composite (3 mm thickness)

Composite Material-2: 50% jute fabric+ 50% cotton blended fabric reinforced polyester composite (4 mm thickness)

Composite Material-3: 60% jute fabric+ 40% cotton blended fabric reinforced polyester composite (3 mm thickness)

Composite Material-4: 60% jute fabric+ 40% cotton blended fabric reinforced polyester composite (4 mm thickness)

Composite Material-5: 70% jute fabric+ 30% cotton blended fabric reinforced polyester composite (3 mm thickness)

Composite Material-6: 70% jute fabric+ 30% cotton blended fabric reinforced polyester composite (4 mm thickness)

Composite Material-7: 100% jute fabric reinforced polyester composite (3 mm thickness)

Composite Material-8: 100% jute fabric reinforced polyester composite (4 mm thickness)

Some Pictorial view of project activities

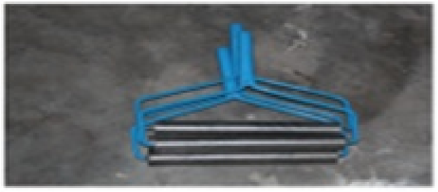


Fig. 1(a): Roller

Fig. 1(b): Small dice

Fig. 1(c): Big dice

Fig. 1(d): Composite cutter machine

Fig. 1(e): Hand ball press

Fig. 1(f): Metal plate

Fig. 1(g): Digital Twist Meter

Fig. 1(h): Digital Thickness Meter

Fig. 1(i): Fabric Strength tester

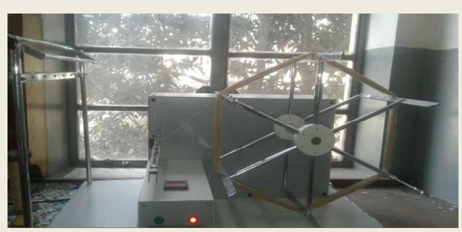


Fig. 1(j): Wrap Reel

Fig. 1: Lab Instrument

Fig. 2(a): Fabric preparation

Fig. 2(b): Fabric Sample

Fig. 2(c): Fabric weight

Fig. 2(d): Fabric ironing

Fig. 2(e): Cutting of milot paper

Fig. 2(f): Polyester resin and Hardener

Fig. 2(g): Weighing of polyester resin

Fig. 2(h): Stirring of polyester resin and hardener

Fig. 2(i): Virgin polyester resin

Fig. 2(j): Stirring of polyester resin and hardener

Fig. 2(k): Pouring of polyester resin on milot paper

Fig. 2(l): Wetting of jute fabric with polyester resin

Fig. 2(m): Air bubble removing

Fig. 2(n): Formation of corrugated sheet

Fig. 2(o): Pressure applied on composite during curing

Fig. 2(p): Final composite sheet

Fig. 2: Different stages of composite sample fabrication

Fig. 3: Different composite samples using different jute-cotton blended fabrics as reinforcement

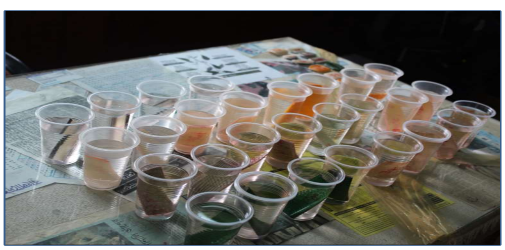


Fig. 4(a): Water absorption test

Fig. 4(b): Preparation of sample for TGA test

Fig. 4(c): TGA machine

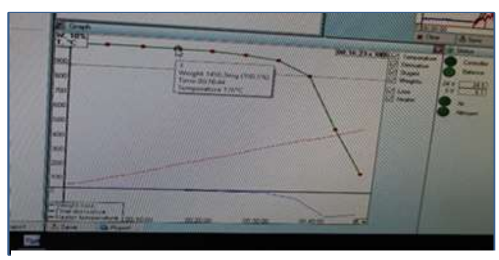


Fig. 4(d): TGA graph

Fig. 4: Water absorption and TGA test of composite samples

Fig. 5(a): Thermal conductivity sample Fig. 5(b): Thermal conductivity tester

Fig. 5: Measurement of Thermal conductivity with sample

Fig. 6(a): Monitoring team of BARC Fig. 6(b): Monitoring team of BARC

Fig. 6: Monitoring Project Activities

H : Test conducted for the composite samples:

(i) Water Absorption Test: To study the behavior of water absorption of the jute fibre reinforced polymer composites, water absorption tests were carried out according to ISO. Composite samples were immersed in a water bath (deionized, 23°C) during a time period until the saturation was reached. Five specimens from each fiber volume fraction with dimensions 90 mm × 15 mm × 3 mm were cut from composite panels. An oven was used, firstly to dry all the samples at 50°C during 24 h, and then they were cooled to room temperature. The drying process was repeated, until the weight of the specimens was constant (mass m_1). After 24 h, the samples were removed from the water and were weighed (mass m_2) using a digital scale immediately after they were dried with dry cloth. This process was repeated, to weigh the specimens regularly (mass m_t) over 32 days of water immersion.

At different periods of time, the percentage of weight gain was calculated and it was plotted versus square root of water immersion time. As a result, the average value was reported. The difference of weight between the sample in dry conditions and that after water immersion at time t was obtained as follows:

$$M_t\,(\%) = (m_t - m_1)/m_1 \times 100$$

Where, m_t is the weight of the sample at t time during water immersion and m_1 is the weight of the dry sample at initial time.

(ii) Thermal Conductivity Test:

On knowing the temperature of discs A, B and C at the steady state from the thermal conductivity tester, thermal conductivity K can be evaluated by the following formula,

$$K = \frac{ed}{2\pi r^2 (T_B - T_A)} \left(a_S \frac{T_A + T_B}{2} + 2 a_A T_A \right) W\text{m}^{-1} {}^{\circ}C^{-1}$$

And

$$e = \frac{VI}{a_A T_A + a_S \frac{T_A + T_B}{2} + a_A T_B + a_c T_c} \quad \text{Joules Sec}^{-1}\ \text{m}^{-2}\ {}^{\circ}\text{C}^{-1}$$

Where,
e= Amount of heat energy transferred from heat to cold end {Joules/(Sec^{-1} m^{-2} ºC $^{-1}$)}
d= Thickness of sample (= Width of material in machine=L) (m)
T_A= Temperature of Disc A (ºC)
T_B= Temperature of Disc B (ºC)
T_C= Temperature of Disc C (ºC)
a_A= Surface area of Disc A=29.755×10^{-4}m^2

a_B= Surface area of Disc B=16.430×10^{-4}m^2
a_C= Surface area of Disc C=29.755×10^{-4}m^2
a_S= Surface area of Sample=2πrL m^2
r = radius of circular copper disc = 2.06×10^{-2}m^2
L = Width of material in machine (= Thickness of sample=d) (m)

V= One of the potential difference across element in volt =6.4 volt
I= The current flowing in ampire = 0.35 ampire
W= VI= 2.24 Joules/sec= 2.24 watts

The thickness is one of the important factors that affect the thermal conductivity of jute and jute polymer composites. For a solid material like a sheet of wood or metal, the procedure is simple. Difficulties can arise if the thickness is not uniform, but it is usually possible to obtain an average value. Thickness of the composites samples have been measured by using digital thickness gauge.

Thermal resistance R is calculated by the following formula,

$$R = \frac{L}{K}$$

Where, L is the thickness of the material in mater and K is thermal conductivity in W/m/ºC. Each value calculated for the thermal resistance and conductivity is the average of three tests for each sample.

(iii) TGA Test:

A thermogravimetric analyzer continuously measures mass while the temperature of a sample is changed over time. Mass, temperature, and time in thermogravimetric analysis are considered base measurements while many additional measures may be derived from these three base measurements.

A typical thermogravimetric analyzer consists of a precision balance with a sample pan located inside a furnace with a programmable control temperature. The temperature is generally increased at constant rate (or for some applications the temperature is controlled for a constant mass loss) to incur a thermal reaction. The thermal reaction may occur under various atmospheric conditions such as: ambient air, vacuum, inert gas, oxidizing/reducing gases, corrosive gases, carburizing gases, vapors of liquids or "self-generated atmosphere"; as well as various pressures such as: a high vacuum, high pressure, constant pressure, or a controlled pressure.

The thermogravimetric data collected from a thermal reaction is compiled into a plot of mass or percentage of initial mass. A TGA was used for materials characterization through analysis of characteristic decomposition patterns. It is an especially useful technique for the study of polymeric materials, including thermoplastics, thermosets, elastomers, composites, plastic films, fibers, coatings, paints, and fuels.

Thermal stability

TGA was used to evaluate the thermal stability of a material. In a desired temperature range, if a specimen is thermally stable, there will be no observed mass change. Negligible mass loss corresponds to little or no slope in the TGA trace. TGA also gives the upper use temperature of a material. Beyond this temperature the material will begin to degrade.

TGA is mainly used to investigate the thermal stability of polymers. Most polymers melt or degrade before 200°C. However, there is a class of thermally stable polymers that are able to withstand temperatures of at least 300°C in air and 500°C in inert gases without structural changes or strength loss, which can be analyzed by TGA.

10. Results and discussion:

Table 3: Physico-mechanical properties of jute-cotton blended reinforcing material

Fabric Type	Fabric tensile Strength (lbs)		TPI (Twist per inch)		Yarn Count		Fabric weave	Elongation (%)	
	Jute	Cotton	Jute yarn	Cotton yarn	Jute yarn (lbs/ spyndle)	Cotton yarn (Ne)		weft direction (jute yarn)	warp direction (Cotton yarn)
100% Jute	250	-	4.0	-	8.0	-	-	1.50	-
70%Jute+ 30% Cotton)	240	60	4.00	15	7.5	15	Plain	1.50	2.00
60%Jute+ 40%Cotton)	239	63	4.27	15	7.5	15	Plain	1.44	2.04
50%Jute+ 50%Cotton)	139.6	65	6.12	15	7.5	15	Plain	1.24	2.12

Table 4: Calculation of thermal conductivity of composite samples with 6% Nano + 1.5% MEKPO

Sample ID	Temp. at Disc A T_a (C)	Temp. at Disc B T_b (C)	Temp. at Disc C T_c (C)	Sample Temp. $T_s=(T_a+T_b)/2$ (C)	Temp Diff. (T_b-T_a) (C)	Circum. of disc $2\pi r$ (m)	2 × area of the disc $2\pi r^2$ (m^2)	Sample thickness l(d) (m)	Surface area of sample A_s(m^2)	Surface area of disc A A_a (m^2)	Surface area of reference A_b(m^2)	Surface area of disc C A_c(m^2)	Volt-Amp VI Jule/sec	Heat transfer capacity $e=VI/(A_aT_a+A_bT_b+A_cT_c+A_sT_s$	Thermal Conductivity $K=ed/(2\pi r^2(T_b-T_a))\times(A_sT_s+2\times A_aT_a)$ Watt/m/°C
S_1	46	59	61	52.5	13	0.12938	0.002665	0.00399	0.00051623	0.0029755	0.001643	0.0029755	2.24	5.063092284	0.12488
S_2	46	61	62	53.5	15	0.12938	0.002665	0.0046	0.00059515	0.0029755	0.001643	0.0029755	2.24	4.940260147	0.16611
S_3	46	60	61	53	14	0.12938	0.002665	0.0044	0.00056927	0.0029755	0.001643	0.0029755	2.24	5.009729655	0.09403
S_4	58	60	61	59	2	0.12938	0.002665	0.00644	0.00083321	0.0029755	0.001643	0.0029755	2.24	4.463718811	0.10969
S_5	46	62	60	54	16	0.12938	0.002665	0.00563	0.00072841	0.0029755	0.001643	0.0029755	2.24	4.905792279	0.11043
S_6	46	61	62	53.5	15	0.12938	0.002665	0.00462	0.00051774	0.0029755	0.001643	0.0029755	2.24	4.938752256	0.16521
S_7	58	60	61	59	2	0.12938	0.002665	0.00506	0.00065466	0.0029755	0.001643	0.0029755	2.24	4.559428851	0.17372
S_8	46	62	60	54	16	0.12938	0.002665	0.00351	0.00054412	0.0029755	0.001643	0.0029755	2.24	5.07026292	0.17955

Table 5: Calculation of thermal conductivity of composite samples with 1.5% MEKPO

Sample ID	Temp. at Disc A T_a (C)	Temp. at Disc B T_b (C)	Temp. at Disc C T_c (C)	Sample Temp. $T_s=(T_a+T_b)/2$ (C)	Temp Diff. (T_b-T_a) (C)	Circum. of disc $2\pi r$ (m)	2 × area of the disc $2\pi r^2$ (m^2)	Sample thickness l(d) (m)	Surface area of sample A_s(m^2)	Surface area of disc A A_a (m^2)	Surface area of reference A_b(m^2)	Surface area of disc C A_c(m^2)	Volt-Amp VI Jule/sec	Heat transfer capacity $e=VI/(A_aT_a+A_bT_b+A_cT_c+A_sT_s$	Thermal Conductivity $K=ed/(2\pi r^2(T_b-T_a))\times(A_sT_s+2\times A_aT_a)$ Watt/m/°C
S_1	46	61	62	53.5	15	0.12938	0.002665	0.00253	0.00045412	0.0029755	0.001643	0.0029755	2.24	5.101468785	0.19435
S_2	46	61	62	53.5	15	0.12938	0.002665	0.00287	0.00037132	0.0029755	0.001643	0.0029755	2.24	5.074271798	0.196545
S_3	46	60	61	53	14	0.12938	0.002665	0.00274	0.0003545	0.0029755	0.001643	0.0029755	2.24	5.14059689	0.10233
S_4	58	60	61	59	2	0.12938	0.002665	0.00363	0.00046965	0.0029755	0.001643	0.0029755	2.24	4.663035186	0.18230
S_5	58	60	61	59	2	0.12938	0.002665	0.00352	0.00045542	0.0029755	0.001643	0.0029755	2.24	4.671200277	0.19034
S_6	46	62	60	54	16	0.12938	0.002665	0.00462	0.00059774	0.0029755	0.001643	0.0029755	2.24	4.982796867	0.19976
S_7	46	61	62	53.5	15	0.12938	0.002665	0.00563	0.00072841	0.0029755	0.001643	0.0029755	2.24	4.863782572	0.18335
S_8	58	60	61	59	2	0.12938	0.002665	0.00192	0.00024841	0.0029755	0.001643	0.0029755	2.24	4.79328256	0.20678

Table 6: Calculation of water absorption of composite samples with 6% Nano+1.5% MEKPO

Sample No.	Sample weight with water absorbed (m_w)	Dry Sample weight (m_d)	Water Absorption $(m_w-m_d)/m_d \times 100\%$	Average water absorption %
1.1	11.9	11.6	2.56	2.51
1.2	12.2	12.5	2.46	
2.1	7.7	7.5	2.67	2.75
2.2	7.3	7.1	2.82	
3.1	10.7	10.5	1.90	1.80
3.2	12.0	11.8	1.70	
4.1	10.8	10.5	2.86	1.93
4.2	10.2	10.1	1.00	
5.1	10.4	10.2	1.96	1.94
5.2	10.6	10.4	1.92	
6.1	15.4	15.1	1.99	2.33
6.2	15.4	15.0	2.67	
7.1	11.4	11.0	3.64	3.36
7.2	16.8	16.3	3.07	
8.1	6.4	6.2	3.23	3.95
8.2	6.6	6.3	4.76	

Table 7: Calculation of water absorption of composite samples with 1.5% MEKPO

Sample No.	Sample weight with water absorbed (m_w)	Dry Sample weight (m_d)	Water Absorption $(m_w-m_d)/m_d \times 100\%$	Average water absorption %
1.1	10.8	10.5	2.86	2.81
1.2	8.94	8.7	2.76	
2.1	13.8	13.4	2.99	2.95
2.2	14.1	13.7	2.91	
3.1	7.54	7.40	1.90	2.00
3.2	8.88	8.7	2.10	
4.1	8.68	8.5	2.12	2.08
4.2	8.98	8.8	2.04	
5.1	11.12	10.9	2.01	2.04
5.2	11.84	11.6	2.07	
6.1	10.8	10.5	2.86	2.98
6.2	11.65	11.3	3.10	
7.1	12.56	12.1	3.80	3.98
7.2	14.27	13.7	4.16	
8.1	7.64	7.3	4.66	4.50
8.2	8.66	8.3	4.34	

Table 8: TGA temperature of composite samples with 6% Nano + 1.5% MEKPO

Sample ID	Decomposition start temp (^oC)	Weight loss (%) at decomposition	Ash temp (^oC)	Condition of sample
1	189	15.58	580	Ash
2	186	19.35	570	Ash
3	200	14.15	600	Ash
4	195	22.8	580	Ash
5	198	21.86	575	Ash
6	202	30.59	586	Ash
7	205	26.67	590	Ash
8	207	25.7	595	Ash

Table 9: TGA temperature of composite samples with 1.5% MEKPO

Sample ID	Decomposition start temp (^oC)	Weight loss (%) at decomposition	Ash temp (^oC)	Condition of sample
1	179	17.55	565	Ash
2	172	20.63	556	Ash
3	198	15.25	567	Ash
4	182	23.78	560	Ash
5	185	25.25	555	Ash
6	190	32.95	570	Ash
7	190	28.8	572	Ash
8	198	26.7	576	Ash

Properties of Fabricated composites:

In this section important results of composite samples are highlighted. Water absorption, TGA, thermal conductivity is improved due to 6% nano incorporation in the jute-cotton polyester composite as shown in the Table 10. Whereas with the increase of composite thickness the above properties is also increased. The TGA particularly ash content temperature is decreased with the thickness of the composite as their results are disclosed in the upcoming section.

From Table 3, it was found that fabric tensile strength of 100% jute is higher than that of others. Tensile strength (weft direction) of 70% jute + 30% cotton and 60% jute + 40% cotton are similar. But tensile strength (warp direction) of 60% jute + 40% cotton is higher than 70% jute + 30% cotton. TPI of jute yarn of 60% jute + 40% cotton sample is higher than 100% jute, 70% jute + 30% cotton but less than 50% jute + 50% cotton. Elongation percentage of jute yarn of 60% jute + 40% cotton sample is higher than 50% jute + 50% cotton but less than 100% jute and 70% jute + 30% cotton. This is due to yarn twist and fabric weave pattern.

Nano cellulose imparts excellent heat and electrical resistance property on the produced composites. From Table 4 and 5 it was found that thermal conductivity of composite fabricated with 6% nano + 1.5% MEKPO is found better than others.

Water absorption of natural fibre composites is a serious concern especially for their outdoor application. Water absorption tests were conducted by immersing composite specimen in distilled water at room temperature for a period of 3 weeks. From Table 6 and 7 it was found that water absorption of composite with 6% nano + 1.5% MEKPO is the lowest which indicates better performance.

The decomposition and ash temperature of different composite sample are shown in Table 8 and 9. It is observed that decomposition and ash temperature of composite samples with 6% Nano and 1.5% MEKPO is comparatively higher than that of sample with 1.5% MEKPO. Therefore, it is revealed that thermal stability of composite samples with 6% Nano is better than that of composite samples without Nano. Among the composite samples 60% Jute + 40% Cotton reinforced composite having 3mm thickness shows the best results, (As shown in Table 10).

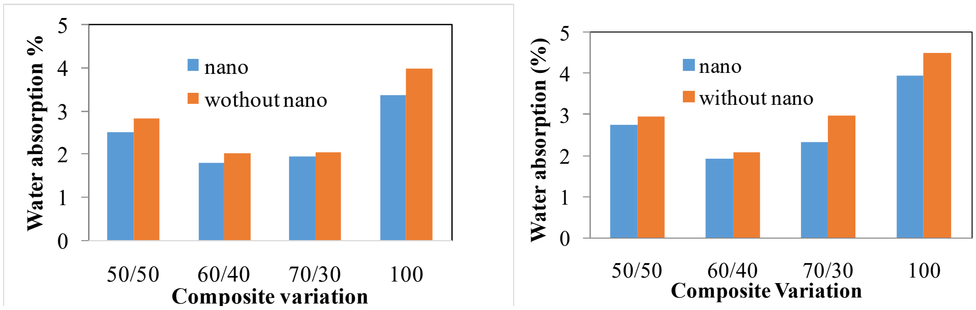
Table 10: Test results of water absorption %, TGA and thermal conductivity

Reinforcement parameters (fibre wt%)	6% Nano + 1.5% MEKPO			1.5% MEKPO		
	Water Absorption %	TGA (Decompo sition-Ash Temp) ^oC	Thermal conductivity (watt/m/^oC)	Water Absorption %	TGA (Decomp osition-Ash Temp) ^oC	Thermal conductivity (watt/m/^oC)
1. 50% jute + 50% cotton (3 mm thickness)	2.51	189-580	0.12488	2.81	179-565	0.19435
2. 50% jute + 50% cotton (4 mm thickness)	2.75	186-570	0.16611	2.95	172-556	0.196545
3. 60% jute + 40% cotton (3 mm thickness)	1.8	200-600	0.09403	2.00	198-567	0.10233
4. 60% jute + 40% cotton (4 mm thickness)	1.93	195-580	0.10696	2.08	182-560	0.18230
5. 70% jute + 30% cotton (3mm thickness)	1.94	198-575	0.11043	2.04	185-555	0.19034
6. 70% jute + 30% cotton (4 mm thickness)	2.33	202-586	0.16521	2.98	190-570	0.19976
7. 100% jute (3 mm thickness)	3.36	205-590	0.17372	3.98	190-572	0.18335
8. 100% jute (4 mm thickness)	3.95	207-595	0.17955	4.50	198-576	0.20678

Test results of water absorption %, TGA and thermal conductivity of fabricated composite samples with 6 wt% Nano and composites without nano are given in Table 10. For composite sample with 6 % Nano and 1.5% MEKPO, water absortion values obtained in the range of 1.80 to 3.95 % and the lowest water absoption % was obtained for composite prepared from 60% jute and 40% cotton union fabrics having 3 mm thickness, similarly, the lowest water absorption percentage (2%) are obtained for composites prepared with 1.5% MEKPO for 60% jute and 40% Cotton union fabrics. These results are presuted in Figure 7.

Water absorption is also increased with the increase of thickness in composite as shown in Figure 7. Whereas it is the lowest in case of 60:40 jute cotton polyester composite for raw as well as 6% nano composite. It is clear from the Figure 7 that 2nd lowest water absorbent composite is same composite whose thickness is 4mm. On the other hand it is highest in case of 100% jute composite having 4 mm thickness, 3.95% and 4.50% for nano and without nano respectively. From Figure 7 it is clearly observed that the 2nd highest water absorbent composite samples absorb water 3.36% and

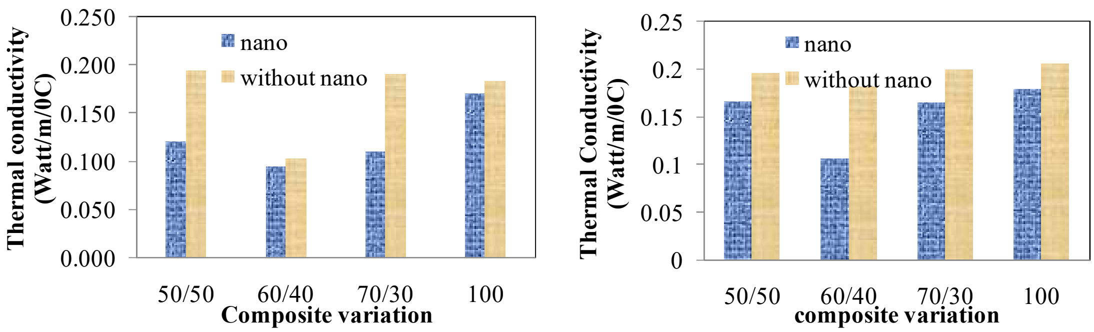
3.98% regarding nano and without nano composite respectively. Water absorbent is the highest in case of 100% jute composite which has 3 mm thickness.



(a) (b)

Figure 7: Water absorption properties of (a) 3 mm and (b) 4 mm jute cotton polyester composites

In this study thermal conductivity as well as ash content temperature are measured regarding thermal properties as shown in Table 10. Thermal resistance property is increased with the thickness of the composites and due to incorporation of the nano in the jute composite that is used for Rural Poultry Housing. Comparison between the thickness of different jute composite and additive incorporation are shown in Figure 8. In this section, the related Figures are drawn using the data of Table 4 and 5.



(a) (b)

Figure 8: Thermal conductivity of (a) 3 mm and (b) 4 mm thickness jute cotton polyester composite (used as raw material for Rural/Poultry Housing)

From Figure 8 it is clear that the lowest thermal conductivity is obtained in case of 60:40 jute composite among all of the treated and untreated jute polyester composite. That means their thermal resistivity is higher. The second lowest thermal conductivity is showed in 60:40 jute cotton composite whose thickness is 3 mm. However, 100% jute composite showed better thermal conductivity, 0.173 W/m/^{o}C for 3 mm thick composite whereas it is 0.179 W/m/^{o}C for 4 mm thick composite.

11. Research highlight/findings:

i) For diversifying uses of jute fibres, it was found that 60% jute and 40% cotton blended union fabrics are suitable for composites fabrication.

ii) Jute composites are fabricated varying the sample thickness of 3 mm and 4 mm, here composite having thickness of 3 mm showed better performance.

iii) Composite fabrication by varying MEKPO (methyl ethyl ketone per oxide) from 1%, 1.5% and 2% (wt%), better performance achieved from the composite samples fabricated with 1.5% MEKPO.
iv) Jute composites are fabricated varying Nano-cellulose at 2%, 4% and 6% (wt%),where 6% is suitable for better performance in fabricated composites.
v) Percentage of Cashew Nut Shell Liquid (CNSL) in Polyester resin is varied at 5%, 10%, 15% (wt%) in fabrication of composite samples and better result is achieved by using 5 wt% of CNSL.

B. Implementation Position

1. Procurement:

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	-
(a) Office equipment 1. Desktop Computer 2. Laser Printer 3. UPS 4. Laptop 5. Digital Camera	5	1,75,000.00	100%	100%	-
(b) Lab &field equipment	5	3,98,500.00	100%	100%	-
(c) Other capital items 1. Hand Ball Press 2. Casting Dice 3. Digital Barometer 4. Metal Plate 5. Vacuum Pump with Vacuum Chamber	-	-	-	-	-

Lab equipment procured for this project:

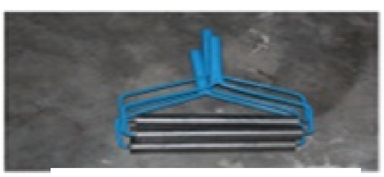


Fig. 9(a): Roller


Fig. 9(b): Small dice


Fig. 9(c): Big dice


Fig. 9(d): Composite cutter machine

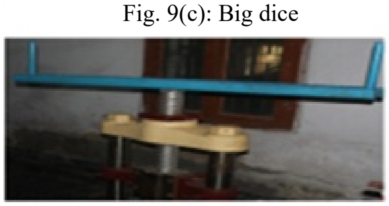


Fig. 9(e): Hand ball press

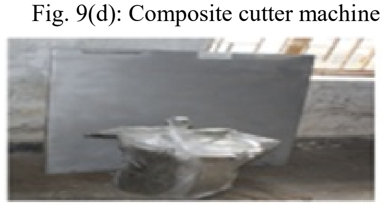


Fig. 9(f): Metal plate

Fig. 9(g): Digital Barometer

Fig. 9(h): Vacuum pamp

Fig. 9: Lab Equipments

List of Equipment with Specification

SL No.	Equipment Name	Specification
01.	Hand Ball Press	-Working Plate Size : 16 " x 24" -Working Plate Thickness : 5"/8 -Base Plate Thickness :4" & Shaft = 3" & Wheel=24"
02.	Casting Dice	size = 6'x 3' Thickness = 1.5 mm (up & down) Down= 1.5 mm.(fixed)
03.	Digital Barometer	Cup Anemometer/Barometer, Lutron ABH-4224, Taiwan
04.	Metal Plate	Size= 3.5'x2.5' Thickness= 6mm Handle= SS(good grade-261 non magnet) SS sheet
05.	Vacuum Pump With Vacuum Chamber	Volt=220 H.P=0.5.
06.	Composite Cutter Machine:	Motor=1.0 h.p Rpm=1450 = 380 volt Round/circular saw= Thickness=2mm Table size=4'x3.5'

Office equipment:

Fig. 10(a): UPS

Fig. 10(b): CPU

Fig. 10(c): Printer

Fig. 10(d): Computer Monitor

Fig. 10(e): Mouse & Keyboard

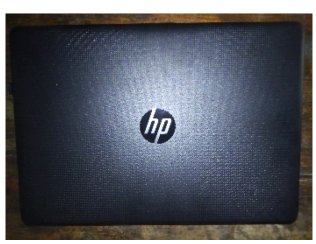


Fig. 10(f): Laptop (HP)

Fig. 10(g): Digital Camera

Fig. 10: Office Equipments

2. Establishment/renovation facilities: Not Applicable

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	
-	-	-	-	-	-

3. Training/study tour/ seminar/workshop/conference organized: Not Applicable

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training	-	-	-	-	-
(b) Workshop	-	-	-	-	-

C. Financial and physical progress (Fig. in Tk)

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
A. Contractual staff salary	4,10,280.00	3,81,837.70	3,04,496.00	77,342.00	79.74%	Time constraint
B. Field research/lab expenses and supplies	12,20,000.00	11,36,529.00	5,51,325.00	5,85,204.00	48.51%	
C. Operating expenses	1,50,000.00	1,41,246.70	27,055.00	1,14,192.00	19.15%	
D. Vehicle hire and fuel, oil & maintenance	-	-	-	-		
E. Training/workshop/seminar etc.	-	-	-	-		
F. Publications and printing	1,20,000.00	1,11,757.00	0.00	1,11,757.00	0%	
G. Miscellaneous	50,000.00	47,166.00	6,000.00	41,166.00	12.72%	
H. Capital expenses	8,29,000.00	8,16,959.00	5,65,800.00	2,51,159.00	69.26%	

D. Achievement of Sub-project by objectives: (Tangible form)

Specific objectives of the sub-project	**Major technical activities performed in respect of the set objectives**	**Output(i.e. product obtained, visible, measurable)**	**Outcome(short term effect of the research)**
To increase diversified uses of jute fibre.	Testing the physical and mechanical properties of jute fabrics	Testing of jute fabric	Developed jute-cotton reinforced polymer composite suitable for rural poultry housing
	Testing the physical and mechanical properties of jute-cotton blended fabrics	Testing of Jute-cotton blended fabric	
	Designing and development of raw materials	Designed jute-cotton blended fabric	
To produce jute-cotton reinforced polymer corrugated sheet for rural poultry housing .	Composite fabrication	Jute-cotton reinforced polymer composite	
	Testing of the developed composite	Tested Jute-cotton reinforced polymer composite	
To reduce inner temperature of poultry house.	-	-	-

E. Materials Development/Publication made under the Sub-project

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/ booklet/leaflet/flyer etc.			
Journal publication	√		
Information development	√		
Other publications, if any			

F. Technology/Knowledge generation/Policy Support (as applied)

i. Generation of technology (Commodity & Non-commodity)

In this project, jute-cotton fabric reinforced polyester composites was fabricated successfully using different weight proportion of jute and cotton and suitable resin and hardener proportion. Different tests were carried out to evaluate its performance to use these composites in making rural poultry housing. The report revealed that the fabricated composites may be applied in rural poultry housing to minimize the temperature effect during summer season in Bangladesh.

ii. Generation of new knowledge that help in developing more technology in future

For diversified uses of jute fibres, it was found that 60% jute and 40% cotton blended union fabrics are suitable reinforcement for composites fabrication. Jute composites are fabricated varying the sample thickness of 3 mm and 4 mm, MEKPO (methyl ethyl ketone per oxide) wt%, and Nano-cellulose wt%. The best weight proportion of MEKPO (methyl ethyl ketone peroxide), nano-cellulose and the optimum thickness of the composites are 1.5%, 6% and 3mm respectively.

iii. Technology transferred that help increased agricultural productivity and farmers' income

Our developed technology is a lab scale technology. Pilot scale production of the developed composite samples is required to conduct for technology transfer at industry level. However, it is expected that the technology transferred from lab scale to pilot scale production will help to increase agricultural productivity as well as farmer's income of rural areas in Bangladesh.

iv. Policy Support

By using this developed jute-cotton reinforced polyester composite, rural people could make their poultry house. As a result, inner temperature of the poultry house would be reduced. Pilot scale production of jute-cotton reinforced composite will remove our unemployment problem in rural areas, thus, increase an income generation among the poor people of rural areas in Bangladesh.

G. Information regarding Desk and Field Monitoring

i) **Desk Monitoring [description & output of consultation meeting, monitoring workshops/seminars etc.]**
Different monitoring team of BJRI and BARC had visited the project activities and they suggested that the project may be viable for making rural poultry housing by using cost-effective jute-cotton reinforced composite material.

ii) **Field Monitoring (time& No. of visit, Team visit and output):**

Monitoring Status			
Monitoring team	**Date(s) of visit**	**Total visit till date (No.)**	**Remarks**
Engineering Division/ Unit, BARC	**11.02.2018**	**01**	Honorable members of Engineering Division of BARC observed the project activities and gave different suggestion for conducting the research work successfully.
PIU-BARC, NATP-II	**-**	**-**	**-**
Internal Monitoring Team, BJRI, Dhaka	**11.09.2018**	**01**	Internal monitoring team of BJRI observed the project activities and monitoring team suggested to make cost-effective composite samples.

I. Lesson Learned/Challenges (if any)

i) Bad odor generates from polyester resin during composite fabrication.
ii) Processing cost increased in lab scale production.
iii) Micro dust generates during cutting the composite samples.

J. Challenges (if any)

i) Procurement of jute-cotton blended union fabric is not easy as it is not readily available in the local market. Besides this, production related personnel are not experienced with this new technology of composite fabrication.

ii) Suitable amount of hardener (MEKPO) added with polyester resin is very sensitive. If more amount of hardener is added than the optimum level, exothermic reaction may be occurred, as a result excessive heat may be generated.

Signature of the Principal Investigator
Date:

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Counter signature of the Head of the organization/authorized representative
Date:

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