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STRUCTURAL PROPERTIES OF CONCRETE BLOCK WITH AGRICULTURAL AND INDUSTRIAL WASTE – A REVIEW.

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Abstract: Concrete is the most important material in the construction industry in view of its compressive strength, high mouldability thermal conductivity, stability and economic considerations. Agricultural waste and Industrial wastes cause series threats to human health, pollution problems due to its improper disposal and utilization. These wastes created opportunities in the construction industry. This agro and Industrial waste can be used as non-structural element. The density, compressive strength thermal insulation, water absorption was experimentally conducted with various agricultural and Industrial wastes such as coconut coir, thermacol, e-waste, Bamboo, Straw, wood dust etc. Still there are more waste as well as tests are to be explored. So, this review is aimed to utilize this agricultural and industrial wastes in the construction industry to the alternative of concrete.

***Index Terms* — Agricultural waste, compressive strength, durability, thermal conductivity**

1. INTRODUCTION

There are many building materials based on Agricultural and Industrial wastes such as Bamboo, cork, bagasse, cereal, straw, cotton stalks, rice husks, rice, sunflower hulls, banana stalks, coconut coil, palm leaf, corn cob etc., are recommended for manufacturing of different thermal insulation products and non-structural elements. There were many experiments using the above Agricultural wastes have been done for building solutions in the building industry.

Among the above some materials which has the additional advantage of not colliding with other material even though they may have similar micro structure and chemical elementary composition be generally considered as agricultural waste. The main scope of this review consists on analyzing the potential use of agricultural waste as a sustainable solution as an alternative to commonly used material. Some waste material was not used for non-structural elements.

2. LITERATURE REVIEW

Nahro Radi et.al.(2013) investigated strength capacities of two different light weight sandwich panels (LWSP) one is with aerated concrete as a core and another one is thermacol encased with ferrocement.

It deals with strength under flexural loading with one-point load and third point load by using these LWSP'S as a floor also studied strength in axial load for the use of these LWSP's as a wall.

Thirteen specimens were casted with a size of 500mm x 400mm x 100mm and each core size was 450mm x 105mm x 60mm.

Ten specimens were casted using aerated concrete as a core and three specimens were casted using thermacol encased with ferro cement as a core.

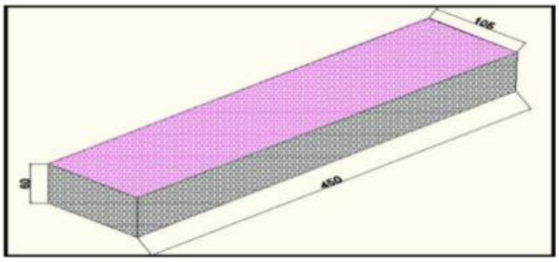

Figure (1) showing Aerated concrete & thermacol as a core for web sandwich panel

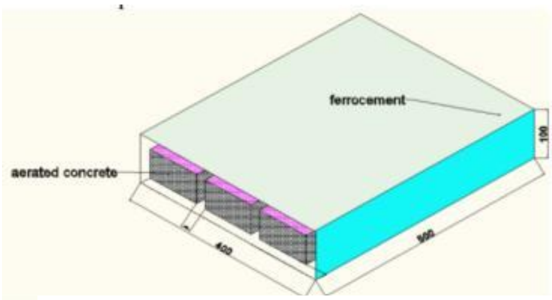

Figure (2) showing web sandwich panel aerated concrete encased by ferrocement

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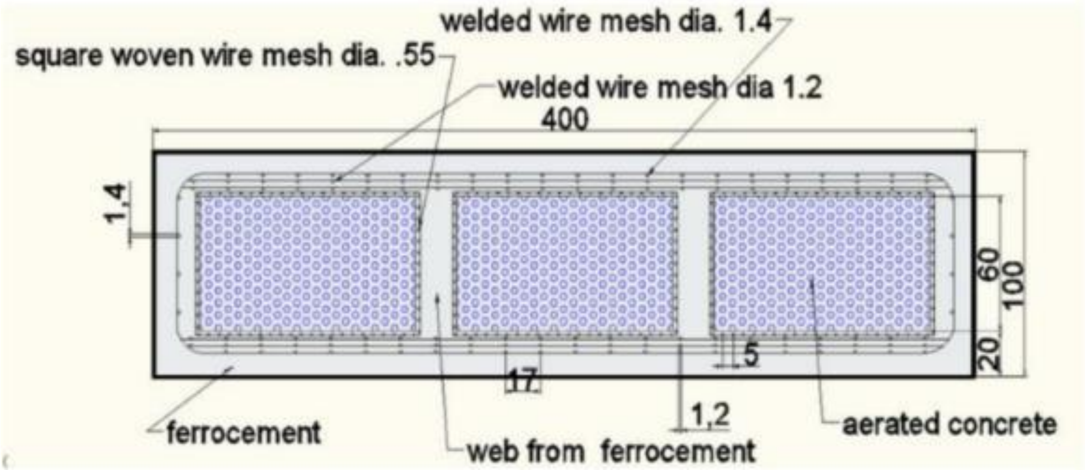


Figure (3) showing the distance and wire mesh detail of the web sandwich panel in front view

With different water cement ratio and admixtures performance were investigated in terms of first crack load, load deflection curve, modulus of rupture, ultimate flexural load and failure mode.

Exclusion: Light weight web sandwich panel showed significant resistant under flexural load and axial load.

The reduction percentage of weight between normal concrete and LWSP'S concrete is reduced by 20% in weight.

Different sample blocks with different testing

Sample name	Core Material	W/C	admixture	Type of testing
S1A	Aerated	0.55	0.44	Flexure (two-point load)
	Aerated	0.55	0.44	Flexural (one-point load)
	Aerated	0.55	0.44	Axial load
S2A	Aerated	0.6	0.4	Axial load
	Aerated	0.6	0.4	Flexural (one-point load)
	Aerated	0.6	0.4	Axial load
S3A	Aerated	0.55	0.5	Flexural (one-point load)
S4A	Aerated	0.56	0.5	Flexural (two-point load)
S5A	Aerated	0.56	0.6	Flexural (two-point load)
S6A	Aerated	0.58	0.5	Flexural (one-point load)
S7 TH	thermacol	0.6	0.4	Flexural (one-point load)
	thermacol	0.6	0.4	Flexural (one-point load)
	thermacol	0.6	0.4	Axial load

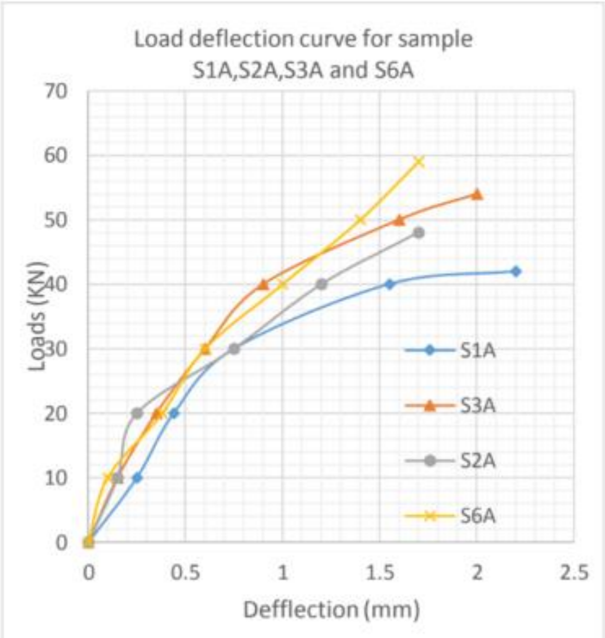


Chart-1 showed that point flexural strength with one-point load specimen S2A has a resistant against flexural about 33% more than S7.

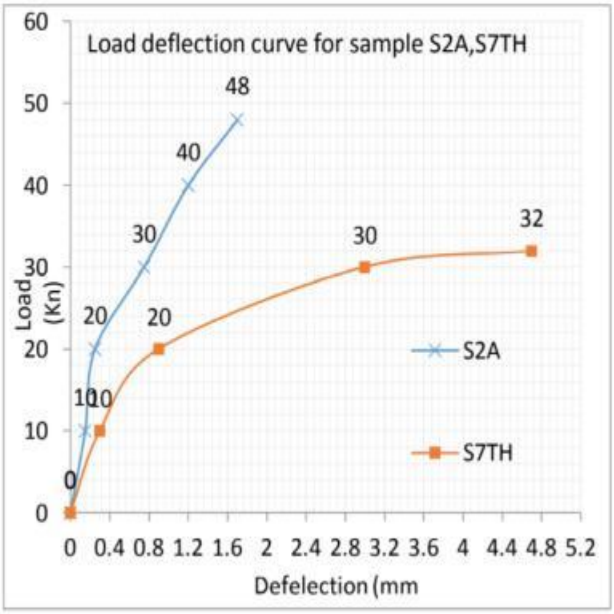


Chart -2 showed S2 has a resistant against flexure about 40% more than S7 similarly in axial load LWSP'S aerated concrete specimen had better performance than LWSP'S thermacol specimen.

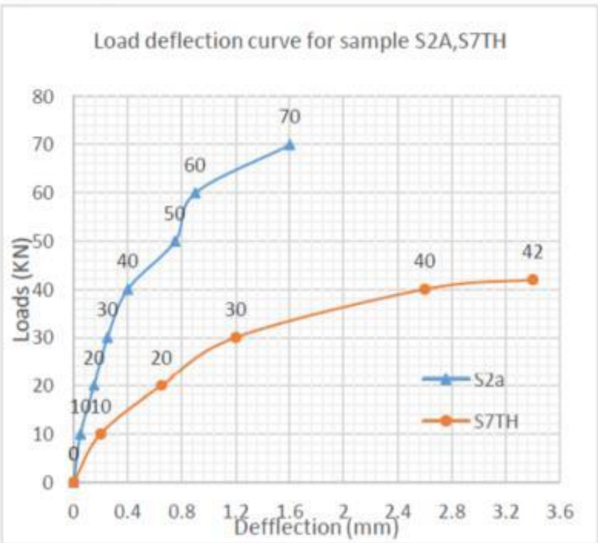


Chart -3 shows flexural third point loading resistance with w/c 0.55 and water proofing admixture 0.5

Mahmoud Abo El-wafa and kimio fukuzawa conducted tests with six numbers of light weight ferrocement beams (LWF) and two reinforced concrete (RC) beams

The performance between these two is investigated for crack load, load deflection curve, stiffness, ductility index, crack width and failure mode.

Tests results show remarkable enhancement in the flexural behavior and potential uses of LWF sandwich composite beams with polystyrene foam block as a core material

Experimental program: Specimen of size for LWF with a cross section of 300 x 200mm and 300mm x 250mm were compared with RC beam of size 300mmx200mm

It was tested for flexure under three point in a simply supported beam over span length of 1800mm up to failure. Details of LWF & RC beams are given in the table.

Details of LWF and RC beam

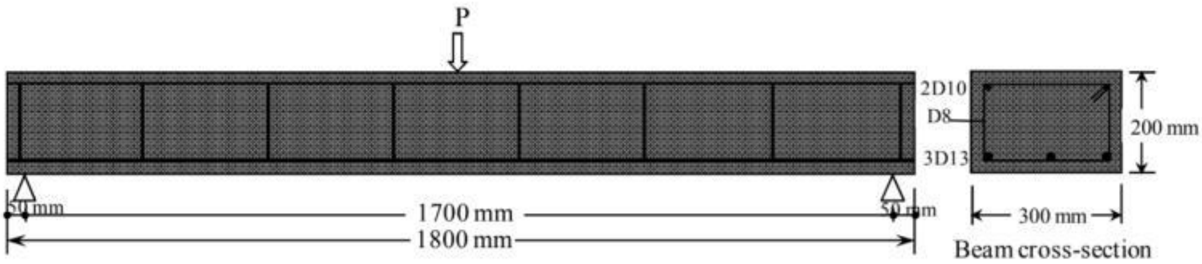
Measuring materials

Materials and their properties. Materials such as ordinary Portland cement, fine & course grained aggregates, wire mesh, binders, polystyrene foam & water.

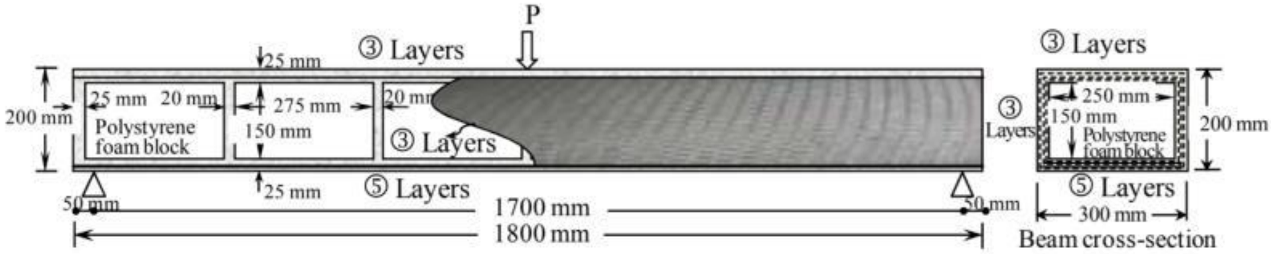
Making mould ready with core

Beam Specimens		Beam Cross-Section b x d (mm)	Tension Reinforcement Area (mm^2) - µ (%)	Compression Reinforcement	Web Reinforcement (Stirrups)	Unit Weight (Density - t/m^3)
RC Beams	RC-200-3D13	300 x 200	3D13 mm - 398.2 mm^2 - 0.76 %	2D10 mm	8 Str.-D8 mm	2.5
LWF Beams	LWF-200-④	300 x 200	④ Layers - 129.2 mm^2 - 0.25 %	③ Layers	③ Layers	1.06
	LWF-200-⑤	300 x 200	⑤ Layers - 161.5 mm^2 - 0.31 %	③ Layers	③ Layers	1.06
	LWF-200-⑥	300 x 200	⑥ Layers - 193.8 mm^2 - 0.38 %	③ Layers	③ Layers	1.06
RC Beams	RC-200-4D13	300 x 200	4D13 mm - 530.9 mm^2 - 1.01 %	2D10 mm	8 Str.-D8 mm	2.5
LWF Beams	LWF-250-④	300 x 250	④ Layers - 129.2 mm^2 - 0.19 %	③ Layers	③ Layers	1.02
	LWF-250-⑤	300 x 250	⑤ Layers - 161.5 mm2 - 0.24 %	③ Layers	③ Layers	1.02
	LWF-250-⑥	300 x 250	⑥ Layers - 193.8 mm^2 - 0.29 %	③ Layers	③ Layers	1.02

Curing for 7,14 & 28 days

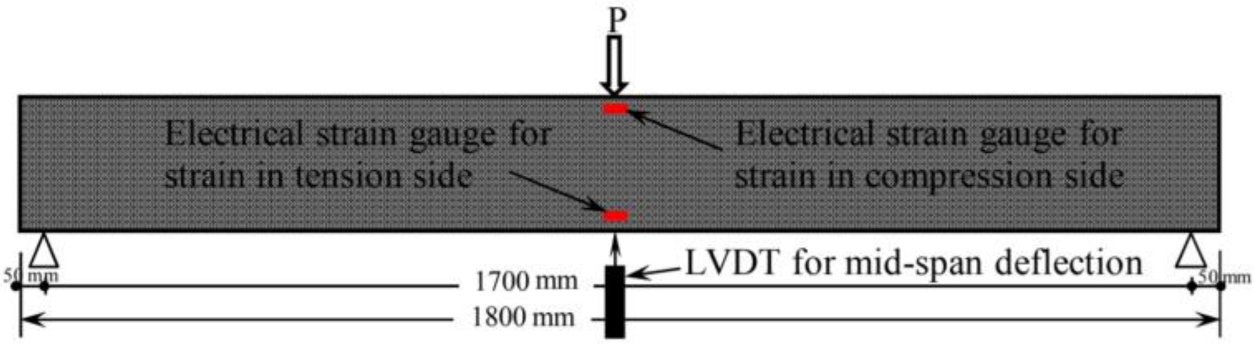


RC Beams

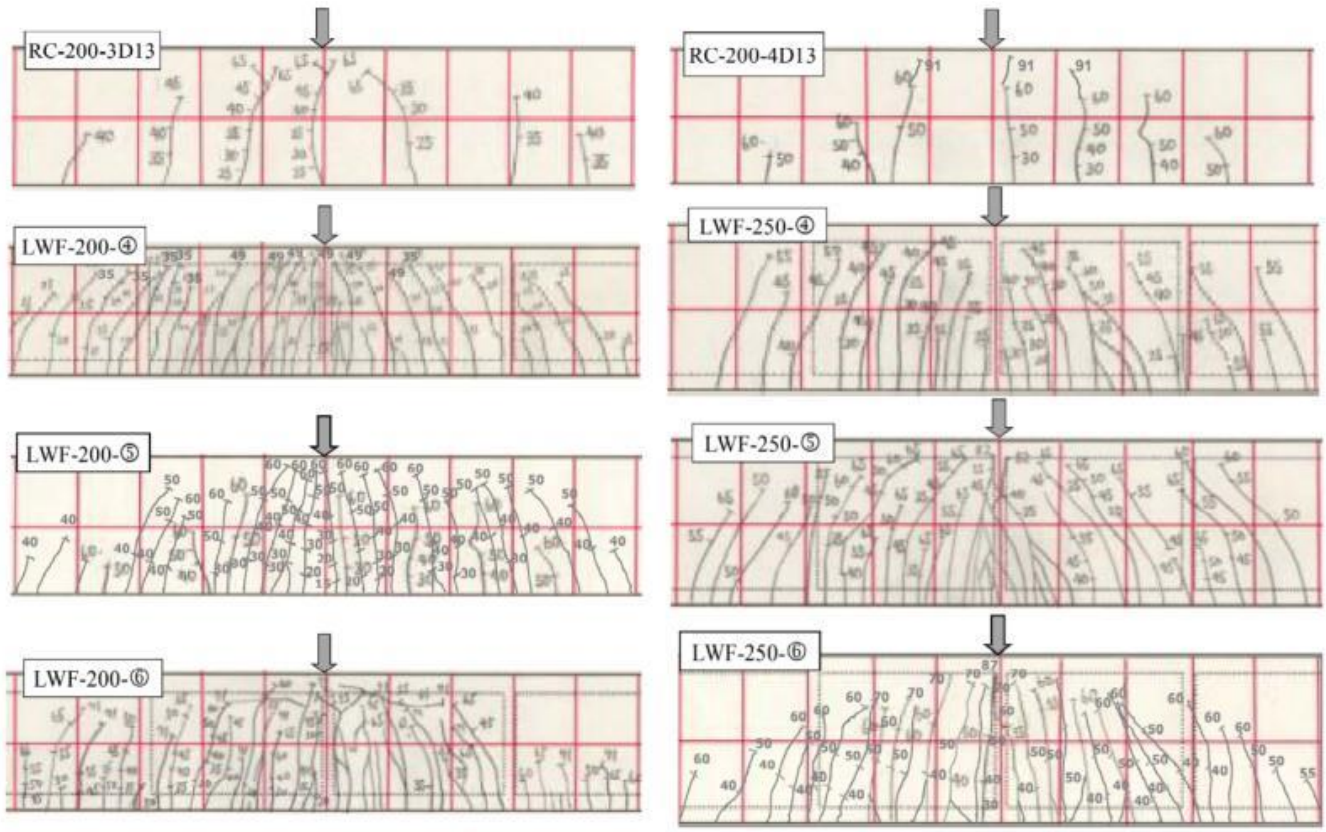


LWF Beams

Flow chart for the preparation of blocks.



Application of load



Crack formation diagram

Results and discussion. Regarding hardened properties for the specimen of 28 days curing LWF has better performance than RC beam which obtained 100% more compressive strength.

Regarding flexural load-deflection behavior of LWF has slightly weaker than RC Beams.

Regarding crack characteristic of LWF & RC beams. LWF has comparatively more formation of cracks than RC beams under central point flexural load.

It is also important to note that LWF beams have hair cracks that reflects more ductility of the LWF beams compared with RC beams.

R.Agrawal et.al. carried out the research using coconut fiber as good and hazardous less material in the construction industry, since conventional construction material made some problem to the environment.

Concrete cylinders of dimension 150mm x300mm were cast to take the compressive as well as tensile strength test. They found the compressive strength increases with curing age but decreases with increase in quantity of coconut fiber, whereas its tensile strength increases.

For manufacturing the block OPC-53grade, river sand with specific gravity 2.605, coconut fiber and potable water coarse aggregates 20mm were used.

Concrete grade of M30 was designed, weight of content required per block is shown in table

Mix Proportions for One Cum of Concrete Block (Volume of One Block=0.0053m^3)	
1. Mass of Cement in kg/block	2.25
2. Mass of Water in kg/block	1.125
3. Mass of Fine Aggregate in kg/block	4.68
4. Mass of Coarse Aggregate in kg/block	6.93
• Mass of 20mm in kg/block	4.62
• Mass of 10mm in kg/block	2.31
5. Water Cement Ratio	0.45

Mix proportion

The use of coconut fiber used in this mixture was 5% by weight of cement.

All the materials were mixed properly by adding water in the concrete mix pan. Three specimens were prepared and kept dry for one day and all specimen cured for 28 days.

Testing results were given for tensile test.

Sr. No.	Diameter of block (mm)	Length of block (mm)	Load applied (KN)
1	150	300	229.6
2	150	300	208
3	150	300	228.7

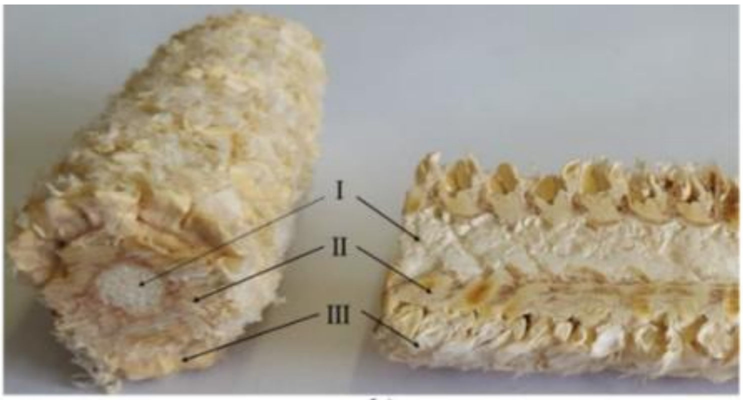
Test results

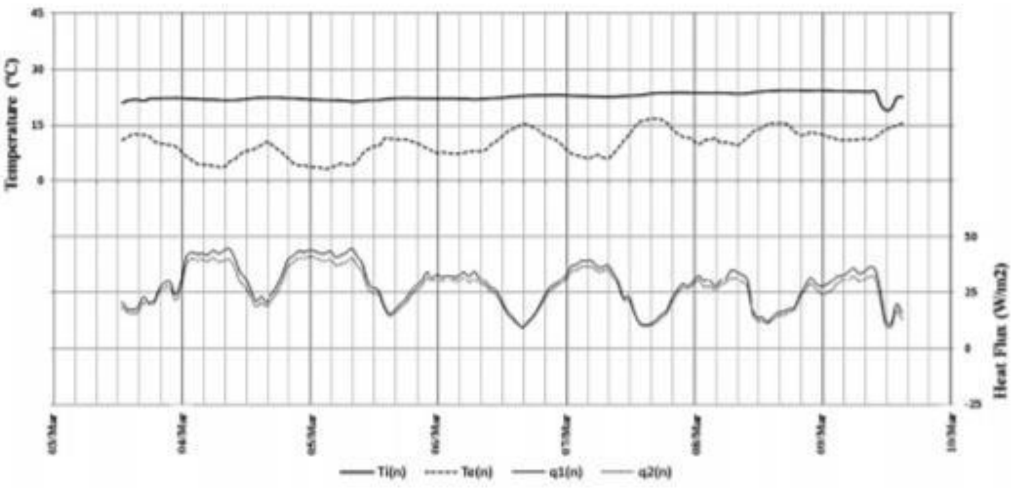
Tensile strength arrived 3.1 Mpa average

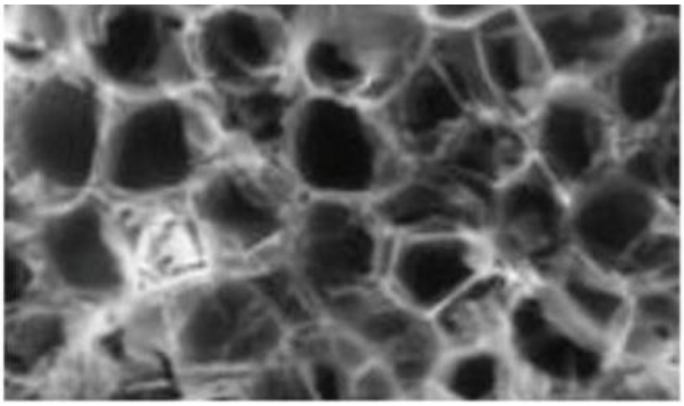
$$\text{Tensile strength} = \frac{2 \text{ X applied load}}{3.14 \text{ X } 300 \text{ X } 150}$$

Results and discussions.

Coconut fiber addition in the concrete increases torsion, toughness and significant tensile strength due to uniform thickness of coconut fiber decreases the voids in the concrete for non-structural elements coconut coir mixed concrete helps cost reduction and green environment.







General view of corncob

Duration for test periods varies depends upon the temperature variation.

Case – II: Thermal conductivity for granulated corncob particle board conducted

Granulated corncob particle board

A sample of 3cm thick corncob particle board was tested in terms of thermal insulation. Thermal insulation of this product may be improved by increasing its thickness.

Insulation materials	Thermal conductivity (λ; W/m°C)
Granulated corncob	0.058
Corncob particleboard	0.101
EPS	0.04
XPS	0.032
Polyurethane	0.023
Cork (granules)	0.032–0.045
Glass wool	0.039
Rock wool	0.037
Expanded clay	0.103–0.108

Thermal conductivity result

Considering the values of the heat transmission coefficient (μ) and thermal conductivity (λ) estimated based on the experiment result was 0.058 w/mic.

According to ISO 9869 thermal conductivity of a conventional industrialized thermal insulation product must be less than 0.065 w/mic

Jorge pinto et.al (2011) presented there different building products using granular corn cob such as particle board, concrete masonry unit and light weight concrete for non-structural purpose and all these products were experimentally studied for thermal insulation behavior.

General view of corncob:

Properties: Density of corncob was experimentally measured and found 212.11 kg/m^3

Water absorption capacity was 327%

Fire resistant of corncob seems to have an acceptable fire resistance when compared with other building materials.

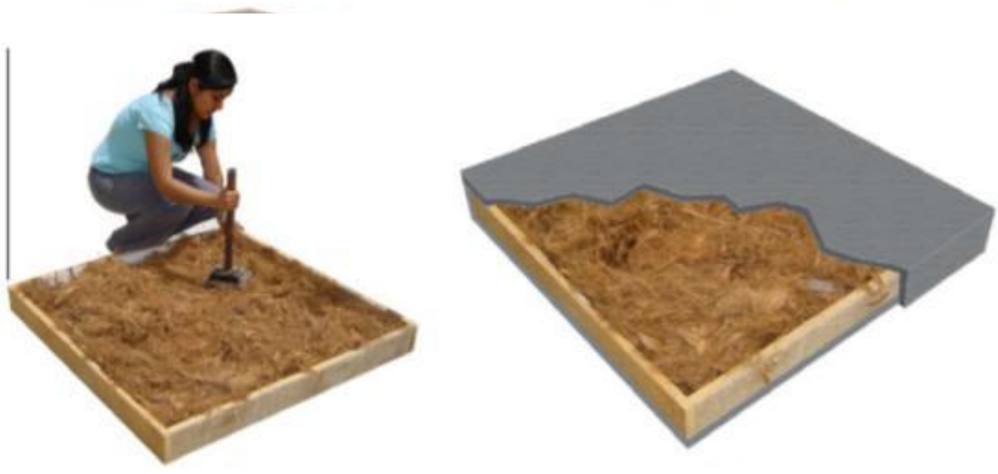
Methodology: To find thermal performance they made a room of size 4.00m x 3.00m x 2.54m ht. using corncob blocks.

For the test they used a heat flux meter two thermohydrometric devices and a domestic heat device.

Thermal conductivity of some industrial as well as agricultural wastes were experimented and their values are presented below.

Case study 3: Light weight concrete masonry unit (CMU)based on processed Granulated corn cob research work was performed on CMU (Ingredients were cement, sand, coarse aggregated, Portland cement and water). According to experiment the quantified thermal transmission coefficient was 1.75 w/m$^{2\cdot}$c. Thus, the results showed CMU have increased thermal insulation. As a result, showed that agricultural waste like corn cob are the potential use of making light weight non-structural walls and component of thermal insulation.

R.Alavey et.al: Conducted tests using coconut fiber filled ferrocement sandwich panel in terms of thermal conductivity, water absorption and moisture content tests and results were compared with ferrocement concrete brick, hollow concrete block and red clay bricks. Fabrication of coconut fiber filled ferrocement panels: panel of size 1mx1mx0.15m molded in a wooden box with coconut fiber, mesh, fine aggregates, cement and water and cured for 28 days before testing.



Size and section of coconut coir board

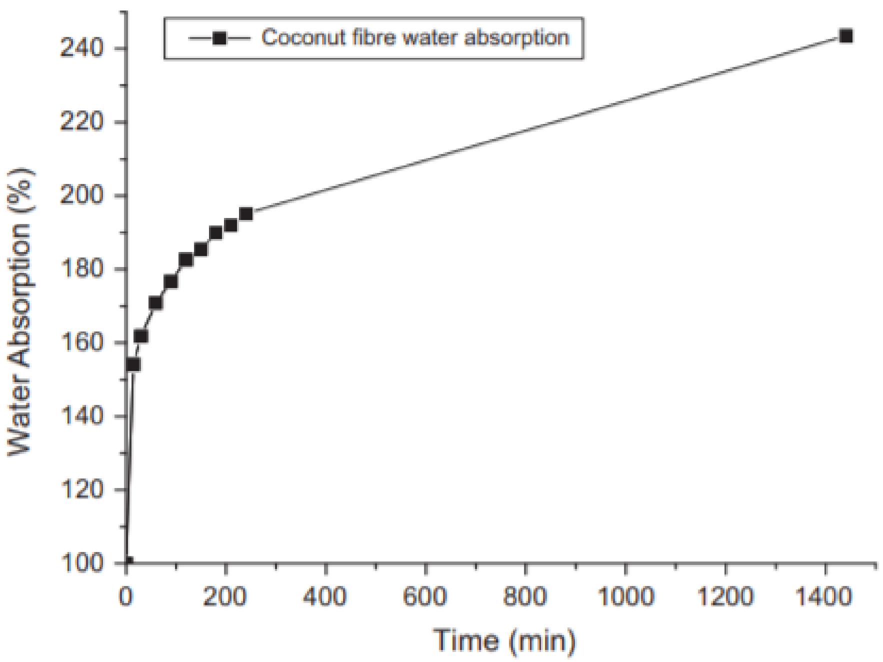
Thermal conductivity measurements were done on homemade hot plate conductivity meter in which heat is generated by means of an electric heating system. The walls of the box are thermally isolated with a ceramic fiber material. Thermal conductivity determined by using

$\lambda = Q + L\ /(A\ \ T)$

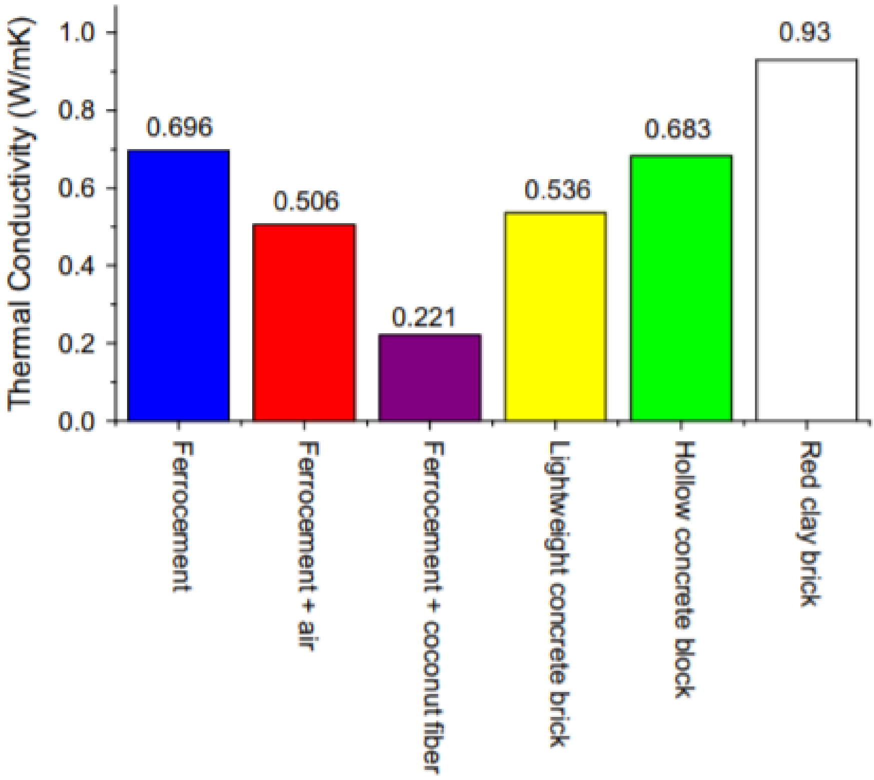
Moisture content and water absorption of coconut fiber

Moisture content of coconut fibre.

Wet coconut fibre weight	1.94 kg
Coconut fibre weight after 5 days sun dried	0.515 kg
Coconut fibre weight after 5 h oven dried at 45 °C	0.448 kg
W_m after 5 days sun dried	73.4%
W_m after 5 h oven dried at 45°	13.0%
W_m to constant mass	3.04%



In the study it was found that coconut fiber loss 73.4% water for the first 5 days, further drying of fiber until the change between successive weighing was less than 0.1% to a moisture value of 3.04%



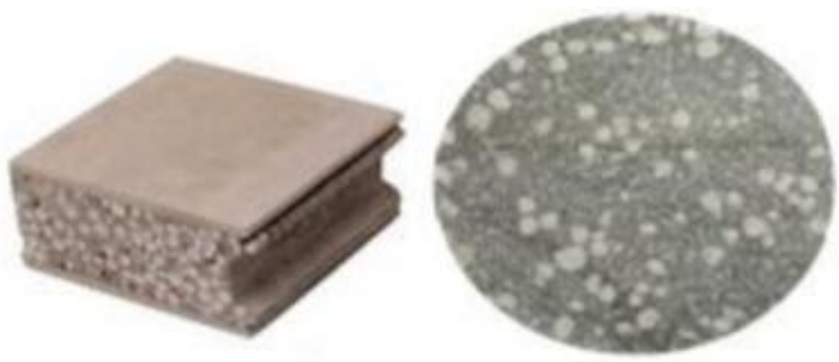
Thermal conductivity of different combination of materials

Water absorption capacity to coconut fiber absorbs 240% water in a period of 24 hours to reach a constant value.

Conclusion: Coconut fiber filled ferrocement can be used as an insulator

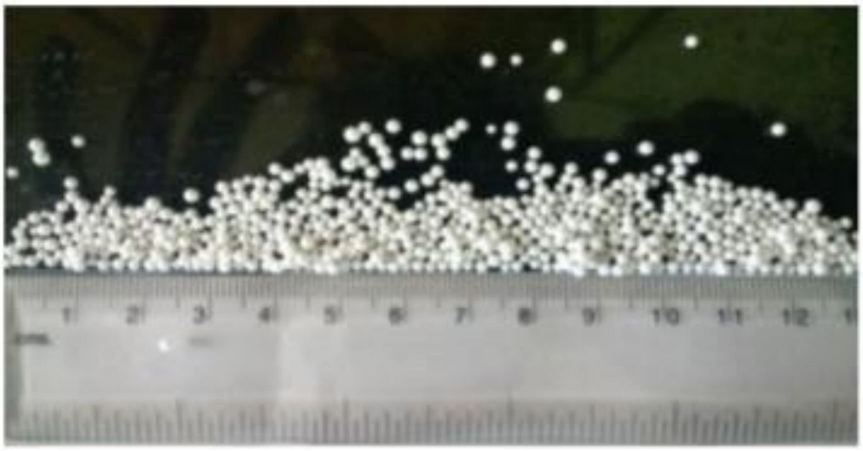
It can be used as a light weight partition wall for non-structural buildings. It is an environmentally friendly and sustainable material in construction industry in hot weather area.

Abhijit Mandlik et.al. Conducted test using expanded poly styrene (EPS) waste used as a light weight structural concrete. This EPS replacing coarse aggregate with equal volume of concrete results of drying shrinkage and creep.



EPS board

Materials: It is made with 53 grade PPC cement, silica fume, sand, plasticizer and EPS with 1mm and 2mm Ø balls.



EPS balls of 1mm and 2mm

Mixing: Steel mold of size150x150x150mm for specimen, mortar along with EPS beads of design mix with a target strength of 160Mpa for 1 Cum filled in three layers with hand compaction, after compaction excess mortar removed from the mold after 24 hours of setting time it was demolded and curing done for 3 days.

Material for cubic meter	Quantity	Rate	Per	Amount (RS.)
PPC	890kg	370	50kg	6586
Sand	837kg	1.25	1kg	1047
Silica Fume	222kg	20	1kg	4440
Plasticizer	30lit	60	1lit	1800
EPS	6.23kg	22	1kg	137
Total				**₹14010**

Material for cubic meter	Quantity	Rate	Per	Amount (RS.)
PPC	890kg	370	50kg	6586
Sand	837kg	1.25	1kg	1047
Coarse aggregate	1223kg	4	1kg	4892
Silica fume	222kg	20	1Kg	4440
Plasticizer	30lit	60	1lit	1800
Total				**₹18765**

Comparisons of manufacturing cost

Experimental results show that the compressive strength depends on the size of EPS beads, the smallest the size the highest the performance. Strength comes to 180MPa. It appeared this light weight material is an alternative for conventional building material for non-structural works.

EPS is a green building product because of its light weight and good thermal insulation. It is also flame retardant with no CFCs. It is also used in the applications of wall panel, partition walls etc.

CONCLUSION

In order to make use of building materials more efficiently and make people aware of its benefits, an organized technique is required to promote them. It is very important that people are aware of the benefits of using the substitutes for construction materials. According to various experts related to the real estate sector, the best environment friendly construction can be acquired though the usage of agricultural & industrial wastes to avoid over – exploitation of natural resources like river sand and clay. Sandwich blocks these days are being used incredible projects taken up by business tycoons and real estate builders. It is also necessary that the government should start promoting these environment friendly construction substitutes to boost market acceptance. The government authorities have put a stop to the mining of sand due to environmental concerns but the manual operations in the sand mining have increased its prices. The sand prices have climatic changes. Owing to all these reasons it is better than the usage of the Sandwich with agricultural & industrial wastes.

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