Journal of Civil Engineering and Environmental Technology (JCEET)

Print ISSN: 2349-8404
Online ISSN: 2349-879X

Published by:
Krishi Sanskriti Publications
E-47, Rajpur Khurd Extn., Post Office – I.G.N.O.U. (Maidangarhi)
New Delhi-110068, INDIA
Contact No. +91-8527006560
Website: http://www.krishisanskriti.org/jceet.html

Journal of Civil Engineering and Environmental Technology (JCEET)

Website: http://www.krishisanskriti.org/jceet.html

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Quarterly (depending on the number of literature being accepted for publication, the volume will be split in numbers as required).

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Journal of Civil Engineering and Environmental Technology (JCEET),
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Journal of Civil Engineering and Environmental Technology [JCEET]

Volume 1, Number 6; August, 2014

Contents

Journal of Civil Engineering and Environmental Technology
Print ISSN: 2349-8404; Online ISSN: 2349-879X; Volume 1, Number 6; August, 2014 pp. 1-3

http://www.krishisanskriti.org/jceet.html

PET Bottles as Sustainable Building Material: A Step Towards Green Building Construction

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Abstract: **This paper proposes the use of waste plastic PET bottles as construction entity to standardised bricks. As plastics are non-biodegradable its disposal has always been a problem. Waste plastic bottles are major cause of solid waste disposal. Polyethylene terephthalate is commonly used for carbonated beverage and water bottles. This is an environmental issue as waste plastic bottles are difficult to biodegrade and involves processes either to recycle or reuse. Today the construction industry is in need of finding cost effective materials for increasing the strength of structures. This project deals with the possibility of using waste PET bottles as a partial replacement. It can be concluded that benefit of the use of PET bottles include both improved ductility in comparison with raw blocks and inhibition of crack propagation after its initial formation. The solution offered in the paper is one of the answers to long standing menace of waste disposal.**

1. INTRODUCTION

Plastics are produced from the oil that is considered as non-renewable resource. Because plastic has the insolubility about 300 years in the nature, it is considered as a sustainable waste and environmental pollutant. So reusing or recycling of it can be effectual in mitigation of environmental impacts relating to it. When the society gets affected, then it will be uneconomical for the nation to create sustainable development [1]. Plastic bottle can assist to obtain a social equity by avoiding the gap between the rich and the poor people in the society. With population growth in today's world, the need to the building has increased and to respond to this demand, the countries tend to use the industrial building materials and decline the use of indigenous and traditional materials. These factors in spite of increasing the energy consumption in the industry section; they can also raise the cost of homes and are considered as the barrier for users to obtain the basic needs of the life.[2]

At the present time, the possibility of utilizing the renewable resources such as solar, wind, geothermal has been provided for us more than before, and development of this science is making progress. But those energies can be chosen as one of the renwable and alternative energies instead of fossil fuels which are cheap as possible and have fewer environmental impacts [3]. Various kinds of homes have been built from plastic bottles such as: ecological house constructed using 8000 bottles in Honduras; an Eco-Tec home in Bolivia constructed using the PET and wine bottle; a house of waste plastic bottles built in Serbia by Tomislav Radovanic; Taiwan's plastic bottle building; ecological bottle house built using 1200 PET plastic bottles for the walls near the lquazu Falls, Misiones, Argentina; and etc [4].With a serious housing shortage but no shortage of plastic bottles littering the streets, the Development Association for Renewable Energies an NGO based in Nigeria – decided to build an incredible two-bedroom bungalow entirely out of plastic bottles which is bullet and fireproof, earthquake resistant, and maintains a comfortable interior temperature of 64 degrees Fahrenheit year round[5]. Hundreds of plastic bottles were filled with sand and then linked together at the neck by an intricate network of string. The bottles were then strategically laid and packed down with a combination of mud and cement, creating a building material that is stronger than blocks. Thus in relation to the various experiments conducted till now by various researchers, in this research paper we have tried to explore the relative strength and cost of the bottle brick as compared to the conventional brick

2. OBJECTIVES

a) To evaluate the possibility of recycling waste PET bottles.

b) To investigate the mechanical behaviour of the unit.

c) To test and compare the compressive strength of brick bottle with brick.

3. METHODOLOGY

In this study, the first step taken was collection of waste PET bottles from stores, waste collectors and other possibresources. Once the bottles are collected they have to be filled with local available soil so as to provide them the structural strength. In our experimental work we have taken 60,100 and PAN mesh size soil which is first screened by a sieve shaker properly so as to remove any unwanted foreign large size particles. Once all the collected bottles are filled with this prepared soil and tamping it in instalment they are tightly capped and sealed. Now to check the structural strength various tests are performed and comparison is made against those for a brick. A comparative economic analysis is also done.

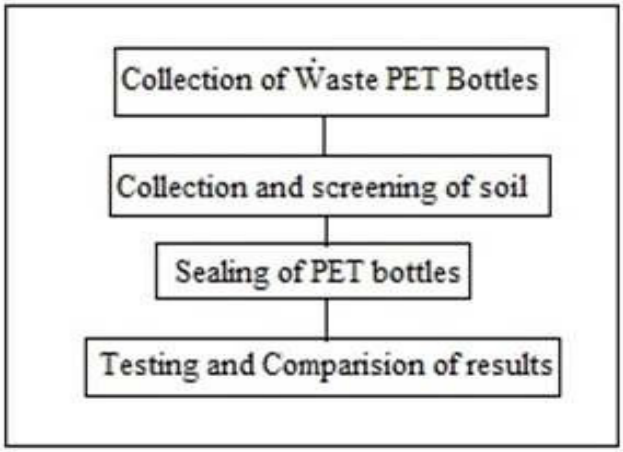

Fig. 1. Process Steps of methodology adopted

4. EXPERIMENTAL TESTING

Compressive strength test for each bottle was determined on universal testing machine and the average value was considered for analysis. Weight of empty PET bottles and completely filled PET bottles were noted and amount of soil used was calculated for the same. Similarly, compressive strength of brick was calculated by taking the average value and the results were compared and analysed.

The formula used is:
Compressive strength =P/A (N/mm^2)
Where
P = Load at failure in N.
A = Area subjected to compression in mm^2

Fig. 2. Weighing balance to weigh Sealed PET bottle before testing

Fig. 3. Test applied on a waste PET bottles filled with soil and sealed tightly

Fig. 4. Compressive strength universal testing machine

5. RESULT AND DISCUSSION

After compressive strength testing done on about 8 bottles an average calculation for concluding a result is done. The Data obtained as per universal testing machine is tabulated in table 1.

TABLE 1: EXPERIMENTAL TESTING DATA

Load (Kg)	Area (mm^2)	Compressive Strength (MPa)	Average
13000	14202.5	8.98	
13000	14205	8.977	
13001	14201.9	8.98	
13000	14201.6	8.97	8.99
13002	14202.5	9.11	
13011	14202.1	8.98	
13005	14201.9	8.98	
13023	14202.8	8.98	

Sample Calculation of first reading: Load in kg = 13000 kg
Load in N. = 13000×9.81 = 127530 N Area
= 14202.5 mm^2 Compressive strength
=127530/14202.5
= 8.98Mpa

5.2. Cost calculation:

Calculation of bottle market price:

Average wt. of 600ml PET bottle = 30gms. Cost of waste plastic bottles in market is Rs.8/kg.
=> (1000÷30) = 33 nos. of bottles in
1kg. => (8÷33) = 0.242 paisa (approx =0.2)

Cost of soil to be filled:

Quantity & Cost of 1 trolley soil = 2.8 m^3 (say =3m^3) in Rs. 900
Cost & wt. of 1 m^3 soil Rs. 300 & 1600kg Cost of 1kg soil = 300÷1600 0.187(say=0.190)

- **Total cost of bottle brick:**

Wt. of empty bottle= 30gms Wt. of bottle with soil= 1430gms So, wt. of soil in 1 bottle = 1400gms Cost of soil used in a unit bottle

= 1.4×0.190= 0.266 paise Therefore total cost of bottle brick cost of empty bottle+ cost of soil =0.25 + 0.266= Rs.0.516 (say = 60 paisa)

- **Calculation of Profit:**

Cost of a unit brick = Rs 5
Therefore it shows a direct profit of (5-0.60) =Rs. 4.40

Thus based upon these observations we can infer that wall made of PET bottle can be use as partition wall or secondary walls and in frame structure as external wall. These are very useful in construction of yarn, warehouses etc.

6. CONCLUSION

From the above experimental observations we can infer that no curing time is required if waste PET bottles are used as building material as compared to bricks which require 28 days curing time. Also while baking of bricks there is a major issue of carbon emission which is negligible in using PET bottles. PET bottles generally have a durability of over 300 years which is more as compared to standard bricks. Cost of construction in case of brick bottle is more economical than standard bricks. Weight of a unit bottle brick was found to be less than that of a standard brick. Compressive strength of the bottle brick is also nearly equal than that of a standard brick. Thus we can conclude that using the concept of brick bottles is cost effective, energy efficient and commercially feasible. Using PET bottles is also Bio-climatic and thus we can say it is a Green construction.

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Journal of Civil Engineering and Environmental Technology
Print ISSN: 2349-8404; Online ISSN: 2349-879X; Volume 1, Number 6; August, 2014 pp. 4-6

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Experimental Investigation of Bituminous Mixes Using Fly Ash as Filler Material

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Abstract: **The effect of addition of fly ash (as replacement of filler) in bituminous concrete mix on the rutting performance of the mix has been evaluated in the study. Different percentages of stone dust were replaced by fly ash to modify the bituminous mixes. Strength and durability tests like Marshall Stability Test, Retained stability and Static Creep Tests were conducted on unmodified or modified mixes and the results were analyzed and compared. Rheological properties of extracted binder from bituminous concrete mixes were evaluated and analyzed for rutting performance based on value of G*/ Sin(δ). The study indicated that increase the percentage of fly ash as filler material by replacing from stone dust, improves the rutting resistance and moisture susceptibility of bituminous concrete mixes.**

1. INTRODUCTION

Fly ash is one of the residues formed in combustion and consists of the fine particles that rise with the flue gases. It is a waste material and is dumped on the land. In India, 95 million ton of fly ash is generated every year which has occupied approximately 65,000 acres of land. Coal requirement and generation of fly ash estimated for the year 2031-2032 is around 1,800 million ton and 600 million ton respectively (MOST-2010). From the above figures, it is clear that there is huge amount of unused fly ash which has to be disposed of each year. Highway industry is capable of using waste material in large quantities if their effect on pavement performance proves to be technically, economically and environmentally satisfactory. Fly ash has successfully been used as filler for bitumen mixes for a long time and has the advantage of increasing the resistance of bitumen mixes to moisture damage. In addition to filling voids, fly ash was reported to have the ability to work as a bitumen extender [6].

2. METHODS AND MATERIALS

Fly ash was used as filler material replaced by stone dust at different percentage (0%, 50% and 100%) and prepared Marshall sample with different percentage of binder.

2.1 Fly ash

Class F type fly ash was used as filler material with specific gravity of 2.09.

Table 1. Grain size analysis (used hydrometer)

Sieve (μ)	72.3	53.2	41.6	11.2	6.9
% finer	19.35	17.2	15.01	13.8	12.4

Table 2. Chemical Composition of Fly ash

Compounds	SiO_2	Al_2O_3	K_2O	Fe_2O_3	CaO	O_2
% in mass	37.76	36.66	1.2	3.6	4.78	16

2.2 Aggregates

Basic physical tests were performed on the aggregates which have been used in preparation of mix to check their suitability.

Table 3. Physical Properties of Aggregates

Parameters	Test Method	Result	Specification
Water absorption	IS 2386-part 3	0.7%	Max 2%
Aggregate Impact value	IS 2386-part 4	12%	Max 24%
Aggregate Crushing Value	IS 2386-part 4	14%	Max 30%
Flakiness and Elongation Index	IS 2386-part 1	27%	Max 40%
Specific gravity	IS 2386-part 1	2.7	……..
Los Angeles Abrasion value	IS 2386 part 4	12.5%	Max 30%
Stripping value	ASTM D3635-96	2-3%	Max 5%

2.3 Binding Material

Viscosity graded binder VG 40 was selected for the present study. Different physical and consistency properties of the selected binder were determined as per relevant Indian standards.

Table 4. Test results on binder (VG 40)

Parameters	Test Method (BIS	VG 40	
		Result	Spec.
Absolute viscosity at 60^0C, poise	1206 (part 2)	3600	Min 3200
Kinematic viscosity @ 135^0C	206 (part 3)	697	Min 400
Penetration at 25^0C, 100g,5sec,0.1mm	1203 (1978)	38	30-40
Softening point (R & B),^{0}C	1205 (1978)	57	Min 50

2.4 Marshall Mix Design

Mixing and compaction temperatures play an important role in the mix design of bituminous mixes. BC-I gradation was selected for present study.

Table 5. Mixing and Compaction temperature

Binder	Mixing Temperature (^{0}C)	Compaction Temperature (^{0}C)
VG 40	177	167

3. RESULTS AND DISCUSSION

3.1 Marshall Mixes parameters

Table 6. Values of OBC, Stability and Flow

Type of mix	Fly sh (%)	OBC (%)	Stability (KN)	Flow (mm)
BC	VG 40 +0%	6.0	17.82	4.561
BC	VG 40 +50%	5.9	22.39	3.354
BC	VG 40+100%	5.85	21.42	3.647

3.2 Indirect Tensile Strength

Bituminous mixes were prepared by using VG 40 binder with different proportions of fly ash as filler at 6% constant binder content for all mixes. The indirect strength test was done in static mode.

Table 7. Indirect Tensile Strength at 25^0C

Type of mix	Fly ash %	ITS (kPa) after 30 min.
BC	VG 40 + 0%	1584
	VG 40 + 50%	1245
	VG 40 + 100%	1230

3.3 Moisture Susceptibility of Mixes

MoRTH (2001) prescribes Retained indirect Tensile strength test for determining the moisture susceptibility of Marshall mixes.

Table 8. Indirect Tensile strength (kPa) @ 60^0C

Type of mix	Fly ash %	ITS (kPa) after 30 min.	ITS (kPa) after 30 24 hrs.	Retained ITS (%)
BC	VG 40 + 0%	864.2	734.4	84.9
	VG 40 + 50%	804.6	674	83.7
	VG 40 + 100%	786.09	638.2	81.1

3.4 Rut testing of Bituminous Mixes

The permanent deformation of bituminous mixes was evaluated by static indentation test [5]. All the samples used for this test was made of 6% binder content and was compacted using Marshall Compactor. The test was performed after conditioning the sample in water bath at 60^0C for 90 minutes. An indentation pressure (creep) of 0.7MPa was applied using circular contact areas of 38 mm for 30 minutes and the sample was allowed to recover for the 1 hour after loading. The strains in the sample were measured using a dial gauge, which was having a least count of 0.01mm

Table 9. Static Indentation Results

Type of mix	D_{max}	D_r	$(D_r / D_{max}) \times 100$
VG 40 mix	36	2	5.0
VG 40 + 50 % fly ash filler	32	7	21.8
VG 40 + 100% fly ash filler	20	6	30.0

Figure 1 shows the relation between deformation and time of unmodified and modified bituminous concrete mixes.

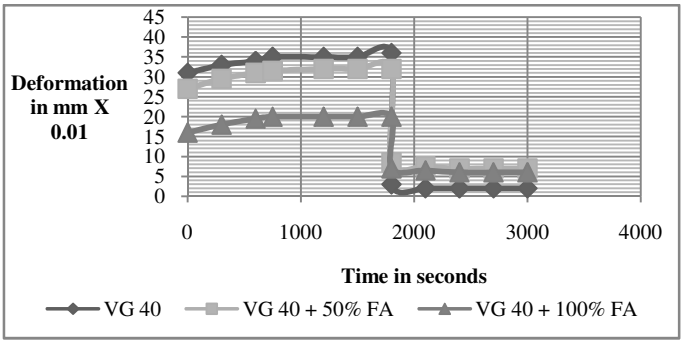

Fig. 1. Plot of deformation with time

3.5 Result of Dynamic Shear Rheometer Test for extracted binder

DSR tests were carried out after extraction of binder (VG 40) from different mixes. Test was carried out on different temperature with constant frequency of 10 rad/sec.

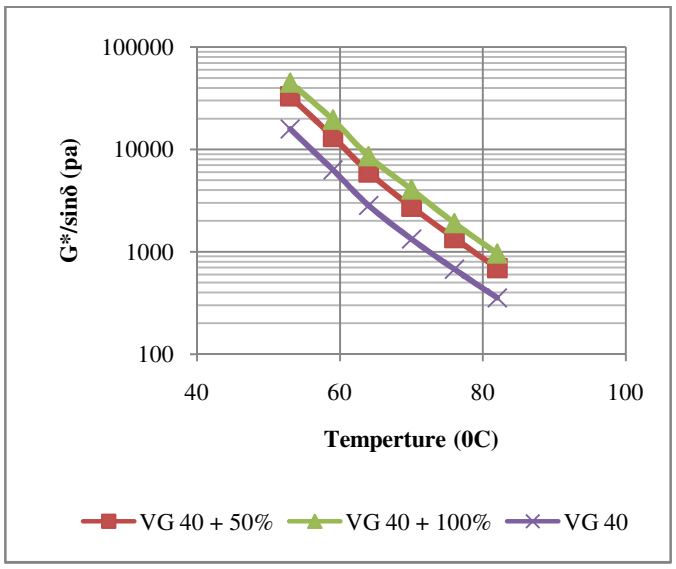

Fig. 2. Variation of $G^*/\sin\delta$ (Pa) versus Temperature

4. CONCLUSIONS

a) From volumetric analysis, it was found that optimum binder content decreases with increase in fly ash content. This tendency might be due to better coating or holding property of binder – filler matrix with coarse aggregates.

b) From Marshall Stability test, the stability value is also found to increase when stone dust filler was replaced the fly ash. The flow values tended to decrease. This indicates improvements in the resistance to permanent deformation of mixes with addition of fly ash.

c) The retained Marshall stability of the mix was found to decrease in mixes prepared using fly ash compared to that of unmodified mix.

d) Dynamic shear and static indentation test conducted on bituminous concrete specimen indicated improved rutting resistance due to addition of fly ash.

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Journal of Civil Engineering and Environmental Technology
Print ISSN: 2349-8404; Online ISSN: 2349-879X; Volume 1, Number 6; August, 2014 pp. 7-11

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Effect of Coconut Shell Ash on Properties of Fired Clay Brick

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Abstract: **This study analyzed the influence of coconut shell ash CSA on the properties of burnt clay bricks. 2 to 10 % CSA was blended with the clay. Atterberg limits, specific gravity and compaction tests were conducted on the soil sample while density, water absorption and compressive strength tests were conducted on fired clay bricks at variable admixture content. The results show that the addition of CSA improves the strength properties of fired clay bricks. The optimum amount of CSA to be added for the production of fired clay bricks was found to be 2%.**

Keywords: **sawdust ash, temperature, lateritic soil bricks.**

1. INTRODUCTION

There is a wide range of material available for the construction industries. The choice and sustainability of a particular material depends largely on its availability, nature of project, individual preference, durability, proximity and economic consideration.

Cocos Nucifera trees, otherwise known as coconut palm trees, grow abundantly along the coast line of countries within 15^0 of the equator. They prosper in sandy, saline soil and in tropical climates. A healthy coconut tree will produce approximately 120 watermelon-sized husks and shells per year, each with a coconut imbedded inside. There are three constituents of the Cocos Nucifera that can be used for fuel: the husk, the coconut shell, and the coconut oil that is in the white coconut "meat" or copra as it is usually called. Thus, the coconut tree is a very abundant, renewable resource of energy. When coconuts are harvested, the husks are removed, thereby leaving the shell and the copra. These husks are considered as waste materials and are usually dumped into refuse bin. When consumers buy the coconut, they buy it with the shell and when it is to be consumed it is broken and the shell is removed. Large quantities of the shells can be obtained in places where coconut meat is used in food processing. The husk and the shell are both regarded as waste materials. The shells are then burnt into ashes in a furnace at a very high temperature to produce the coconut shell ash.

Utilization of these industrial wastes to improve on the engineering properties of clay bricks would serve as a means of disposing of these waste as their primary means of disposal currently is on land. More so, as Nigeria is currently undergoing a 'zero emission' i.e. no industrial waste should be left unused, this research will serve as a mean of recycling these industrial wastes.

Burnt or rather fired clay bricks are made by forming a plastic mixture of a suitable soil and water in to appropriately shaped units, drying the units and then firing or burning them in a kiln.

Clay soils and lateritic soil are the most commonly used soil for brick manufacture. Firing them at high temperature (400-1200^0c) results in a relatively higher compressive strength and other engineering properties and sometimes even performs better than some sandcrete blocks [1].Industrial and agricultural wastes can be used to improve on the engineering properties of most of the clay soils.

More recently, clay soil improvement/stabilization has found use for industrial and agricultural waste such as rice husk and other pozzolanic materials [2, 3], rice husk ash [4] and sawdust [5]. [5] Reported that at relatively small concentrations 2 % by weight of sawdust additive greatly enhanced the properties of burnt brick and that additives above 3 % by weight were found to be deleterious. [3] Recommended that important properties of burnt bricks such as compressive strength and water absorption can be improved substantially by adding rice husks.

[6] Reported that the liquid limit, plastic limit and CBR value of alluvial soil increases with addition of Kolaghat pond ash and rice husk ash. [7] Found that the optimum amount of rice husk ash for stabilization of cement added lateritic soil is 6%. [8], conducted different studies on lateritic soil using different stabilizing agents like sugarcane ash, bamboo leaf ash, coconut husk and shell ash etc and showed the improvement of engineering properties of the soil. [9], Discovered that 7% coconut shell, leaf and husk ash can be used to stabilize lateritic soil for pavement construction.

Bricks are classified based on the average or minimum compressive strength, linear shrinkage, density and the percentage water absorption. According to this classification, minimum compressive strength of bricks should be 3.5 MN/m^2 and the water absorption should not exceed 20 %. [10]. [11] sets 20.7 N/mm^2, 17.2 N/mm^2 and 10.3 N/mm^2 as the minimum fired compressive strengths for Grade SW (Severe weather), Grade MW (moderate weather) and Grade NW.

[1] specified minimum density requirement of 2.0Mg/m^3.

[12] specified 15% linear shrinkage limit for bricks of classes 3.5N/mm^2 to 12N/mm^2 .

The present study concentrates on the effect of coconut shell ash on the properties of fired clay bricks.

2. MATERIALS AND METHODS

2.1. Soil

A disturbed soil sample used for this study was obtained from Dawakin Tofa Local Government, Kano State. It was collected from a pit about 1m depth with the aid of hoe. Table presents the basic characterization of the soil resulted from Experiments conducted on the soil sample at Laboratory of Civil Engineering Department, Bayero University Kano.

Table 1. Basic characterization of soil

Soil properties	Values
Natural moisture	12.2%
Liquid limit(LL)	39.3%
Plastic limit(PL)	19.2%
Plasticity index(PI)	20.1%
Linear shrinkage LS	10%
Specific gravity(G.S)	2.75
MDD	1.62MN/m^3
OMC	18.2%
Particle size distribution	
Sand	36%
Clay	40.4%
Silt	21.6%
AASHTO classification	A-6

2.2. Coconut shell ash CSA

The coconut shells were obtained from a market waste dump. They were subsequently spread on matting and allowed to properly dry to facilitate proper combustion during burning. This material was burnt into ashes in a furnace at a temperature of 500 – 550^{0}c for 2 hours to produce the coconut shell ash. The ash was allowed to cool and kept in an air tide container.

Table 2. Oxides composition of CSA.

Oxides	Compositions
SiO_2	44.05
Al_2O_3	14.60
Fe_2O_3	12.40
CaO	4.57
MgO	14.20
MnO	0.22
Na_2O	0.45
K_2O	0.52
ZnO	0.3
LOI	8.69

Experimental Program and Results.

Note: All the tests were conducted as per [13, 14].

3. ATTERBERG'S LIMIT TESTS

The liquid limit and plastic limit tests were conducted on the soils with and without CSA.

3.1. Effect of CSA on Liquid Limit, Plastic Limit and Plasticity Index.

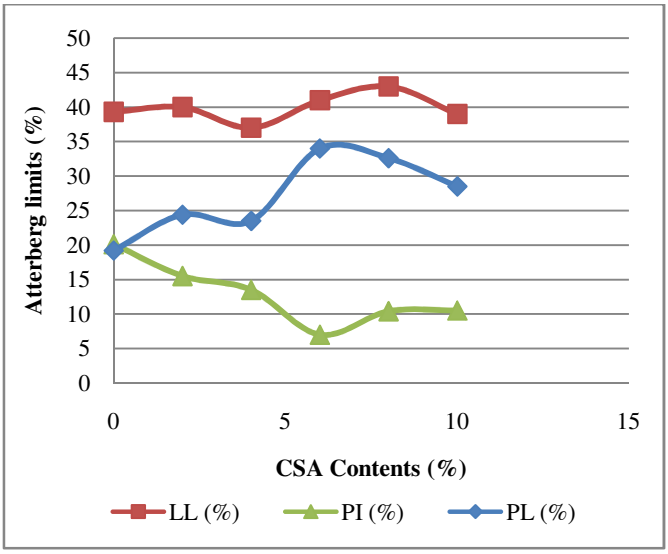

Fig.1. Effect of CSA on LL, PL and PI

LL, PL and PI tests were conducted on sample after adding 0, 2, 4, 6, 8 and 10% CSA in it. From the experimental results it

is observed that the liquid limit is minimum when CSA added is 4%, the plastic limit increases with increase in %CSA content but the variation is marginal, which is clear from fig.1, while Plasticity index decreases with increase in CSA content. The reduction in the PI may be because of the decrease in the amount of clay sized fraction owing to the flocculation and agglomeration of clay particles and also the formation of cementitious compounds of greater effective grain size as a result of pozzolanic action of CSA. The plasticity index is minimum when 6%CSA is added which is clear from fig. 1

4. COMPACTION TEST

Standard compaction tests were conducted on the sample after addition of 0, 2, 4, 6, 8 and 10% CSA in it to find out the effect of CSA on maximum dry density MDD and optimum moisture content OMC of the soil sample.

4.1. Effect of CSA on MDD and OMC

Optimum moisture content of the soil is found to increase with increase in CSA content in general; this may be attributed to the fact that CSA absorbs more moisture when added to the clay which may be required for the pozolanic reaction. Also from the compaction test results it is observed that the Maximum dry density of the soil increases at 2% CSA and then continue to decrease with the increase in CSA content. This may be attributed to the molecular rearrangement resulting in the formation of transitional compounds of different densities. Maximum dry density is maximum at 2% CSA. Fig. 2 shows the effect of CSA on maximum dry density and optimum moisture content.

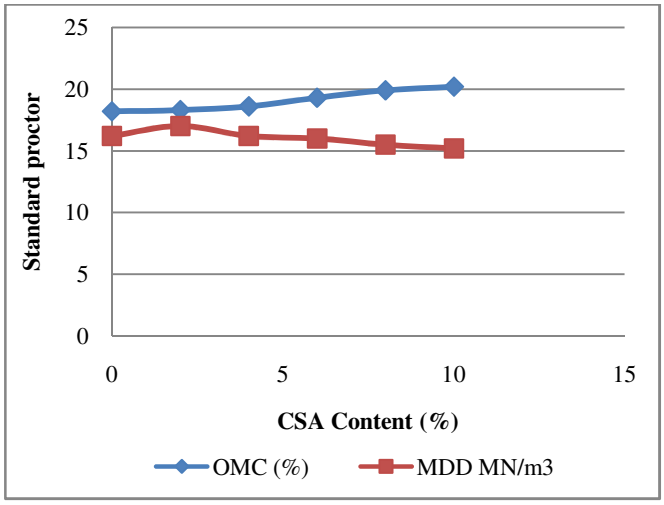

Fig. 2. Effect of CSA on MDD and OMC

5. BRICKS PRODUCTION

The Different percentages of CSA (0, 2, 4, 6, 8 and 10 of dry weight of soil) were thoroughly mixed dry according to their proportion by weight. The required amount of water approximately the optimum moisture content for each determined previously was added gradually and mixed thoroughly with shovel until a uniform homogenous mix was obtained. The mould inner surface was oiled or lubricated and the soil put into $100mm \times 100mm \times 100mm$ mould in three layers, each layer compacted by receiving 27 blows from a rod, the surface leveled and smoothened with straight edge and trowel.

The molded brick was extruded by loosening the mold and carefully removing the brick. The brick was cured at room temperature for 12 days prior to burning.

Three bricks were molded for each test and level respectively. After careful drying and curing at room temperature, the bricks were subsequently fired in an electric furnace with a rise of 200°C/h and a 4 hour soak at 800°C.

6. AVERAGE DENSITY OF BRICKS (MG/M^3)

Density tests were conducted on the bricks produced after adding 0, 2, 4, 6, 8and 10% CSA in the soil samples respectively. Density of the bricks was measured by weighing the bricks dry and dividing by the volume of each brick. The volume of each brick was calculated approximately by taking the reduced lengths of the sides after firing. Three $100mm$ ×100mm×100mm sized bricks were tested at each % of CSA and average is taking as the density of the brick at that level.

6.1. Effect of CSA on the Density of Fired Clay Bricks.

From the results of the experiment conducted, the density decreases with the increase in %CSA content. Only bricks at 2%CSA satisfy the requirements as per BS3921: British standard specifications for bricks which stated the minimum density of 2Mg/m^3. As shown in fig.3

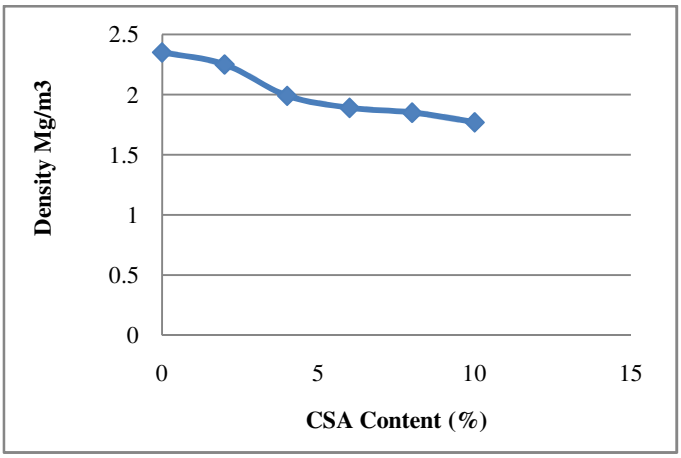

Fig. 3. Effect of CSA content on the density of the bricks

7. AVERAGE WATER ABSORPTION OF BRICKS (%).

Water absorption tests were conducted on bricks produced after adding 0, 2, 4, 6, 8 and 10% CSA in the samples. The water absorption of a brick is a measure of its porosity. Some degree of porosity is desirable but highly porous bricks may absorb and transmit too much water and thus may swell and shrink or may lack durability. Water absorption was measured by immersion of the bricks in cold water for 24 hours and expressing the water absorbed as a percentage of its dry weight. The water absorbed is given by the relation;

Water absorption = (B – A)/A × 100……I
Where B = saturated weight of bricks, A = dry weight of bricks.
3 specimens were tested for each level. The average of these values gives the water absorption.

7.1 Effect of CSA on Water Absorption of Fired Clay Bricks

From the experiment conducted, water absorption decreases at 2%CSA after which it continue to increase with increase in %CSA. All the results conform to the BS specification of water absorption not to exceed 20% except for the 10% CSA adding which is 20.2%. Water absorption of as low as 14.7% is obtained at 2%CSA addition; this can be confirmed from fig.4 below

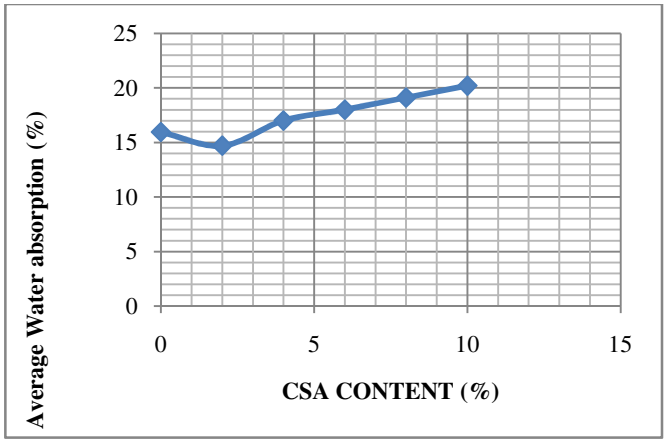

Fig. 4. Effect of %CSA content on water absorption of the fired bricks.

8. AVERAGE COMPRESSIVE STRENGTH OF BRICKS.

The compressive strength tests of the bricks were carried out after testing for water absorption and allowing drying at 50^0c for 24 hours. Avery dennison universal testing machine at civil engineering laboratory faculty of engineering Bayero University Kano was used. The specimens were packed at the bottom. The compressive strength of bricks was read with the aid of a load meter readable to 0.1KN attached to the machine. Three brick cubes were tested at each level. The average value recorded as the compressive strength of the bricks in MN/m^2.

8.1. Effect of CSA on Compressive Strength of Fired Clay Bricks.

The result showed increase in the compressive strength at 2%CSA after which the compressive strength continue to decrease with increase in %CSA content. The compressive strength is maximum at 2% CSA with a value of $18.5MN/m^2$.fig.5 showed the effect of CSA content on the compressive strength of the bricks at various % 0f CSA.

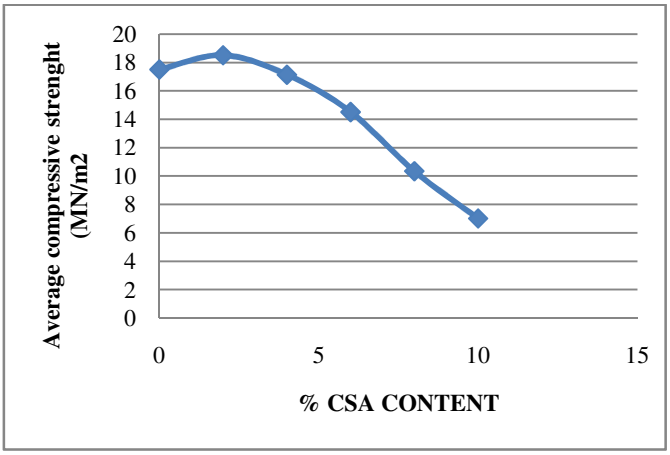

Fig.5. Effect of CSA on compressive strength of the fired bricks.

9. CONCLUSION

From the various tests performed by adding different amount of CSA, it can be concluded that addition of CSA improve the properties of fired clay bricks within the limit of experimental error.

All the results pointed that addition of 2%CSA gives optimum performance with the increase in compressive strength by 7.89%, reduction in water absorption by 5.71% and reduction in density by 4.25% compared to 0% CSA respectively.

2% CSA can be recommended for use in improving the properties of fired clay bricks.

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Journal of Civil Engineering and Environmental Technology
Print ISSN: 2349-8404; Online ISSN: 2349-879X; Volume 1, Number 6; August, 2014 pp. 12-14

http://www.krishisanskriti.org/jceet.html

Practical Aspects in the use of Steel Fibre Reinforced Concrete for Industrial Flooring

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Abstract: **The concrete industrial grade floor slab is a key structural element inmost industrial enterprises. The art of designing most industrial floors is to provide sufficient reinforcement to control the amount and size of cracks to a level consistent with the intended use of the floor. However, one of the most common causes of cracking in ground-floor slabs is that the tensile stresses imposed on the concrete by external restraint to thermal or shrinkage contraction exceeds the tensile strength of the concrete. Therefore, the function of the steel-fabric reinforcement or the fibre-reinforcement is to limit the crack width by preventing micro-cracks from becoming macro-cracks and thus protect concrete from aggressive environmental attack.**

The use of fibres in flooring concrete has increased with the development of fast-trackconstruction. In fact nearly 65% of the fibres produced worldwide are currently used inindustrial floors, road pavements and other slabs-on-grade. Fibre-reinforced concretefloors offer significant economic and technical advantages over conventional steel-fabricreinforced concrete floors, such as increasing toughness and ductility, tighter crackcontrol and improved load-carrying capacity.Currently, the use of fibres in concrete, while growing, is not as widespread as itsmechanical advantages would suggest it should be. A possible reason for this is thenatural hesitancy of engineers and practitioners to use a material for which adequate; experience, experimental data and code provisions have not been well developed in India.Moreover, the availability of various commercial types and brands of fibres could haveadded to the difficulty of selecting the proper materials for particular field applications. This paper focuses upon the practical aspects of using Steel Fibre Reinforced Concrete as areplacement to Reinforcement HYSD/ Tor Steel, steel-fabric reinforcement in industrial ground floors.

Keywords: **Concrete, fabric-reinforcement, fibre reinforced concrete, ground-floor slab.**

1. BACKGROUND

Warehousing demand is increasing day-by-day particularly in developing countries like India. Warehouse floor is important element of whole structure and floor should have particular properties to service the needs. The features desired for warehouse floors are - 'Vertical storage racks, material handling equipment, impacts & abrasions during material handling, long term serviceability need, etc. SFRC floors are now choice for Warehouses in India like elsewhere in world.

2. TECHNOLOGY

Concrete is multifaceted material; it can derived to chosen properties by technology inductions. There are so many ways to enhance concrete properties to suit desired properties. Thanks to technological developments. Warehouse floor demands hard, durable, tough, smooth floor with long term serviceability. As normal concrete can't have these properties, advancements like reinforced concrete, Ferro cements, fiber reinforced (poly & metal fibers); polymer concrete has evolved over period of time. However Steel Fiber Reinforced Concrete is the most appropriate for Warehouse floors. Nowadays SFRC is being used extensively for industrial floors, ports, tunnel lining etc. by developed countries.

Steel fibres are mixed in concrete to form uniform, homogenous, random oriented, non-continuous matrix structure. This matrix provides enhanced properties to concrete like ductility, flexural strength, fatigue resistance and impact resistance. Random orientation of fibers arrests crack formation in all directions.

3. STEEL FIBERS USAGE

Steel fibers properties which are paramount to derive composite matrix properties are – Tensile Strength of Fiber, Diameter/Length/Aspect Ratio and Shape of fiber. These parameters shall be verified before design stage of SFRC floor. Other supporting parameters like chemical composition of steel and uniformity dimensions of wire shall be confirmed before acceptance.Some properties of fibre affect fresh concrete are important and those phenomenon guide properties and behavior of hardened concrete matrix. Shape, aspect ratio, gluing/bundling & dosage are the factors affecting concrete workability, pump-ability and placing ease. And hence shall be well considered with reference to concrete parameters.

Fibers are coated with glue to form staples so that they should not form ball during mixing process. However if mechanical dosing device is used the glue is not necessary. In case the fibers are glued, the glue should be water soluble and should not have adverse effect on concrete and admixtures.

4. CONCRETE

Concrete provide body, place, shape, orientation and certain type of strength to the steel fibers. As concrete occupies more than 99.5 % of mass, the properties of concrete govern performance of combine matrix; particularly physical parameters of matrix are governed by concrete. One should focus on concrete design and placing, finishing, curing methodology of concrete while designing SFRC floor system.

The concrete should be designed as normal concrete generally; however certain effects it should have in its plastic and hardened stage as SFRC concrete. The grouping of ingredients must derive homogeneous mass so as to match with fine structure of steel fibers; Aggregates used for concrete should have fairly cubical shaped. Flaky, angular and elongated aggregates may affect the orientation and distribution of steel fibers. Aggregates produced from secondary processors like VSI (Vertical SandImpactor) are most suitable. The maximum particle size also important and generally 20 mm however lower size is preferred where SFRC thickness is lower.

Fine aggregate properties are also vital; spherical/cubical shaped particle with right distribution curve is must. Well graded natural sand, well processed crushed sand or combination of natural/crushed sand should be chosen suitably. Crushed sand should be processed through VSI; care shall be taken that ultra-fines should not be excessive.

Chemical admixtures are also became necessary ingredient for SFRC. Concrete for SFRC should give suitable flow till the time of placement and should have viscous matrix. Excess fluid concrete may allow steel fibers to settle down. The concrete should not bleed; the bleed particles won't allow Steel fibers and strong concrete at wearing surface.

If concrete is placed by using Pumps; it should be workable & cohesive enough. The powder content and sand content in the mix should be slightly higher than normally placed concrete for pumped one.

The concrete mix shall be designed considering above parameters. Further trial mix must be performed to experience the properties of concrete in plastic stage. The focus should not be only given to workability but also given to workability retention, pump-ability, cohesion, bleeding, segregation etc. The tools, plants, manpower & weather conditions shall be considered in designing the mix and planning concrete. Yield of concrete shall be ascertained during trial mix precisely. Adequate number of cube/cylinder & beam samples should be prepared for compressive and flexural strength.

5. PRACTICAL ASPECTS

The SFRC concrete is made for specific intent with specialized materials and processes. Therefore specialized tools, plants, skilled workforce and testing shall be deployed for SFRC concrete.

Concrete is generally mixed in RMC plant. The RMC plant must be equipped with steel fibers feeding devices. The fibers shall feed into mix with uniform rate. Such feeders are rarely available in India and hence rarely being used. Manual feeding of steel fibers though inspection window is hazardous method but also may result into non-uniform distribution of steel fibers in matrix. RMC operators produce concrete just keeping mostly with same practice as normal RMC; however prolonged mixing time of 10 to 15 seconds can be allowed for uniform mixing of fibers.

It is also practice to add steel fibers into transit mixers and those are added at the pouring point. Again this is not safe practice and chances of human errors are more. Feeding of steel fibers by dumping to hopper may result into non-uniform distribution and ball formation of fibers. Also as the fibers are added just before placing concrete, no sufficient time is allowed for mixing of fibers. If unavoidable – the steel fibers added to transit mixer drum; drum shall be reverse rotated with max speed to achieve even matrix.

Transit mixer shall be inspected visually for uniform and cohesive look before unloading. First sample shall be taken for testing workability. Slump shall be suitable pumping/placing and no segregation/bleeding should be observed. Cohesion ball test is best method of test. Further suitable test like fiber washout test shall be conducted to ensure fiber content.

In case concrete is more fluid to result bleeding, segregation or fiber settlement; the transit mixer may be hold for some more time. In case concrete is less workable; similar admixture used for mixing may re-dosed and agitated.

Concrete after placing shall be consolidated well by mechanical means. Suitable advanced devices shall be used like lesser control screeds shall be used for leveling. Frequent level measurements and control shall be exercised during placing and consolidation so that level & flat surface is ensured before hardening of concrete. Use of rammers & floats excessively will result in subsiding steel fibres from top surface.Floating & trowelling operation shall be commissioned after concrete is initially set and before final set. The concrete surface shall bear machine pressure and should be still workable.There are chances of steel fibers may surface partially; the ends of such fibers shall be plucked off without disturbing the adjoining surface. Care shall take that

plucking shall be conducted after proper initial setting to avoid footmarks.SFRC floors should be hardened with approved hardeners. Application of hardeners shall be done uniformly.

Concreting operations shall be planned in such that concrete is adequate between construction joints. Groove cutting and sealant filling shall be performed timely. Grooves to the floors are provided to counter shrinkages. Delayed groove cutting will cause haphazard shrinkage cracks. Grooves size shall be provided as per design. It is tendency to provide small depth grooves.Grooves shall be of 1/3rd depth of floors. The width of groove is also paramount; wider grooves will upshot impact damage to joint corners.

The floor shall be surveyed after concrete finishing as per acceptance standards. Currently TR 34 is being followed for SFRC floors. The survey shall be analyzed for all desired properties to ensure that TR34 compliance is met with in terms of all parameters.

6. CONCLUSION

Concrete & Steel fibres together form single matrix to give the desired properties. Mostly steel fibres are focused during design and construction phase. It is paramount as steel fibres give the innovative properties. However equal focus should be also given to concrete part. It is also important to know practical aspects, Indian scenario, in-process as well as acceptance testing. An attempt has made to cover practical aspects of SFRC for the ease of practicing Construction professionals or First time users.

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Journal of Civil Engineering and Environmental Technology
Print ISSN: 2349-8404; Online ISSN: 2349-879X; Volume 1, Number 6; August, 2014 pp. 15-17

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Compressive Strength of Concrete Using Palm Oil Nut Shell as Light Weight Aggregate

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Abstract: **This research work tested concrete cubes made of palm oil shell as partial replacement for course aggregate as 5%, 10%, and 15% in a mix ratio of 1:3:6 to determine the most suitable palm oil shell percentage replacement to attain acceptable compressive strength. Concrete cubes were cast, cured and crushed at the age of 7, 14, and 28 days. From the results obtained, the maximum compressive strength for control cubes was 26.37N/mm2, 18.00N/mm2, 14.30N/mm2 and 16.89N/mm2 for 0%, 5%, 10%, and 15% respectively after 28 days. This suggests that, the maximum compressive strength of control cube for 28 days is higher than the compressive strength for 5%, 10%, and 15% mix. The 5% and 15% mix gained more strength as the curing age increases while 10% mix dropped in strength after 14 and 28 days of curing. It is therefore discovered that palm oil shell can be used as partial replacement of aggregate in producing lightweight concrete and as construction material in low-cost building.**

Keywords: **Palm oil shell, light weight aggregate, concrete, compressive strength, insulation of buildings.**

1. INTRODUCTION

Light weight concrete is not a new invention in concrete technology, it has been known since ancient times, [1]. Kenneth has reported that Light weight concrete has many and varied applications including multi-story building frames and floors, bridges, offshore oil platforms, and pre-stressed or pre-cast elements of all types [2]. He also presented that Structural lightweight aggregate concrete solves weight and durability problems in buildings and exposed structures. Lightweight concrete has strength comparable to normal weight concrete, yet is typically 25% to 35% lighter.

Light weight concrete contains aggregate that are all light weight or a combination of light weight and normal weight aggregates. The use of light weight aggregate is becoming necessary especially when building structures are to be erected on soil of poor bearing capacity and even for economic reasons. This can help to mitigate building structural failures as a result of foundation failure.

In this study, palm oil nut shell which is hard and light in weight has been used as partial replacement in concrete to be used in low-cost building with a view to reduce cost of production and motivate the interest of low income earner to have the hope in owning personal residential building.

Nigeria is blessed with Palm oil tree as one of assets with high economic value in the nation, and its importance is realized and potentials fully harnessed. Palm kernel tree can be sourced from oil palm plantation scattered in the rain forest region in southern Nigeria which include Ekiti, Edo, Ondo, Anambra, Cross River, Oyo, Abia and Enugu. The product is usually available in large quantity during raining season from May to September and extends to December [3].

The palm nut shell is used as a source of fuel for the boilers. Residual shell is disposed of as gravel for roads maintenance. Blacksmiths also buy the shells to use as fuel material in their casting and forging operations. Palm nut shell is also used in the preparation of pozzolana, a cement substitute material that has been developed by the Kwame Nkrumah University of Science and Technology, Kumasi, Ghana [4].

[5] while referring to density-strength relationship, drew a conclusion that the higher the density of the light weight aggregate concrete mixture the higher the strength

1.1 Type of Light Weight Concrete

There are several types of light weight concrete and these are low density, moderate strength and structural concrete. Low density concrete is employed chiefly for insulation purposes with low unit weight, seldom exceeding 800kg/m^3. Heat insulation value is high and the compressive strength is low in the range of 0.69 and 8.89N/mm^2. The use of moderate strength concrete requires a fair degree of compressive strength and sometimes used as fill material. Most light weight aggregate is produced form materials such as clay, shale or slate. Blast furnace slag, natural pumice, vermiculite, and perlite can be used as substitutes.

1.2 Palm Oil Shell as Coarse Aggregate

The concrete obtained from using palm oil shell aggregate satisfies the minimum requirements of concrete. Concrete using palm shell resulted in acceptable strength required for structural concrete. Palm oil shell may be used as construction material at the same time solves the environmental problem of reducing the generation of solid waste.

1.3 Uses of Light weight concrete

The benefits of using lightweight aggregate concrete include:

i. Reduction in dead loads making savings in foundations and reinforcement.
ii. Improved thermal properties.
iii. Improved fire resistance.
iv. Savings in transporting and handling precast units on site.
v. Reduction in formwork and propping.

2. MATERIALS

Materials used in this research work are Portland cement produced by Dangote Cement Company, sand, crushed stone, palm oil shell and water.

3. METHODOLOGY

3.1 Batching

The materials (cement, sand and crushed stone) were measured by volume in the ratio 1:2:4. Percentages 5%, 10%, 15% of crushed stone were removed and replaced with equivalent percentage of palm oil shell.

3.2 Mixing

Cement and sand were mixed dry on a mixing tray until a uniform mix was attained. The material was sprayed and the crush stone and the palm oil shell were then added followed by water on a water cement ratio of 0.55. Immediately after adding the water, the whole material was mix thoroughly until to consistency.

3.3 Casting of cubes

Moulds were cleaned and lubricated. The concrete mix was cast into a total number of 36 moulds and compacted in three layers. Each layer was given twenty-five strokes which were uniformly distributed. A straight edge was used to level off the concrete in the mould.

3.4 Curing

The top of each cube was covered with an impervious sheet immediately and placed on non vibrating surface for 24 hours. They were also marked on the top for identification. The cubes were then immersed in curing tank until period of testing.

3.5 Testing

The cubes were removed from the curing tank and allowed to drain sufficiently before weighing. The compressive strength of the cubes of each mix ratio was determined using compression machine at different ages of 7, 14 and 28 days. The value of applied load was recorded and the compressive strength was determined in N/mm^2.

4. RESULT

Table 1 below shows the average value of the compressive strength of the concrete cubes.

Table 1: average strength of concrete

Age (Days)	Strength (kN/m^2)			
	0%	**5%**	**10%**	**15%**
7	15.18	15.57	15.34	14.07
14	16.45	15.93	14.07	16.67
28	26.37	18.00	14.30	16.89

5. DISCUSSION OF RESULT

Replacement of aggregate with palm nut shell at 5% and 15% indicate progressive development of concrete strength with age with values from 15.57 N/mm^2 to 18.00N/mm^2 and 14.07N/mm^2 to 16.89N/mm^2 respectively. However, the strength of concrete produced from 10% partial replacement shows decline with age from 15.34N/mm^2 to 14.30N/mm^2. The result indicate that the replacement of aggregate can be made for up to15% but with reduced strength of about 36%. The concrete produced from this mix can be used in elements which bear light weight loads or insulation of buildings as established by [6].

6. CONCLUSION

In conclusion, it is discovered that the use of palm oil nut shell in cement concrete can help in waste reduction. It can therefore be used as construction material in low cost buildings since it has attained compressive strength of 18N/mm2.

7. ACKNOWLEDGEMENTS

This work was supported in part by a grant from the Tertiary Education Trust Fund (tetfund Nigeria) 2014.

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Journal of Civil Engineering and Environmental Technology
Print ISSN: 2349-8404; Online ISSN: 2349-879X; Volume 1, Number 6; August, 2014 pp. 18-20

http://www.krishisanskriti.org/jceet.html

Workability of Self-Compacting Concrete (SCC) Made with FLY-ASH

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Abstract: **Self-compacting concrete (SCC) is an innovative concrete that does not requires any vibration for placing and compaction. The main objective of this study is to investigate the effect on the workability of self compacted concrete, when OPC is partially replaced by 18 % of fly-ash. With different locally available material, experimental tests are performed to check the workability of SCC. Several tests, such as Slump test, T50, V-funnel, J-ring, L-box and orimet test were carried out to determine the properties of fresh concrete. On the basis of experimental results it may also conclude that out of the seven trial mixes under test, three mixes comply with the required criteria for SCC.**

Keywords: **Self-compacting Concrete; Fly Ash; Fresh Properties**

1. INTRODUCTION

Self–compacting concrete (SCC) is as emerging technology to the construction industry, and has been described as the most revolutionary development in concrete construction for several decades. Okamura of the Koche University of Technology (Japan) had first developed SCC in year 1986. Through their definition it can be defined as concrete that is able to flow and consolidate under its own weight, completely fill the formwork even in the presence of dense reinforcement, whilst maintaining homogeneity and without the need for any additional compaction. In order to do this, SCC requires higher paste content and lower coarse aggregate fraction compared to conventional vibrated concrete or non vibrated concrete, and uses superplasticizer. These would ensure high deformability of paste and resistance to segregation. For SCC, it is generally necessary to use superplasticizer in order to obtain high mobility. Adding a large volume of powdered material or viscosity modifying admixture can eliminate segregation. The powdered materials that can be added are fly ash, silica fume, lime stone powder, glass filler and quartzite filler. Natural sand and aggregates (maximum size 12.5 mm) obtained from Gola barrage and OPC 43 grade cement were used in the presented investigation for preparing SCC. For preparing SCC, 18 % OPC was replaced by FA (class F-fly ash). The use of fly ash in concrete is both economical and modifies the properties of concrete in fresh states which improve its workability. In addition, the storage and disposal problem of fly ash, which is an industrial waste or by-product, is also solved by the use of fly ash in concrete; otherwise, fly ash has to be disposed of in landfills at a considerable cost.

2. EXPERIMENTAL INVESTIGATION

2.1 Materials and Concrete Mix Proportions.

2.1.1 Cement

Ordinary Portland cement (Grade 43) was used.

Table 1: Physical characteristics of Portland cement

Type of cement	Fineness m^2/kg (min)	Soundness by Le-cchatelier (%) max.	Setting time Initial (min)	Setting time Final (min)	Min. Compressive strength (mpa) 1 days	3 days	7 days	28 day
43 grade OPC (IS 8112-1989)	225	10	30	600	Ns	23	33	43

Table 2: Chemical Composition of Portland cement

Sr. No	Name of compound	Oxide composition	Abbreviation	Approx. Percentage	Function
1	Tricalcium silicate	$3CaO.SiO_2$	C_3S	45-55	Mainly responsible for early strength (1 to 7 days)
2	Dicalcium silicate	$2CaO.SiO_2$	C_2S	20-30	Mainly responsible for later strength (7 days and beyond)

3	Tricalcium aluminate	$3CaO.Al_2O_3$	C_3A	6-10	C_3A increases rate of hydration of C_3S. C_3A gives flash set in absence of gypsum
4	Tetracalcium aluminoferrite	$4CaO.Al_2O_3.Fe_2O_3$	C_4AF	15-20	It hydrates rapidly but Its contribution to strength is uncertain and generally very low.

Fly ash

Class 'F' Fly ash obtained from ''Lalkuan Pulp and Paper Mill", Lalkuan (Uttrakhand) was used. For preparing SCC, 18 % OPC was replaced by FA (class F-fly ash).

Table 3: Chemical composition of Portland cement and fly-ash

	Portland cement (% by mass)	Fly-ash (% by mass)
CaO	64.01	0.37-27.68
SiO_2	20.13	27.88-59.40
Al_2O_3	5.78	5.23-33.99
Fe_2O_3	2.35	1.21-29.63
MgO	1.19	0.42-8.79
SO_3	3.53	0.04-4.71
Na_2O	0.11	0.20-6.90
K_2O	0.77	0.64-6.68
TiO_2	0.37	0.24-1.73
LOi	1.63	0.21-28.37

2.1.3 Aggregate

Natural sand and crushed aggregate from "Gola river" (Haldwani, Uttrakhand) were used. The sand complied with the requirements of BS812. The specific gravity and fineness modulus of fine aggregate was 2.60 and 2.59.

2.1.4 Superplasticizer

Conplast SP430-SRV obtained from Fosroc chemicals (I) ltd. was used in present experimental research. It conforms to Indian standard code, IS: 9103-1999. Conplast SP430-SRV is used where a high degree of workability is required and also as an aid to workability retention where delays in transportation or placing are likely or when high ambient temperatures cause rapid slump loss to facilitate production of high quality concrete of improved durability and water tightness 2 litres of superplasticizer per 100 kg of cementitious material was used as per the manufacture recommendations.

Table 4: physical properties of superplasticizer

Properties	Conplast SP430
Composition	Sulphonated naphthalene Formaldehyde condensate
Active solids (% by wt.)	40
Appearance	Brown liquid
Specific gravity	1.20 at 20°c
Air entrainment (%)	< 2
Chloride content (%)	Nil
Ph value	7.0 - 8.0

2.1.5 Mix Design

The weights of various constituent materials per m^3 of concrete are given below:-

Table 5: Mix design for one m^3 concrete of SCC

Mixes design	Mortar percentage (In %)	Aggregate percentage (In %)	Mortar			Aggregates	Water/binder ratio (by volume)
			Cement (Kg)	Fly-ash (Kg)	Sand (Kg)	Coarse aggregates (Kg)	
SCC 1	40	60	419.119 401.8	70.07 88.2	665.162	905.52	1.30
SCC 2	45	55	437.71 419	73.18 91	699.66	830.06	1.30
SCC 3	50	50	456.299	70.29	724.16	754.61	1.30
SCC 4	55	45	470.79	78.71	753.67	679.14	1.32
SCC 5	40	60	489.225	81.79	783.17	603.68	1.32
SCC 6*	40	60	493.47	82.50	783.17	603.68	1.30
SCC 7	37	63	504.63	84.37	800.87	558.40	1.30
Superplasticizer = 2 litre per 100 Kg of paste							

****SCC 6 was used in the present study***

3. RESULTS AND DISCUSSION

3.1 Fresh Concrete

Table: Fresh concrete properties of SCC with fly-ash

Mix	Slump test		V-Funnel (sec)	J-Ring Height difference (mm)	L-Box (H_2/H_1) ratio	Orimet (sec)	Result
	Slump Flow (mm)	T_{50} (Sec)					
Limit value	650-800	2 - 5	6 - 12	3 - 10	0.8 – 1	0 - 5	
SCC 1	400	-	-	-	-	-	Failed*
SCC 2	480	-	-	-	-	-	Failed*
SCC 3	520	4.8	6	6	0.98	6	Failed*
SCC 4	600	7	9	10	0.98	5	*passed*
SCC 5	*655*	*6*	*8*	*8.3*	*0.95*	*5*	*passed*
SCC 6	*720*	*5*	*7*	*6.5*	*0.89*	*3*	*passed*
SCC 7	870	4	5	5	0.81	3	Failed#

Failed* = Slump Flow value below the standard limits (concrete does not flow)

Failed# = Slump Flow value beyond the standard limits (segregation occurs, concrete over flows)

4. CONCLUSION

On the bases of the experimental results it is concluded that the mix SCC4, SCC5 and SSC6 have been passed the slump test (slump flow and T_{50}), V- funnel, J- ring, L-box and Orimet test, and results are within the required limits. Out of the three passed mixes i.e. SCC4, SCC5 and SCC6, SCC6 gives comparatively better result for good workability.

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Journal of Civil Engineering and Environmental Technology
Print ISSN: 2349-8404; Online ISSN: 2349-879X; Volume 1, Number 6; August, 2014 pp. 21-24

http://www.krishisanskriti.org/jceet.html

Health by Design- A Patient Centered Approach in Hospital Design to Create Healing Environment

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Abstract: **Hospital design has an influence on performance of the hospital. With globalization and medical tourism healthcare sector has changed enormously in every aspect to cater to the expectations and need of people. Today hospitals are largely working in corporate style for its customer satisfaction, good working environment and patient safety which required architects and designers to change their outmoded hospital design process. Hospital design is about creating physical environment which has its direct impact on the patient recovery and safety. Recent researches advocated that certain design elements should be considered in the design of a hospital building to promote the healing environment which is critical to the patient recovery rate and safety. This proposes the vital role of Hospital Architects and designers to be played in coordination with the hospital administration and staff at the early stage of project conceptualization so that all the required steps can be well preplanned and implemented for a successful design and functional hospital building with a healing environment.**

Keywords: **Hospital Architects, Hospital Design Principles, Design Parameters, Patient recovery, healing environment.**

1. INTRODUCTION

Hospital design has an influence on performance of the hospital. Hospital design is about creating physical environment which has its direct impact on the patient recovery and safety. Recent researches advocated that certain design elements should be considered in the design of a hospital building to promote the healing environment which is critical to the patient recovery rate and safety. Architects and designers need to play vital role in coordination with the hospital administration and staff at the early stage of project conceptualization so that all the required steps can be well preplanned and implemented for a successful design and functional hospital building with a healing environment.

2. PRINCIPLES OF HOSPITAL DESIGN

Involvement of all the stake holders at the initial stages of project development helps in identifying the crucial design factors important in effective healthcare delivery from different point of view. The points raised in common by the stakeholders will help in preparing the list of design factors which matters them may be considered as the basic guideline of hospital design. Patient-centeredness, Safety, Effectiveness, Efficiency, Timeliness and Equity are considered as the basic principles of the hospital design with focus on different priority areas by individual user.

2.1 Patient-Centeredness

At the end patient is the focus of every hospital. He is the one for which whole hospital is working. Every design parameter must cover the interest of patient. The designed spaces should always respond to the health and psychological need of the patient. This includes providing well designed spaces with open, easy, approachable and accident free layout in all units as well as wards with sufficient space to accommodate family members. Design should ensure easy access to healthcare information and clear signage to find the way in the hospital.

2.2 Patient Health and Safety

Every step in hospital is crucial to the health and safety of the patient whether it is the step of a nurse or a doctor. The design should be focused to the health and safety of the patient. Reducing the movement or steps of the staff is one way of achieving it. The departmental adjacency plays very important role in reducing the steps which can only be achieved by exhaustive meetings with the hospital staff to understand the direct or indirect relationship and interdependencies of different hospital departments. Patient safety involves considering the design which eases the patient transfer or movement and reduces accident like rounded corners, availability of devices that are designed to prevent patient falls, ventilation and air filtration systems for avoiding spread of infections and using eco-friendly products, finished surfaces that can be easily decontaminated and addressing of the sensitivities associated with the interdependencies of care including work spaces and work processes.

2.3 Environmental Control

This includes use of ventilation, air conditioning and lighting. It plays important role in designing the physical environment

as healing environment. Environmental control may be achieved by natural means and artificial means both. Use of lighting is crucial to the performance of the hospital staff. Adequate lighting including under-bed nightlights aid care giving yet not disturb to the patients. Environmental control also implies to the ability to control effects of noise on the patient.

2.6 Efficiency

Efficiency is the key to cater to the health and safety of the patients. It involves the standardization of the spaces such as room layout with respect to the furniture, fixture and medical equipment. It helps in minimizing potential safety threats, and improving patient satisfaction by minimizing patient transfers to different rooms. Standardization of units and ward requires proper understanding of need of patient and staff.

2.5 Timeliness

This includes ensuring rapid response to patient needs, eliminating inefficiencies in care delivery, and facilitating the clinical work of nurses. Design is an essential tool to ensure the timeliness by categorizing the different departments and their adjacency with each other at macro level of planning and decentralization of facilities at micro level for quick response to the need of patients and staff.

2.6 Equity

This is about focusing the patient from every angle of spatial planning of hospital achieved by ensuring that the different care needs of patients are met by the size, layout, and functions.

3. DESIGN PARAMETERS

The physical surroundings have its direct impact from staff to patient. Effective physical surroundings may reduce staff stress and fatigue and increase effectiveness in delivering care. It Improves patient safety and reduces stress and improve outcomes and finally Improve overall healthcare quality.

Findings show that patients are responsive and expressive about their architectural environment. Patients appear to make significantly better progress in new properly designed hospital buildings.

There are two types of relationship which are highly appreciated to be achieved using design as a tool that is with people and nature. A sensible Hospital design process aims to create healing environment in three main ways as described by Agency for healthcare research and society (AHRQ):

1. Enhance patient safety by reducing infectivity risk, injuries from falls and medical errors.
2. Eliminate environmental stressors, such as noise, that negatively affect patient outcomes and staff performance.
3. Reduce stress and promote healing by making hospitals more pleasant, comfortable and supportive for patients and staff alike.

To achieve this in the hospitals there is a constant need of clear orientation, connection with nature, association with people, proper scale and positive symbolic representation. These are all essential elements for increased rate of healing in patients. To create the healing environment architects need to focus the design issues while planning the healthcare facilities. There are studies conducted on the affect of design involving patient experience which identify the design categories and related design issues of a hospital building.

1. Site planning – Building location or zoning on site with external development or site optimization is the first thing to be worked upon before proceeding to hospital building design. Hospital is all about the movement of the people; it starts with site planning considering the different types of traffic. Entrances need easy approach and separation of traffic like visitors, Out-patient, in-patient, emergency etc. All drop off and parking is required to be categorically provided for all types of traffic with necessary proximity. Relationship between the building and open areas plays important role in creating the common spaces which can be effectively used to create healing environment by providing landscaped interactive spaces which reduces the stress of patient and their family during their long stay at hospital.
2. Departmental adjacency – hospital is a complex building and needs to be studied thoroughly before designing. Hospital departments show strong interrelationship and interdependencies to function. Their adjacency and categorization can be achieved by properly zoning the different departments vertically and horizontally within the building. Zoning reduces the movement of patient and staff and appropriate location helps in controlling the traffic.
3. Spaces and Spatial planning – It deals with the size and layout of the workplace. Spatial layout, privacy, personal control and independence have been found to be particularly important in reducing stress. Design factors that gives patient the feeling of being at home and less institutional, that are barrier free and support patient's self-respect and support family contribution. Today's hospital should provide amenities such as libraries, kitchens, and lounges, with comfortable accommodations for family members. Hospital interiors and exteriors are equally important and include fountains, gardens, fish tanks, and waterfalls, all designed to be nurturing and relaxing for patients.

4. Building fenestrations and envelope - Extensive research has been conducted on the psychological effects of windowless environments and result show windows are not just luxury but it is about comfort, as lack of contact with the exterior environment escalates stress and depression. Windows are a source of light, sunshine, and one get to know about outside weather and generally about what is going on in the outside world. Studies have found that patients prefer rooms with a view. It helps them to connect with the outside visually while remaining in the physical environment of the hospital.
5. Building specifications and FFE (furniture Fixture and Equipments) - The standard of any hospital is displayed by the specifications it uses like any other building. The hospital building specification becomes more important with its special requirements at many places in roofing, flooring, wall cladding and everything over surfaces which creates an enclosure. Special types of flooring which are resistant to skidding and disinfectant agents along with its appearance me reduce the cases of accidents. A proper layout needs to be developed for the furniture fixture and equipments in coordination with the hospital administration for optimum space planning.
6. Lighting – in particular natural vs. artificial light. A large number of studies have shown that exposure to natural light reduces depression and fatigue and improves alertness. Improved lighting allows staff to improve their performance of visual tasks. It also helps support circadian systems and affects mood and perception. The review also showed that exposure to sunlight can decrease the length of hospital stay of patients. Poor lighting contributes to medication errors. Providing abundant natural light also helps cut energy costs.
7. Environmental control, Ventilation and air-conditioning system – The ability to control the environment by individual is one of the important factors which imparts satisfaction to the patients and staff. Research shows that a cause of frustration is the inability of inpatients to control important aspects of their immediate environment, for example to control their own personal environment, to regulate the airflow and temperature, to turn off the radio or light. Staff may also become dissatisfied with their own inability individually to regulate temperature and fresh air. Sufficient ventilation rates and standard cleaning and maintenance of the ventilation system are vital for controlling the level of pathogens in the air. Some special precautions to prevent infection during periods of construction and renovation include using portable HEPA filters and installing barriers between patient care and construction areas.
8. Acoustics/ aural environment – The amount of noise generated in a hospital is crucial to the patients and visitors stress level. Studies in the aural situation have found that noise levels can have an undesirable effect on patients and can develop sensitivity of pain. Lack of sufficient rest and sleep is one of the main causes of stress facing patients in hospitals and the most frequent and important cause is noise. Providing technically specified sound absorbing acoustical treatment considerably reduces the negative impact of sound on the health of patients and increases the audibility between patient and staff avoiding any error. Also, this design measure increases speech privacy as less sound travels into adjoining spaces. In addition, providing single bedrooms and removing noise sources from the unit helps to reduce noise levels at the patient's bedside.
9. Olfactory environment – the element of smell that pervades particular areas of a hospital. Most environments have a particular smell and in hospital environments medicinal smells can bring about a level of anxiety amongst patients. Unpleasant odors are known to increase heart rate and respiration, whereas pleasant fragrances can lower blood pressure and heart rate. Of all the senses, smell is the most intimate and elusive, reaching more directly into memory and emotions. Often the olfactory sense is underestimated both as a cause of stress and, when positive, as a therapy or destressant. Studies have demonstrated that odors impact on people's health and well-being. This can include tasks, mood, perceived health and perceptions of the environment. In terms of design, hospitals have areas of residual bad smells, for example crowded spaces or day rooms where inadequate ventilation has left unpleasant odors. It has been identified that deep plan buildings are even more susceptible to residual smells.
10. Taste – the element of taste that people perceive in hospital by observation through its senses directly to his likings and disliking. Research is indicative of that in addition to the environmental factors such as natural light and pleasant views, artwork and use of certain colors have the potential to change what would else be a extremely traumatic and terrifying encounter into one that imparts a influential healing and healing effect. Definite colors are said to promote activity, while others promote inactive behavior.

4. ASPECT

There is a tool designed by the University of Sheffield called ASPECT. A Staff Patient Environment Calibration Tool (ASPECT) is a staff/patient environment calibration tool designed by University of Sheffield and now in general considered to offer the best chance of linking design issues in healthcare design to the known research on the impact on staff and patients. It has eight sections which deal with:

- Company
- Privacy and dignity
- Views, nature and outdoors
- Legibility of place

- comfort and control of the environment
- appearance
- facilities
- staff

5. EVIDENCE BASED DESIGN

Already familiar with evidence-based medicine, today's healthcare administrators are increasingly comfortable with a growing base of evidence-based design research that supports the idea that the "built environment" can affect patient clinical outcomes. Evidence-based Design is defined as the deliberate attempt to base design decisions on documented research and well-established best practices. Evidence based design seeks to provide a higher quality experience to patients and their families.

Center for Health Design (CHD) Texas, which, since 1993, has been actively engaged in initiating research to promote evidence-based design to create healing environments in Hospitals, Clinics, Physician offices, Nursing homes, and other healthcare facilities. CHD is dedicated to the idea that evidence-based design can enhance the quality of healthcare through the creation of environments that are:

- Therapeutic
- Supportive of family involvement
- Efficient for staff performance
- Restorative for workers under stress.

The Center for Health Design developed a research program that allows innovative healthcare providers to team with CHD in producing research and documenting examples of "how the built environment can positively affect the quality of healthcare and the financial performance of the organization.

6. COMPONENTS OF HEALING ENVIRONMENT

The components of a healing environment can best be defined as those that look after and reinstate balance to the mind, body, and spirit through each of the five senses. Light and color, for example, are two aspects of sight that can have the greatest overall impact on a patient's wellbeing. Research suggests that artificial light, in the absence of natural light, can lead to fatigue, depression, and elevated systolic blood pressure. Conversely, exposure to natural sunlight is associated with improvement in mood and sleep, as well as decreased use of pain medication and possibly even shorter lengths of stay for some patients. Use of color is also a powerful component of the healing environment and dates back to ancient times. the arts can also contribute to the healing environment through imagery that celebrates life, amuses, and imparts messages of peace, hope, tranquility, comfort, and dignity. Art in the form of gardens, sculptures, and water features such as waterfalls and ponds can also be effective. Sense of personal space advocates Single-bed rooms for operational benefits of better communication with staff, minimization of transfers, fewer medication errors, decreased infection rates, and comfortable inclusion of the family.

7. CONCLUSION

Healing environments, which provide comfortable, attractive settings and home-like surroundings, have been shown to be a therapeutic intervention in the reduction of stress. The same healing elements that provide a calm and reassuring environment for patients and families are also beneficial to staff, administrators, and clinicians. For example, natural light and a less noisy environment can help decrease distractions and minimize medical errors. Health providers may benefit from improved lighting and efficient design that eliminates the need to walk long corridors and distances for supplies and medications. The components of a healing environment can best be defined as those that nurture and restore balance to the mind, body, and spirit through each of the five senses.

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Journal of Civil Engineering and Environmental Technology
Print ISSN: 2349-8404; Online ISSN: 2349-879X; Volume 1, Number 6; August, 2014 pp. 25-28

http://www.krishisanskriti.org/jceet.html

Physical Remediation of Grey Waters – A Possible Solution to Clean Cooum River

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Abstract: **The Cooum River, an ancient glory of Tamil Nadu, India, is now one of the dump yards for all the waste that the city of Chennai generates. The stretch of Cooum River through the city is extremely polluted. The study tries to investigate the possibility of producing biogas from the sewage waters of Cooum. Water samples were collected from seven different banks along the river and characterized for biogas production by testing for five basic parameters namely; Chemical Oxygen Demand (COD), Dissolved Oxygen (DO), Total Dissolved Solids (TDS), Total Suspended Solids (TSS) and pH. The highest COD value obtained was 772 mg.L^{-1} at Chennai Central, which wasn't satisfactory for feasible production of biogas. An in-depth analysis of other parameters like comparatively low TDS and TSS values made it possible for the use of common filtration technique to carry out physical remediation of water. Water was passed through two filtering units; gravity sand and carbon filter. The filtering units were optimized for the following parameters; bed height, particle size, diameter of the filter bed and water flow rate. The clear water thus attained was completely characterized. The results obtained were found to be within the permissible limits for potable water, except for increased levels of ammonia. Thus, this water obtained could be used as a source of water for irrigation.**

Keywords: **Cooum River; Biogas; Sand Filter; Carbon Filter; Physical Remediation.**

1. INTRODUCTION

Cooum River, the urban brook of Chennai, earlier known as the Triplicane River, starts 70 km [Bunch M. J et al, 2001, 2003a] away from the city in Tiruvallur district adjoining the Chennai district. The Cooum River originates from a small rural village in the north most part of Chennai, which bears the same name "Cooum". It is one of the shortest classified rivers pouring into the Bay of Bengal, [Bunch M.J et al, 2003b] currently a drainage course inside Chennai collecting in excess of 75 small tankers of sewage every day. Once a fishing river, it is now a drainage tank because of Chennai's sudden population burst and rapid expansion without prior planning.

In the olden times, Cooum River was used as a fresh source of clean water. Later due to various reasons the drainage discharge of the city was mixed along with the river water and this has made the river contaminated and unfit [Ananthapadmanabhan S, 1998]. for any purpose. Even the color of water flowing in the Cooum River has changed because of this continuous discharge. As off today it is one the most polluted and dirty rivers around the world. The toxicity level of water is also above normal. The total catchment area of the river is about 400 square kilometer and the bed width ranges from 40 m to 120 m. The capacity of the river is 19,500 $m^3.s^{-1}$ and the anticipated flood discharge is around 22,000 $m^3.s^{-1}$ [Gunaselvam M, 1999].

Water sample for analysis of biogas production was collected from around seven different banks along the river and tested for five basic parameters namely; COD, DO, TDS, TSS and pH [Wan Azlina et al, 2009]. The highest COD value obtained was 772 mg.L^{-1} at Chennai Central. The values obtained weren't sufficient for feasible production of biogas at any of the seven outlets. A further in-depth analysis of other parameters like comparatively low TDS and TSS [Gilbert M Masters, 2008a] values made it possible for the use of common gravity filtration techniques to carry out physical remediation of water.

Physical remediation is the process of remedying something, in particular of reversing or stopping environmental damage by using physical techniques like sedimentation, coagulation, filtration etc. The two basic gravity filtration units were used to carry out the physical remediation of Cooum water, namely; sand filter and carbon filter. The filter units were optimized for the following parameters; bed height, particle size, diameter of filter bed and water flow rate [Rodgers M et al, 2005] Before passing the water through the filter units, the water was allowed to settle in a sedimentation tank to remove large suspended particles.

The intent of this work was to get pure good quality water which could at least be used for the purpose of gardening and irrigation in parks in and around Chennai. The sand filter basically removes the suspended solids as well as to some extent reduces the total dissolved solids in water. Whereas the carbon filter is used to remove the grayish color of water and also reduce the amount of organic matter present in water [Yuan Tian, 2012]. Finally the water outlet from carbon filter was chlorinated to purify it to a greater extent so that it is suitable for the intended purpose.

2. MATERIALS AND METHODS

2.1 Analysis of water samples

Water samples were collected from seven different banks along the Cooum River namely; Maduravoyal, Arumbakkam, Aminjikarai, Chetpet, Chennai Central, Chintadaripet, Marina Beach Mouth in 500mL sterile sample bottles. The samples were analyzed for five parameters namely COD, DO, TDS, TSS, pH by following the standard protocol [Metcalf & Eddy, 2003a]. The pH of sample was analyzed using a standard pH meter.

2.2 Construction of sand and carbon filter

The sand and carbon filter were constructed using PVC pipes open at one end and the flow rate was controlled using a value. The filtering unit was optimized for the following parameters; bed height, particle size, diameter of filter bed and water flow rate. Figure 1 shows the basic design of filtering units.

The packing material in sand filter differed in micron size of sand used varying from top to bottom in increasing order. Fine particles were placed at the top and gravel sand occupied the bottom most part [Metcalf & Eddy, 2003b]. The water before being pumped into the sand filter was allowed to settle in sedimentation tank for 30 minutes to remove the large suspended particles. The water was then allowed to flow through the sand filter and the flow rate was calculated. The water from the sand filter was again analyzed for the five above mentioned parameters.

The water from sand filter was then passed through carbon filter. Two industrial grade carbon (Grade1 & Grade2) were used in two separate columns, to find out which grade is best for the process. The water was allowed to flow under gravity from the sand filter and outlet flow rate of the carbon filter was estimated. The water collected from the outlet of carbon filter was again subjected to analysis for the above mentioned five parameters.

2.3 Chlorination of water

The filtered water was chlorinated with sodium hypochlorite to disinfect the water. To the filtered water 0.5mL of 1M sodium hypochlorite was added per liter, to the filtered water. The water is allowed to stand for 24h in a tank to remove the odor caused by chlorine.

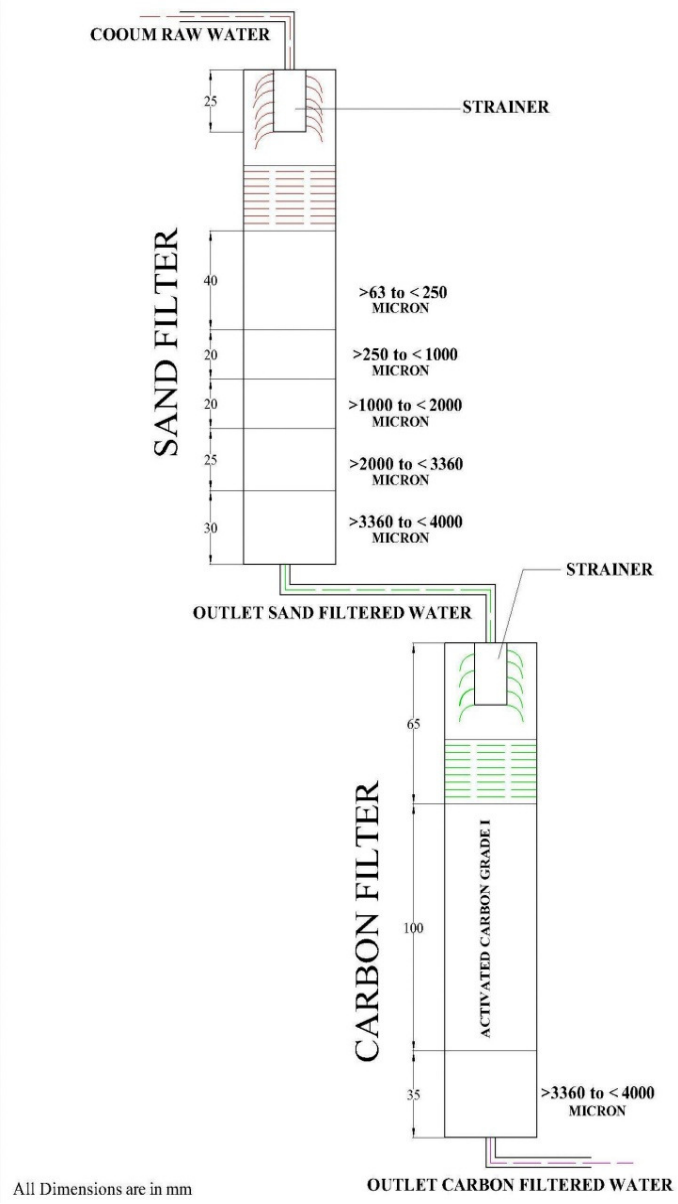


Fig. 1. ***Optimized design of filtering units*** **[Langenbach K, 2009] [Antonina Torrens, 2009]**

2.4 Final analysis of water

The filtered water after chlorination was given to King Institute of Preventive Medicine and Research, Guidy, Chennai, to check if the water sample is potable or not. 5L of water was collected in a sterile sample bottle and given for complete characterization of filtered water. King Institute of Preventive Medicine and Research is a Government of Tamil Nadu, India organized institute for analyzing the potability of water. The results were obtained in 15 days.

3. RESULTS AND DISCUSSION

3.1 Initial Characterization of Cooum water

The samples collected from 7 different banks of the river were analyzed and the experimental values are reported in Table 1. These values were studied in depth for biogas production.

Table 1. Experimental values of different water samples.

S.No.	Place of Collection	COD ($mg.L^{-1}$)	DO ($mg.L^{-1}$)	TSS ($mg.L^{-1}$)	TDS ($mg.L^{-1}$)	pH
1.	Maduravoyal	544	0	45	1010	8.5
2.	Arumbakkam	628	0	78	1020	8
3.	Aminjikarai	756	0	50	1270	8.3
4.	Chetpet	592	0	256	1020	8.5
5.	Chennai Central	772	0	160	1200	8.4
6.	Chindaripet	504	0	355	2110	8.5
7.	Marina Beach Mouth	474	0	1420	4710	8.5

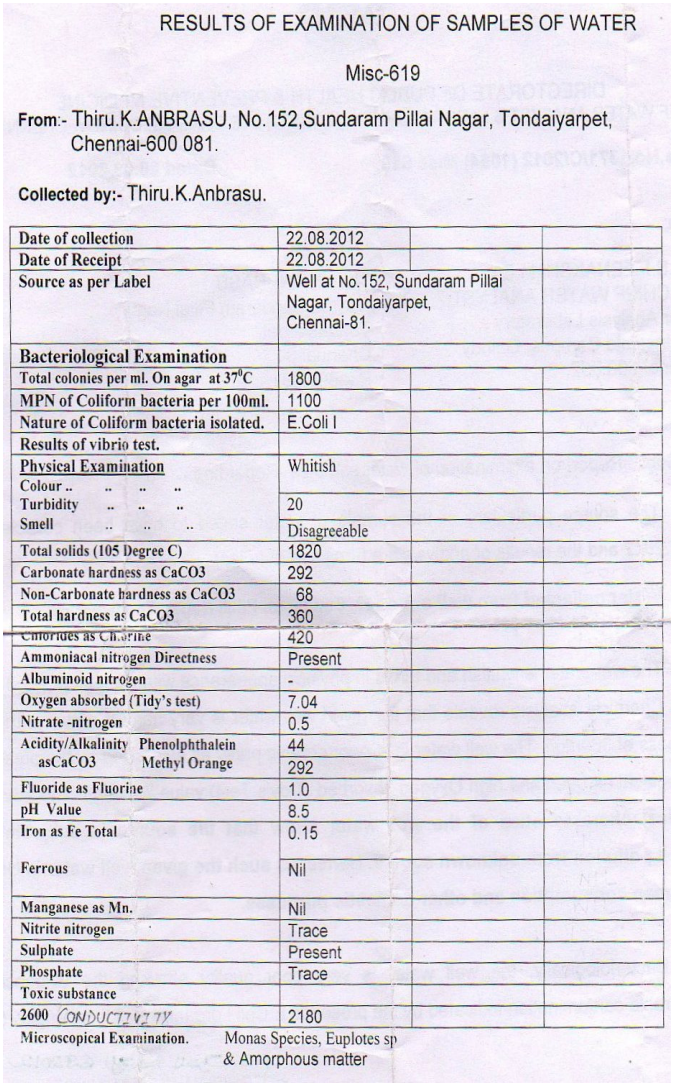
The values obtained had a significant similarity among them. All values when compared, where found to be within a particular range proving that the condition of water is almost similar throughout the city. The average pH value of water in all seven places was around 8.4, giving us a clear idea about the alkaline nature of water and also continuous discharge of human waste into the river [Ayyappan, 2012]. This alkalinity might be mostly due to the presence of dissolved basic salts like ammonia and also due to the presence of carbonates and bicarbonates. The dissolved oxygen content was found to be zero in all the places. This is the main reason for the decrease in the number of flora and fauna species in the river [Rajaram et al, 2008]. This factor favored the production of biogas from the water body, as the production process would face no hindrance from the aquatic life nor will the ecosystem of species growing in the river be affected. The COD values obtained were in the range of 400 to 800 $mg.L^{-1}$, [Gilbert M Masters, 2008b] with the highest value found at Chennai Central ($772mg.L^{-1}$). The COD levels obtained weren't satisfactory for feasible production of biogas.

3.2 Characterization of water after passing through sand and carbon filter

Due to relatively low TDS and TSS values of water samples, the water could be easily be passed through both sand and carbon filter and the water collected was characterized completely. Table 2. reports the five parameters analyzed along with respective experimental values for both sand and carbon filters.

Table 2. Water analysis after passing through sand and carbon filter

S. No.	Parameters	Raw Water	Sand Filter	Carbon Filter	
		(Central)		Grade 1	Grade 2
1.	COD ($mg.L^{-1}$)	736	736	256	704
2.	DO ($mg.L^{-1}$)	0	0	4.9	5.0
3.	TDS ($mg.L^{-1}$)	942	929	927	927
4.	TSS ($mg.L^{-1}$)	160	84	84	84
5.	pH	8.5	8	8	8



RESULTS OF EXAMINATION OF SAMPLES OF WATER

Misc-619

From:- Thiru.K.ANBRASU, No.152,Sundaram Pillai Nagar, Tondaiyarpet, Chennai-600 081.

Collected by:- Thiru.K.Anbrasu.

Date of collection	22.08.2012
Date of Receipt	22.08.2012
Source as per Label	Well at No.152, Sundaram Pillai Nagar, Tondaiyarpet, Chennai-81.
Bacteriological Examination	
Total colonies per ml. On agar at 37°C	1800
MPN of Coliform bacteria per 100ml.	1100
Nature of Coliform bacteria isolated.	E.Coli I
Results of vibrio test.	
Physical Examination	Whitish
Colour	
Turbidity	20
Smell	Disagreeable
Total solids (105 Degree C)	1820
Carbonate hardness as CaCO3	292
Non-Carbonate hardness as CaCO3	68
Total hardness as CaCO3	360
Chlorides as Chlorine	420
Ammoniacal nitrogen Directness	Present
Albuminoid nitrogen	-
Oxygen absorbed (Tidy's test)	7.04
Nitrate -nitrogen	0.5
Acidity/Alkalinity Phenolphthalein asCaCO3 Methyl Orange	44
	292
Fluoride as Fluorine	1.0
pH Value	8.5
Iron as Fe Total	0.15
Ferrous	Nil
Manganese as Mn.	Nil
Nitrite nitrogen	Trace
Sulphate	Present
Phosphate	Trace
Toxic substance	
2600 CONDUCTIVITY	2180
Microscopical Examination.	Monas Species, Euplotes sp & Amorphous matter

Fig. 2. Complete characterization of treated water (SI Units followed)

From the data obtained it is found that there is a significant decrease in COD and TSS which is mainly due to carbon and sand filter respectively. Grade 1 carbon filter is found to be more efficient for the process as it decreases COD content to a greater extend when compared to grade 2 carbon. The color of water also significantly reduced from grayish black to yellow in grade2 carbon and mild whitish in grade1 carbon. The flow rate was found to be $1.5L.h^{-1}$ and $2.5L.h^{-1}$ for gravity sand and carbon filter respectively.

3.3 Final analysis of water

The water obtained from carbon filter after subjection to chlorination was given to King Institute, Guidy, Chennai for complete characterization. Table 3. shows the complete report given by King Institute.

Chemical analysis reveals that the water obtained from carbon filter is hard in nature with total hardness of $360mg.L^{-1}$. The water is of poor organic purity as evident by presence of ammoniacal nitrogen and high oxygen absorbed (Tidy's Test) value $7.04mg.L^{-1}$. The adverse chemical characteristics of the water sample show that the source of water is subjected to subsoil pollution. Bacteriologically the water is very poor in quality showing evidence of undesirable contamination by the presence of *Escherichia coli* organism of faecal origin. Hence, as such the given water is unfit for human consumption and other household purposes but could be used for gardening and irrigation purpose.

4. CONCLUSION

The Cooum River is a polluted river which has been flowing for years through the heart of Chennai. The stinking cesspool has made the city prone to many diseases and at the same time stopped the progress to build a high tech city. Biogas production from cooum waters seems to be a non economical and no gain process because the COD values of water samples obtained are very low when compared to optimal value required for biogas production. In order to utilize this water a simple gravity filtration technique consisting of a slow sand filter and carbon filter can be setup along the banks of the river, so that water gets purified and can be used as a source of water for the gardens in and around Chennai. This will not only utilize the dirty water available in the river in plenty but also help in spreading green energy by providing water for irrigation of gardens. Nature on its own takes care of the recycling of water and this is one additional step in contributing to the nature's ecosystem.

5. ACKNOWLEDGMENT

We are very grateful to King Institute of Preventive Medicine and Research, Chennai, Tamil Nadu, India; for analyzing our water sample and providing us with the report. We express our deep and sincere gratitude to TCMPF, Aavin Dairy, Shollinganallur, Tamil Nadu, India; for giving us a chance to work on this project.

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Journal of Civil Engineering and Environmental Technology
Print ISSN: 2349-8404; Online ISSN: 2349-879X; Volume 1, Number 6; August, 2014 pp. 29-30

http://www.krishisanskriti.org/jceet.html

New Techniques of Waste Water Treatment

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Abstract: **We demonstrate the filtration of water by nano technology, Carbon Nanotubes (CNTs). The unique property of Adsoption in CNTs provide the passage of water by retaining all the impurities inside the cylinders. By arranging the size of CNTs we retained any type of impurity through it. Rather than in conventional method, where reverse osmosis requires enough backward pressure to move the liquid in backward direction. But, here only "push" will be applied. Life span of conventional method is limited but, for CNTs it is not. The CNTs has the ability to remove toxins and harmful contents from water of any type. Reusability, Capability and it's unique fibrous structure of CNTs pave the way for the implications of CNTs in Waste Water Treatment.**

1. INTRODUCTION

As in the present scenario, water is the basic necessity for all type of life existing in our planet. If we are going to ran out of it, there will be world war 3rd so it is badly needed to find out the ways from where we can get water for our sustainable development. Now, some of the measures that have been taken to find the various ways through which water can be preserved for our future.

The recent development in the technology has boomed up with newer invention in carbon nano technology which ultimately helps in getting purified water from contaminated water.

Conventional methods are used to minimize the water scarcity by purifying industrial waste water, Household water, contaminated water but, there are certain limitation of it. After a certain period of time, they becomes unusable, due to many reasons. Firstly, Polluted water contains many heavy metals which leave deleterious impact on waste water treatment plant. Secondly, They are not much capable to make the water potable by removing pathogens from contaminated water.

On the second hand, advanced membrane filtration technique (like Ultrafiltration, Nanofiltration, Reverse Osmosis) demands the backward force to move the liquid in backward direction which increases the cost of treatment plant and it doesnot have any reusability. But, in the recent years nanotechnology brought the invention in water filtration by its property of adsoption due to which it removes heavy metal ions like Cr3+,Pb2+ etc.

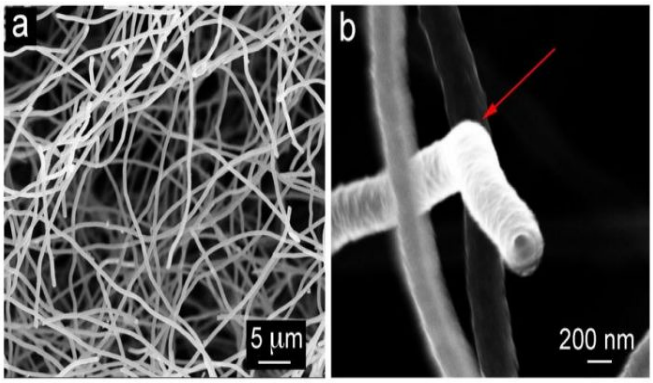

Fig. 1: Fibrous structure of CNTs helps in treatment of Water.

Beyond all the conventional Treatments, Contaminated Water contains cynobacterias which exploits the taste and odour of drinking water.

So, We can say that conventional method has very low efficiency for make water potable.

2. CNTS AS ABSORBANTS FOR REMOVAL OF ORGANIC AND INORGANIC POLLUTANTS

Absorbents	Pollutants	Comments
Graphised CNTs	1,2 DichloroBenzene	Due to have rough surface adsorption made easier on CNTs.
Amorphous Alumunium oxide supported on CNTs	Flouride	Adsorption of fluoride ions becomes quite faster.

Absorption is the simple and efficient method posseses by the CNTs, Activated Carbon (ACs), Carbon sheets etc.But, in the water treatment plant we prefers to use Activated Carbon fibrous structure. Its pores helps in the adsoption of toxic materials. As a result, ACFs posses high adsorption Capacity than ACs for water treatment.

3. HOW CARBON NANOTUBES USED FOR TREATING DRINKING WATER?

CNTs provides the enormous advantage over the membrane system of the current membrane technology.

Water is passed at a high rate of flow just by applying the external force "push" since they posses many additional property of adsorb toxic materials. Presently, it is very limited in use since it requires the development of well defined carbon structure lined up facing in one direction all right next to each other in filtration unit. The variation in size of H2O molecule and of the impurity pave its way to use CNTs in water Treatment. It is achieved by designing the mesh or mat of carbon stack to one another of desired size.

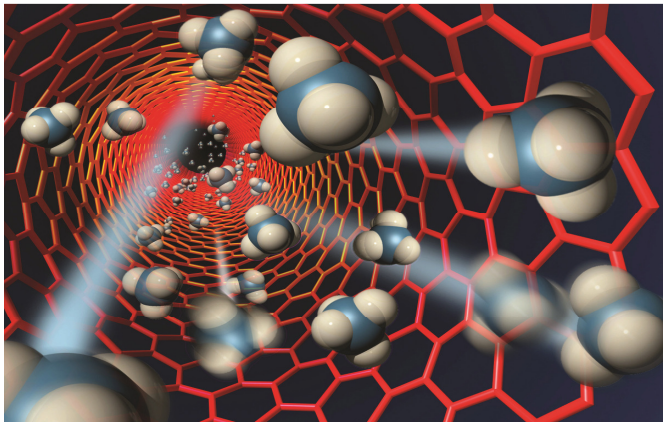

Fig 2. Red colur shows the CNTs and Blue and White colour shows the water molecule.

Here, Mechanism of water entering in CNTs is shown above in which it passes through CNTs by retaining all impurities on the CNTs.

4. CARBON NANOTUBES FILTERS: PRACTICAL CONSIDERATIONS

CNTs serves as the excellent media for concentrating and removal of biological contaminants from water systems.

1. **Cost :** Since due to the development in nano technology, the use of CNTs increased very much in every field so, its cost get reduced for future aspects.
2. **Reusability:** CNTs filters are reusable by using certain simple thermal regeneration technique which is quite cheaper than polymeric filtration.
3. **Feasibility:** It is quite feasible for mass production of potable water at reasonable low pressure. CNTs expressed high mechanical stability than any other membrane since it can withstands upto pressure of 1atm.

5. CONCLUSION

1. CNTs posseses superior adsorption capacity.
2. It is good to remove all bacterial contaminants.
3. Continuous production of CNTs diminishes the cost in coming years.
4. For a particular amount of CNTs it does not cause any impact on the enviorment.

6. ACKNOWLEDGEMENTS

To light our god who guided us throughout the way. I thank to our Parents, Teachers and Friends. For their Warm support and love. To my teacher Mr. A B R Prasad, for his efforts to supervising and leading me. I thanks to all people for believe in me.

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Journal of Civil Engineering and Environmental Technology
Print ISSN: 2349-8404; Online ISSN: 2349-879X; Volume 1, Number 6; August, 2014 pp. 31-34

http://www.krishisanskriti.org/jceet.html

A Study on - Alkali Aggregate Reactivity of Some Quarry Aggregates and River Borne Aggregates Occurring in and Around Lower Assam

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Abstract: **With increasing construction and infrastructure developmental activities in the region, the requirement and necessity of identifying nearby sources for procuring coarse and fine aggregates has become important. However, even if aggregates satisfy some of the parameters with respect to suitability as construction materials, they could be chemically active and thus exhibit expansive behaviour due to the presence of deleterious particles and thus become unsuitable as construction materials. To achieve required dimensional stability, durability and strength of structures, aggregate characteristics and related engineering properties is one of the main issues that are to be addressed.**

An attempt has been made in the present work to analyse the potential alkali reactivity of some major rock units and some river borne aggregates occurring in and around Lower Assam with an object to find their suitability as construction materials.

The results obtained from the chemical test viz. Alkali Aggregate Reactivity Test have shown that all the aggregates have exhibited innocuous characteristics. This is perhaps due to the fact that no significant proportion of deleterious silica particles like opal chalcedony, tridymite and crystobite, xeolite, heulandite, glassy to crypto-crystalline rhyolites, decites, etc. are present in the rock units of the area. Thus the aggregates are found to be suitable as construction materials from alkali aggregate reactivity point of view.

Keywords: **Alkali aggregate reactivity, aggregates, innocuous, deleterious, construction materials**

1. INTRODUCTION

Infrastructure development programme is found top most priority for every government both Central as well as state government. Construction of road network is one of the main pillars of infrastructure development programme. In Assam, the construction works like roads, buildings, etc. are carried out with the rock materials collected from different quarries of the hills as well as some river borne aggregates. Construction and maintenance of roads and buildings have become more costlier now, and therefore, every scientific aspects are to be strongly dealt with before staring the work.

One of the major contributing factors to the quality of road construction or any other construction is the quality aggregates used in the construction. To measure the quality of rock materials used as aggregates, several engineering tests have been developed such as Abrasion test, impact test, shear test, stripping test, etc.

Failure of road surface and concrete structures may start due to expansion behaviour of the aggregates used. The aggregates which contain substantial amount of deleterious silica materials like opal, chalcedomy, tridymite and crytobolite xeolite, beulandite, etc. generally exhibit expansion characteristics.

These characteristics depend on the potential reactivity of aggregates. The I.S. 2386 (Part VII)-1963 describes two tests, one is Mortar Bar method and other is Chemical method to determine the potential expansive alkali reactivity of an aggregate. Aggregates showing expansive characteristics more than specified limit are known as deleterious aggregates and the aggregates showing expansive characteristics less than specified limit are known as innocuous aggregates.

In view of the above facts, the present study is undertaken with an object to know the potential alkali reactivity of some quarry and river borne aggregates found in and around Lower Assam as these are seen to be used as construction materials in the area.

2. SCOPE AND OBJECT OF STUDY

The study is carried out mainly for the following purposes:

a) To study the geo-engineering properties of the quarry and river borne aggregates.

b) To carry out the chemical tests to determine the potential alkali reactivity of the aggregates.

c) And, interpretation of the results to find their suitability as construction materials.

3. METHODOLOGY

The method of work involves-

3.1 Field works

The Field works involves visiting of a number of quarries in the area to study the geological features and collection of rock aggregates for conducting the tests. It also involves visiting a number of river sites for the collection of river borne aggregates.

3.2 Laboratory works

The collected rock and river borne aggregates are subjected to various laboratory tests for studying their different geo-engineering properties

To determine the potential reactivity of aggregates, the I.S. code 2386 (part VII) gives the following two methods:

a) Mortar Bar Method for determination of Potential Alkali Reactivity of cement-Aggregate combinations.

b) Chemical Method for determination of Potential Reactivity of aggregates.

c) In the present study, chemical method is adopted to know the potential reactivity of rock materials and river borne aggregates.

4. QUARRYING FOR AGGREGATES

The area under investigation is a part of the Northern extension of Shillong Plateau which is a part of state of Assam. The various rock unit types, prevalent in the area have been grouped as follows shown in Figure 1 -

Quarrying involves here two processes viz., hill quarrying and river quarrying.

Quarrying generally is the process of collecting rocks from the natural bed rocks and the term "Quarry" itself indicates the exposed surface of the rock beds. This is mostly confined to hill quarrying alone. The method adopted for hill quarrying is mostly blasting. However the river quarrying simply involves the collection of the aggregates from the river beds.

Different sites for collection of rock aggregates and river borne aggregates are mentioned below-

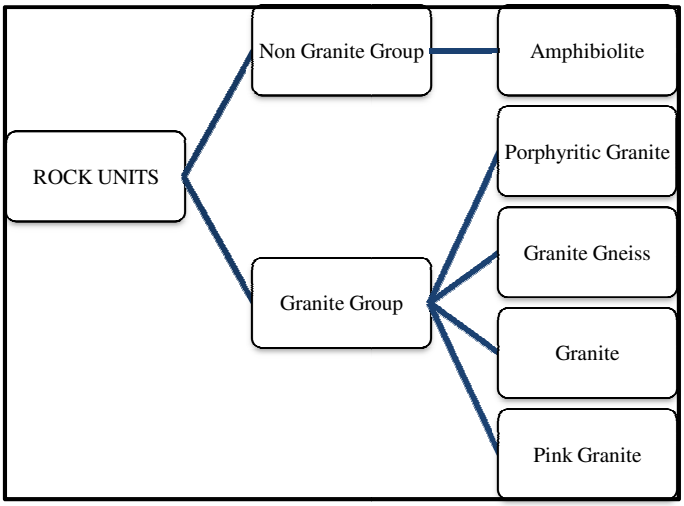

Fig. 1. Field occurrence of Rock Units

Table 1. Collection of Aggregate Samples

Sample	Type of Sample	Sample Collected From	Coordinates
A	Rock (Granite-gneiss)	Pamohi Quarry	26° 06' 01" N 91° 41' 06" E
B	Rock (Granite-gneiss)	Pathar Quarry	26° 10' 03" N 91° 49' 15" E
C	Rock (Porphyritic Granite)	Jalukbari Quarry	26° 08' 57" N 91° 39' 02" E
D	River Borne Aggregate	Kulsi River, Chhaygaon	26° 02' 50" N 91° 23' 18" E
E	River Borne Aggregate	Pagladia River, Nalbari	26° 26' 46" N 91° 27' 48" E
F	River Borne Aggregate	Digaru River, Jorabat	26° 03' 10" N 91° 52' 39" E

5. LABORATORY TEST RESULTS

This method of test covers a chemical method for determining the potential reactivity of an aggregate with alkalis in Portland cement concrete as indicated by the amount of reaction during 24 hr at 80°C between 1 N sodium hydroxide solution and aggregate that has been crushed and sieved to pass a 300-micron IS Sieve and be retained on a 150-micron IS Sieve.

The results of the laboratory tests (viz. Chemical Method) to determine dissolved silica (S_c) and reduction in alkalinity (R_c) of the samples are shown in Table 2.

Table 2. Laboratory Test Result of Alkali Aggregate Reactivity Test

Sample	Sample Collected From	Description Of Sample	Alkali Aggregate Reactivity Test	
			Concentration of dissolved silica "S_c" (millimoles/Litre)	Reduction in alkalinity "R_c" (millimoles/Litre)
A	Pamohi Quarry	Slightly to moderately weathered, fine to medium grained, hard	6.66	92.5
B	Pathar Quarry	Slightly to moderately weathered, fine to medium grained, hard	9.99	135
C	Jalukbari Quarry	Slightly to moderately weathered, medium to coarse grained, hard	13.32	85
D	Kulsi River, Chhaygaon	Fine grained, sub-rounded aggregates	9.99	520
E	Pagladia River, Nalbari	Fine grained, sub-rounded aggregates	13.32	412.5
F	Digaru River, Jorabat	Fine grained, sub-rounded aggregates	16.5	417.5

In general, for most aggregates, a potentially deleterious degree of alkali reactivity is indicated if the plotted data point of a particular test falls to the right of the boundary line of the graph as given in the IS : 2386 (Part-VII) 1963. On the other hand, the innocuous character of the aggregate will be indicated if the plotted data point of the particular test of the aggregate falls to the left of the boundary line of the graph as mentioned above.

The laboratory test results, as presented in Table 2, were represented in the graph in which the dissolved Silica (S_c) plotted in the abscissa and the reduction in alkalinity (R_c) is plotted in the ordinate as shown in Figure 2.

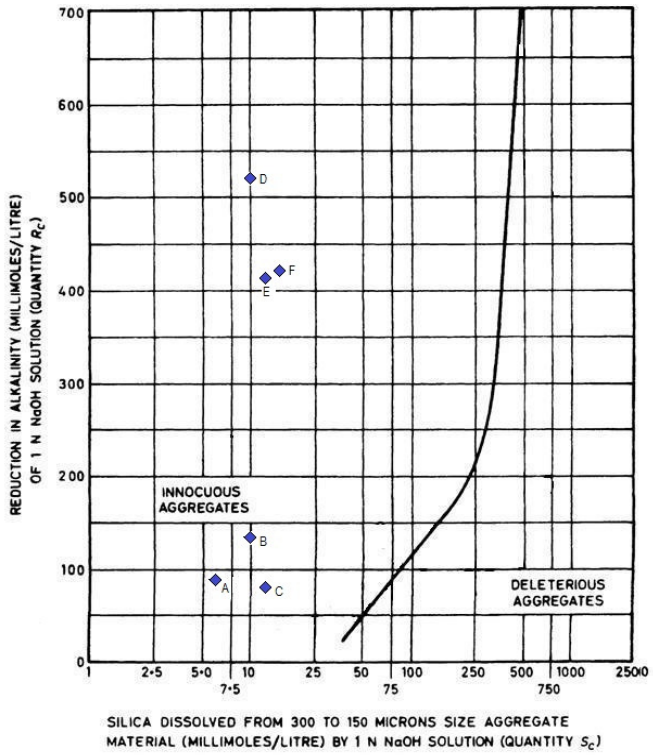

Fig. 2. Representation of Concentration of Dissolved Silica and Reduction in Alkalinity of various samples

(Source: IS : 2386 (Part-VII) 1963)

6. DISCUSSION & INFERENCE

Innocuous aggregate particles are those which do not participate in alkali-aggregate reactions harmful to concrete. These aggregates generally exhibit less expansion characteristics than deleterious aggregates.

Deleterious aggregate particles are those which produce adverse effects on concrete through chemical reactions between particles and cement alkalies. Known reactive substances are the silica minerals, opal, chalcedony, tridymite, and cristobalite, zeolite, heulandite (and probably ptilolite), glassy to crypto-crystalline rhyolites, dacites and andesites and their tuffs, and certain phyllites. IS: 2386 (Part VII) - 1963 gives a boundary line to differentiate innocuous from deleterious aggregates in the form of a graph, which has been used in the present study to represent the alkali aggregate reactivity of the samples viz. A, B, C, D, E & F (Figure. 2). In general, for most aggregates, a potentially deleterious degree of alkali reactivity is indicated if the plotted data point of a

particular test falls to the right of the boundary line of the graph as given in the IS : 2386 (Part-VII) 1963. On the other hand, the innocuous character of the aggregate will be indicated if the plotted data point of the particular test of the aggregate falls to the left of the boundary line of the graph as mentioned above.

Again as per IS : 383- 1970, aggregates shall not contain any harmful material, such as pyrites, coal, lignite, mica, shale or similar laminated material, clay, alkali, soft fragments, sea shells and organic impurities in such quantity as to affect the strength or durability of the concrete. Aggregates to be used for reinforced concrete shall not contain any materials liable to attack the steel reinforcement. Aggregates which are chemically reactive with alkalies of cement are harmful as cracking may take place.

In the present study, the evaluation of the chemical quality of the rock units have been done on the basis of chemical test viz. Alkali Aggregate Reactivity test as described in IS : 2386 (part VII)-1963.

Table 2 shows the overall comparison of chemical quality based on Alkali Aggregate Reactivity test between the different rock and river borne aggregates present in the area under study and Figure 2 shows the graphical representation of the test results. The comparison shows that all the aggregates of the area have exhibited innocuous characteristics from chemical quality point of view (as shown in Table 3).

Table 3. Chemical Quality based on Alkali Aggregate Reactivity Test

Sample	Type of Sample	Sample Collected From	Chemical Quality
A	Rock (Granite-gneiss)	Pamohi Quarry	Innocuous
B	Rock (Granite-gneiss)	Pathar Quarry	Innocuous
C	Rock (Porphyritic Granite)	Jalukbari Quarry	Innocuous
D	River Borne Aggregate	Kulsi River, Chhaygaon	Innocuous
E	River Borne Aggregate	Pagladia River, Nalbari	Innocuous
F	River Borne Aggregate	Digaru River, Jorabat	Innocuous

Further, it can be inferred that among all these aggregate types, Granite-gneiss (sample A & B) and river borne aggregate (Kulsi river) have exhibited highest innocuous characteristics compared to the other types of aggregates. The innocuous characteristics of the various aggregates are shown below in descending order:

Granite- gneiss (Samle A & B) > River borne aggregate (Kulsi river) > Porphyritic granite (Sample C) > River borne aggregate (Pagladia river) > River borne aggregate (Digaru river)

7. CONCLUSION

The requirement of good quality aggregates as construction materials is of paramount importance in the present scenario considering the several ongoing and upcoming infrastructure development schemes launched by the State and Central governments in the area under study.

To achieve required dimensional stability, durability and strength of structures, aggregate characteristics and related engineering properties is one of the main issues that are to be addressed.

The chemical properties of the aggregates chiefly depend on their constituents minerals. Failure of road surface and concrete structures may start due to expansive behaviour of the aggregates used due to the presence of substantial deleterious silica materials.

The rock and river borne aggregates of the area under the present study, have exhibited innocuous characteristics from chemical quality point of the view. Hence these aggregates can be used as construction materials. However, future workers are suggested to carry out such similar studies with greater number of samples for confirmation.

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Journal of Civil Engineering and Environmental Technology
Print ISSN: 2349-8404; Online ISSN: 2349-879X; Volume 1, Number 6; August, 2014 pp. 35-40

http://www.krishisanskriti.org/jceet.html

Bamboo as a Cost Effective Building Material for Rural Construction

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Abstract: **The construction scenario in rural areas of India is getting highly influenced by the materials like cement and steel, as it gives the long life to the structure but in turn it increases the overall cost of construction. These materials like cement and steel use energy extensively from its very beginning to its completion and even after for its maintenance in many forms. Without focusing on availability of renewable construction material in near vicinity of rural areas and also not utilizing the locally produced material, the pressure is increasing on conventional resources. This situation demands the attention of rural community on naturally available renewable local resources and cost effective materials, which will give the same result as that of cement and steel, but economically viable. Bamboo is one such material, which can be used by the rural community in their construction, which has extensive potential in building industry when supported with required treatment and trained workers. The main focus of this paper is to promote the use of bamboo as cost effective material. The present paper suggests the use of bamboo in combination with modern material technology as a building material in rural construction.**

Keywords: **Bamboo, Rural construction, Cost effective.**

1. STUDY BACKGROUND

In today's world, energy is extensively used for construction activities and is the major source of demand for energy. Alone construction sector has been accounted to consume 40% of total energy consumption directly or indirectly. The construction activities in urban development have exploited the conventional resources of the mother earth and now the trend is passing to the rural area too. From the beginning it was understood that many of the concepts applied to shelter and living conditions in urban communities are not always transferable or appropriate in a rural context.

Compared to urban areas, rural areas suffer more from the concentration of deprivation. With incomes generally lower than the urban areas and seasonal unemployment, many households find it difficult to gain ownership of homes. This has implications for social sustainability of rural communities and is causing increased polarization as younger people migrate to the urban areas in search of jobs leaving behind their old folk and children resulting in negative impact on rural enterprise and economic viability [1].

The housing sector in rural India is growing rapidly but with increased cost due to materials like cement and steel, it is getting out of reach of people. Bamboo structures are one, which can replace steel structures, thus providing an eco-friendly and cost-effective option for rural construction industry. This new construction approach shows the rural community an affordable, high quality and durable alternative compared to widely-used but higher cost and less environmentally-compatible construction materials. Bamboo has an advantage of being renewable and fast growing, contributes to higher carbon credit. With proper engineering, use of Bamboo in building can aid in the growth of alternative & sustainable development, meeting the challenges of rural construction industry and growing housing sector. Promoting sustainable and affordable construction delivers significant impacts, spanning both socio-economic and public welfare benefits.

Bamboo as a building material can be used in various forms. Bamboo reinforcement as replacement of steel reinforcement is gaining immense importance today, mainly on account of the improvement in the economical aspect combined with ecological benefits. An engineered Bamboo can substitute steel in making tensile stresses of RCC members and also reduces the consumption of cement in building.

2. RURAL CONSTRUCTION SECTOR

A traditional rural building is based on adaptations to the local environment, and is often built with the labor of the villagers themselves without the need for external mechanized inputs. In rural areas low cost, aesthetics, preserving traditions, and living in climatically suitable houses are all fine notions, but the durability of buildings is also an important consideration.

A mud building with a thatched roof needs continuous maintenance, whereas a building with conventional materials like cement and steel is far sturdier, and has a longer life span. These conventional materials increase the overall cost of construction [2].

As per the Census reports of India and other reports by different Government Departments, the building structure types are gradually transforming to Permanent ("Pucca" – in which the walls and roof of which are made of permanent material) and Semi Permanent ("Semi Pucca " – in which either the walls or the roof is made of permanent material) types from Temporary ("Kutcha " - in which both the walls and roof are made of materials that needs to be replaced frequently) in rural areas [3].

The trend of conversion from Temporary to Permanent or Semi- Permanent structures is likely to continue in view of economic growth of common people. It is expected that large number of buildings with durable and easily available conventional materials like brick, sand, cement, steel reinforcement etc. will be constructed in near future and demand of such building materials will shoot up.

In rural area housing and other building inadequacy is largely felt at the level of low income groups due to continuous rise in cost of construction at all levels.

This necessitates the use of cost effective technologies in building construction using locally available and renewable materials. Though the information in this regard has been developed, there has been a large gap in application. Therefore access to building materials, technologies and construction delivery systems for cost effective construction activity is an important need in rural areas.

The cost of construction is increasing by 50 per cent over the normal inflation due to hike in the cost of basic building materials and labor. Consequently, even basic housing is now beyond the reach of a common person in rural areas. There is an imperative need to utilize technology options leading to cost effective results, which people in rural areas can afford. Although many attempts for evolving cost- effective technologies have been made at the laboratory level by various scientific and R & D agencies, but these initiatives were not finding applications at the field level. Further, the 'awareness' level of these alternative and sustainable options has been minimal among users as well as professionals [4]. The existing construction practices in rural areas, using conventional options, lead to misuse of scarce and costly materials. Such practices have a larger environmental impact in terms of depletion of conventional resources. The lack of support through building regulatory system is another factor that has inhibited the use of cost effective options in construction sector of rural areas. As a cumulative effect, the building structures offered to the rural people are either expensive and beyond the affordable limit. There is a distinct lack of training and skill-enhancement in rural areas, not only for conventional but also cost-effective technologies. This has adversely affected housing and building programs for all target groups and community buildings since financial resources available are always limited.

This issue can be addressed by, training and skill-enhancement of construction artisans in terms of alternative, innovative and sustainable building materials and technologies and also by assisting in the production of various building components at the base level by utilizing the services of trained artisans in the construction program. Providing construction guidance, information and counseling to local people will help in creating 'awareness' about the available alternative options and also an 'appreciation' of these options not only in terms of cost effectiveness but also in terms of structural, functional and aesthetic sufficiency. The use of these "cost-effective options" will change the negative perception of "low cost housing" (eg. low quality, non- durable structures).

3. COST-EFFECTIVE CONSTRUCTION TECHNOLOGIES

Safety, capital cost (production and construction), comfort, expenditure on maintenance, availability of materials and artisans, aesthetics and to some extent the societal status are guiding criterion of acceptability of building construction technologies in India.

Buildings with conventional materials like cement and steel consume very large quantity of energy. Energy consumption in buildings occurs in five phases. The first phase corresponds to the manufacturing of building materials and components, which is termed as embodied energy. The second and third phases correspond to the energy used to transport materials from production plants to the building site and the energy used in the actual construction of the building, which is respectively referred to as grey energy and induced energy. Fourthly, energy is consumed at the operational phase, which corresponds to the running of the building when it is occupied. Finally, energy is consumed in the demolition process of buildings as well as in the recycling of their parts, when this is promoted [5].

Cost-effective construction technologies can bring down the embodied energy level associated with production of building materials by lowering use of energy-consuming materials. The cost-effective construction technologies would emerge as the most acceptable case of sustainable technologies in Rural India both in terms of cost and environment.

Cost-effective construction technologies, which apart from reducing cost of construction by reduction of quantity of building materials through improved and innovative techniques or use of alternate low-energy consuming

materials, can play a great role in reduction of CO2 emission and thus help in the protection of the environment.

Bamboo is one such material, which can be used by the rural community in their construction, which has extensive potential in building industry when supported with required treatment and trained workers.

4. BAMBOO AS A BUILDING MATERIAL

The majority of bamboo construction relates to the rural community needs in developing countries. It is mainly used in housing but other common types of construction include school buildings, community buildings and bridges. Further applications of bamboo relevant to construction include its use as scaffolding, water piping and as shuttering and reinforcement for concrete.

Bamboo has historically been used as a building material due to its inherent properties, being regenerating, biodegradable, with high tensile strength, and lightweight. However, despite its innumerable qualities one does not get to see bamboo as popular building material. Bamboo reinforced Concrete for the key structural elements like slab, walls, columns and beams, of a modest dwelling unit can be successfully utilized for structural and non-structural applications in construction [6].

As an economic building material, bamboo's rate of productivity and cycle of annual harvest outstrips any other naturally growing resource, if today we plant three or four structural bamboo plants, then in four or five years later we will have mature clumps, and in eight years we will have enough mature material to build a comfortable, low cost structure [7].

Main characteristic features, which make bamboo as a potential building material, are its high tensile strength and very good weight to strength ratio. It can withstand up to 3656 Kg/cm2 of pressure. The strength-weight ratio of bamboo also supports its use as a highly resilient material against forces created by high velocity winds and earthquakes. Above all bamboo is renewable raw material resource from agro-forestry and if properly treated and industrially processed, components made by bamboo can have a reasonable life of 30 to 40 years. Though natural durability of bamboo varies according to species and the types of treatments. Varied uses and applications in building construction have established bamboo as an environment-friendly, energy-efficient and cost-effective construction material [8].

4.1 Botanical classification of Bamboo

Bamboo is a perennial, giant, woody grass belonging to the group angiosperms and the order monocotyledon (McClure, 1966, Liese, 1985*)* [9].

Bamboo (Bambuseae) is a tribe of flowering perennial evergreen plants in the grass family Poaceae, subfamily Bambusoideae, tribe Bambuseae. Giant bamboos are the largest members of the grass family. In bamboos, the internodal regions of the stem are hollow and the vascular bundles in the cross section are scattered throughout the stem instead of in a cylindrical arrangement. The dicotyledonous woody xylem is also absent. The absence of secondary growth wood causes the stems of monocots, even of palms and large bamboos, to be columnar rather than tapering. Bamboos are some of the fastest-growing plants in the world, due to a unique rhizome-dependent system. More than 10 genera are divided into about 1,450 species [10].

Characterized by the type of rhizome and the formation of upright canes there are three main groups of bamboo. The first group is called monopodial bamboos. They form long and thin extensions of the rhizome whose buds produce single shoots are regular intervals. The sympodial bamboos constitute the second group. They have short, thick rootstocks the tips of which produce the canes. The third group is called climbing bamboos. They can grow very irregularly and may form impenetrable thickets.

4.2 Growth of the Bamboo

The growth pattern of the bamboos is a singular combination of grass, leaf-bearing tree and palm. Like the grasses they have tubular blades, lancet-shaped cover leaves and panicular flowers and from a subterranean rootstock branch extensively to form dense to loose bushes. The following characteristics distinguish bamboos from grasses: the longevity of their canes, their branching and the lignification. Like leaf bearing trees they increase their crown every year by throwing out new branches and also shed their leaves each year. Emerging with its definitive circumference from the soil without increasing in diameter later.

4.3 Properties of Bamboo:

4.3.1 Mechanical Properties:

It has also been found that bamboo acts very well in buckling due to low stresses than compared to steel .It has been established that in seismic zones the failure of bamboo is very less as the maximum absorption of the energy is at the joints. Cellulose is the main component present in bamboo, which is the main source of mechanical properties of bamboo.

4.3.2 Tensile Strength:

Experimentally it has been found that the ultimate tensile strength of some species of bamboo is comparable to that of mild steel and it varies from 140N/mm^2- 280N/mm^2. Bamboo is able to resist more tension than compression. The fibers of bamboo run axial. In the outer zone are highly elastic vascular bundles that have a high tensile strength. The tensile strength

of these fibers is higher than that of steel, but it's not possible to construct connections that can transfer this tensile strength.

4.3.3 Compressive Strength:

Compared to the bigger tubes, slimmer ones have got, in relation to their cross-section, a higher compressive strength value. The slimmer tubes possess better material properties due to the fact that bigger tubes have got a minor part of the outer skin, which is very resistant in tension. The portion of lignin inside the culms affects compressive strength, whereas the high portion of cellulose influences the buckling and the tensile strength as it represents the building substance of the bamboo fibers.

4.3.4 Elastic Modulus:

The accumulation of highly strong fibers in the outer parts of the tube wall also work positive in connection with the elastic modulus like it does for the tension, shear and bending strength. The higher the elastic modulus, the higher is the quality of the bamboo. Enormous elasticity makes it a very useful building material in areas with very high risks of earthquakes.

4.3.5 Anisotropic Properties:

Bamboo is an anisotropic material. Properties in the longitudinal direction are completely different from those in the transversal direction. There are cellulose fibers in the longitudinal direction, which is strong and stiff and in the transverse direction there is lignin, which is soft and brittle.

4.3.6 Shrinkage:

Bamboo shrinks more than wood when it loses water. The canes can tear apart at the nodes. Bamboo shrinks in a cross section of 10-16 % and a wall thickness of 15-17 %. Therefore it is necessary to take necessary measures to prevent water loss when used as a building material.

4.3.7 Fire Resistance:

The fire resistance is very good because of the high content of silicate acid. Filled up with water, it can stand a temperature of 400° C while the water cooks inside [11].

4.4 Application of Bamboo

- **Bamboo Trusses:**

The bamboo has strength comparable to that of teak and sal. An experiment with the construction and testing of a 4m span truss made of round bamboo and different jointing techniques for web-chord connections gave results that were matching with the strength of timber.

- **Bamboo Roofs Skeleton:**

It consists of bamboo truss or rafters over which solid bamboo purlins are laid and lashed to the rafter by means of G.I. wire.

- **Bamboo walling/ceiling:**

As the bamboo material is light in weight it is more advantageous in earthquake prone areas as its chances of falling are very less and even if it falls it can be re-erected easily with less human and property loss with least efforts and minimum cost.

- **Bamboo Doors and Windows:**

Bamboo frames can replace timber frames appropriate to function. Bamboo mat shutters fixed to bamboo frame or a panel of bamboo board fixed to the frame, which is hinged to the wall, can be used as door.

- **Bamboo Flooring:**

Bamboo can be used as flooring material due to its better wear and tear resistance and its resilience properties.

- **Scaffolding:**

Bamboo poles lashed together have been used as scaffolding in high-rise structures due to their strength and resilience [12].

4.5 Advantages of Bamboo

- Bamboo is an extremely **strong** natural fiber, on par with standard hardwoods, when cultivated, harvested, prepared and stored properly. The strongest part of a bamboo stalk is its node, where branching occurs.
- Bamboo is an exceptionally **versatile** material. It is used in a myriad of ways for building, such as for scaffolding, roofing, flooring, concrete reinforcement, walls and piping. It may be used structurally and as a decorative element.
- Bamboo is extremely **flexible.** During its growth, it may be trained to grow in unconventional shapes. After harvest, it may be bent and utilized in archways and other curved areas. It has a great capacity for shock absorption, which makes it particularly useful in earthquake-prone areas.
- Bamboo is extremely **lightweight** as compared with hardwoods. Consequently, building with bamboo can be accomplished faster than building with other materials.
- Bamboo is considered to be a **sustainable** and **renewable** alternative to hardwoods, foremost because it regenerates at exceptionally fast rates
- Bamboo is **cost-effective**, especially in areas where it is cultivated and is readily available.
- Construction using bamboo ordinarily does not require machinery and can be accomplished with **simple tools.**

- Bamboo is as **long - lasting** as its wooden correlates, when properly harvested and maintained.

4.6 Disadvantages of Bamboo:

- Bamboo does not contain cross fibers and is, consequently, not designed to bear weight width-wise, with the exception of the points at the nodes. Bamboo is prone to splitting.
- Bamboo does not lend itself to being painted because of its natural waxy coating.
- Bamboo is prone to insect invasion, especially when not treated properly after harvest.
- Untreated bamboo is prone to breaking down if it comes in contact with excess moisture.
- Bamboo that has been harvested prematurely cannot bear as much weight as its more mature counterparts.
- Natural variations in species may be difficult for installers to accurately gauge the quality of bamboo material.
- Designing and constructing with bamboo requires a special skill set that the average contractor may not possess [13].

4.7 Chemical treatment for bamboo:

The natural durability of bamboo is lower than for wood. The lifetime of an untreated bamboo can vary between 1 and 15 years depending on conditions, depending on variety. Bamboo needs to be chemically treated. Preservation treatment methods of bamboo are of 2 types: the traditional or non-chemical methods and chemical methods. The choice of treatment method will depend on the state of bamboo, whether it is green or dry, whether whole cane or split, its future application, quantity to be treated and the time available [14].

Traditional and non-chemical methods:

- Smoking:
- Baking over open fire
- White washing
- Soaking in water

Chemical treatment methods:

- Tanalised method - chromated copper arsenate (CCA)
- Treatment with Boric acid / Borax

4.8 Embodied energy of Bamboo compared with conventional building Materials:

Bamboo is used as a cost effective building material due to its various aspects. But the most important factor, which makes it cost effective, is the embodied energy of this material. [4]The use cost effective technology has led to solutions with 15 to 40 percent savings over the conventional costs.

Table 1. Energy Requirement of Construction Materials

Materials	Energy for production MJ/Kg	Weight per volume Kg/m^3	Energy for production Kg/m^3	Stress when in use	Energy per unit stress
Concrete	0.8	2400	1920	8	240
Steel	30	7800	234000	160	1500
Wood	1	600	600	7.5	80
Bamboo	0.5	600	300	10	30

Source: Prof.J.A.Janssen, Eindhoven University The Netherlands [8].

5. CONCLUSION

The initiatives described in this paper can be useful tools for overall cost-effective development of rural areas. Imaginative design and the use of other locally available materials within the cultural context can make the bamboo building desirable rather than just acceptable. The current study reflects that, with the advent of new technology bamboo has become an alternative material to conventional materials thereby substituting the rapidly depleting resources. Bamboo is not merely a material for construction but also sustains the local economy in the process, balances the environment and generates local employment. Thus bamboo will continue to play an important part in the rural construction sector, as an economical building material.

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Journal of Civil Engineering and Environmental Technology
Print ISSN: 2349-8404; Online ISSN: 2349-879X; Volume 1, Number 6; August, 2014 pp. 41-45

http://www.krishisanskriti.org/jceet.html

Experimental Modeal Analysis of Structural Beam Using Piezoelectric Sensor

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Abstract: **Over past 30 years assessment of structural Damages has drawn attention of Civil, Mechanical and aerospace engineers and thus automated nature of seasoning system and continuous performance assessment is gaining importance and thus in modern world structural health monitoring is important. Piezoelectric sensors have been employed for the health monitoring of structures owing to their simultaneous sensing/actuating capability. This paper is aim to assess damages in one dimensional structure using curvature mode shape technique. Occurrence of damages are determined using frequency response function (damaged and undamaged) based on the global dynamic technique. Finally, damage severity was determined in terms of the curvature mode shapes directly obtained through response of piezoelectric sensor.**

1. INTRODUCTION

In the modern technological scenario, structural health monitoring (SHM) is one of the most researched topics. SHM is gaining importance day by day as failure of any infrastructure causes severe loss of life and economy. SHM can be described as the process of continuously monitoring the structure from the day of its construction to the end of its life period. Various methods are available to monitor the structure. The global dynamic techniques are used only in low frequency range (typically < 200Hz) and can detect moderate to severe damage (Akten., 1998[1]; Shanker et. al., 2011[2]). Curvature mode shape technique is a part of global vibration techniques. The primary objective of this work is to assess damage in one dimensional structure using curvature mode shape technique based on piezoceramic sensors.

A structural health monitoring (SHM) system comprises a distributed array of sensors, embedded inside or attached to a structure, along with the hardware to transmit and analyses the data from the sensors. The purpose of the system is to continuously or periodically monitor the integrity of the structure or detect any abnormal behavior and take remedial action. Over the long term, the output of the process is updated information about the ability of the structure to perform its intended function in light of aging and degradation from the environment. Although health monitoring is a maturing concept in the manufacturing, automotive and aerospace industries, there are a number of challenges for its effective applications on civil and defence infrastructure systems. While successful real-life studies on a new or an existing structure are critical for transforming health monitoring from research to practice, laboratory benchmark studies are also essential for addressing issues related to the main needs and challenges of structural health monitoring.

2. VIBRATION TECHNIQUES

The basic principle of vibration techniques is to apply structural excitations through actuators or other means, and to measure structural response through measurement of displacement, acceleration, strain or velocity. Changes in natural frequencies or mode shapes indicate changes in the structure, which in turn can indicate that damage has occurred. Existence of structural damage in an engineering system leads to modification of the vibration modes. These modes are manifested as changes in modal parameters such as the natural frequencies, the mode shapes and the modal damping values, which can be obtained from the results of dynamic vibration testing. Changes in modal parameters may not be the same for each mode since the changes depend on the nature, location and severity of the damage. This effect offers the possibility of using data from dynamic testing to detect, locate and quantify damage.

The advantage of measuring vibration responses is the global nature of the derived natural frequencies which allows measurement points to be chosen to suit the test situation. Modal parameters can be easily obtained from the measured vibration responses with relatively less effort. Conventionally, the responses are acquired by some type of transducer, generally accelerometers, which monitor the structural response to artificially induced excitation forces or ambient forces in the service environment. Low input energy levels are sufficient to produce measurable responses since the input energy is dynamically amplified.

Results from some experimental and numerical studies have suggested that the lower vibration modes are fully capable of damage detection. However, it is also well established that modes higher than first should be used in damage detection so as to improve the identification. The increased sensitivity of the higher modes to local damage has been reported by Alampalli et al. (1992)[3]. Since higher modes are usually unavailable from the results of a full-scale modal survey, their use in damage detection cannot be implemented in real practice through usual dynamic techniques.

During the recent years, PZT patches have been employed for the health monitoring of structures owing to their simultaneous sensing/actuating capability. The structural health monitoring has been gaining more importance in civil engineering areas such as wind engineering and earthquake engineering. However, only few structures such as historical buildings and few critical bridges have been instrumented with structural monitoring system due to high cost of installation, long and complicated system of wires and lack of knowledge about modern sensors.

This paper aimed at developing a generic system to apply global vibration technique in one dimensional structure subjected to damage using Lead Zirconate Titanate (PZT) sensors. PZT sensors are not only cost effective but also small, structure-compatible, durable and long lasting. In this paper the experiment is done on an aluminum beam (simply supported condition) specimen. The PZT sensors are coupled and bonded on surface of steel beam to obtain the curvature mode shapes of the beam (damaged and undamaged).

2.1 Global Vibration Techniques for SHM

The presence of damage or deterioration in a structure causes changes in the natural frequencies of the structure. The most useful damage location methods (based on dynamic testing) are probably those using changes in resonant frequencies because frequency measurements can be quickly conducted and are generally reliable. Abnormal loss of stiffness is inferred when measured natural frequencies are substantially lower than expected (Bhalla., 2001)[4].

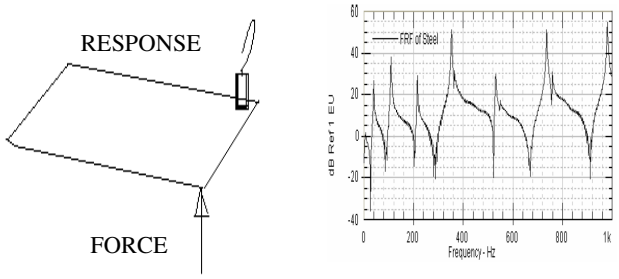
At nodal nodes (points of zero modal displacements), the stress is minimum for the particular mode of vibration. Hence, the minimal change in a particular modal frequency could mean that the defect may be close to the modal node. The other modal frequency variations can still be used to determine the magnitude of damage. When using vibration testing for integrity assessment and for successful utilization of vibration data in assessing structural condition, the measurements should be taken at certain specific points. The simplest way of achieving this is to conduct a theoretical vibration analysis of the structure prior to testing. The best positions would be those points where the sum of the magnitude of the mode shape vectors is maximized.

The advantage of measuring vibration responses is the global nature of the derived natural frequencies and this allows measurement points to be chosen to suit the test situation. The disadvantages associated with the global dynamic technique i.e. of lengthy flexible matrices and structural stiffness has been done away by this technique. Also PZT patches have been employed for the health monitoring of structures owing to their simultaneous sensing/actuating capability, and lower cost as compared to the accelerometers. Modal parameters can be easily obtained from the measured vibration responses with relatively less effort and can be acquired by any commercial data acquisition system.

2.2. Modal Analysis

Modal analysis is a process whereby we describe a structure in terms of its natural characteristics namely the frequency, damping and mode shapes-its dynamic properties.

Let's consider a freely supported flat plate (Figure.1. (a)). Let us consider a fixed frequency of the constant force. We will change the rate of oscillation of the frequency but the peak force will always be the same value-only the rate of oscillation of the force will change. We will also measure the response of the plate due to the excitation with an accelerometer attached to one of the plate.



a) Plate b) Frequency response function (FRF)

Fig. 1 Simple plate excitation/response model (Avitable, 2008)[6]

Now if we measure the response on the plate, we will notice that the amplitude changes as we change the rate of oscillation of the input force (Figure.1. (b)). There will be increase as well decrease in amplitude at different points as we sweep up in time. This is exactly what happens –the response amplifies as we apply with a rate of oscillation that gets closer and closer to the natural frequency (or resonant frequency) of the system and reaches a maximum when the rate of oscillation is at the resonant frequency of the system.

This time data provides very useful information. But if we take the time data and transform it to the frequency domain using Fast Fourier Transform (FFT) then we can compute

something called the frequency response function (FRF).Now, if we overlay the time trace with the frequency trace what we will notice is that the frequency of oscillation at the time at which the time trace reaches its maximum value corresponds to the frequency where peaks in the frequency response function reaches a maximum. So we can use either the time trace to determine the frequency at which maximum amplitude increases occur or the frequency response function to determine where these natural frequencies occur. Clearly, the frequency response function is easier to evaluate.

The modal analysis has the following advantages:

(a) It can assist in the design of almost any structure.

(b) It can help to identify areas of weakness in the design or areas where improvement is needed.

(c) Uses modal data to determine the effects of changes in the system characteristics due to structural changes.

(d) A very important aspect of modal testing is that it can be correlated and corrected with the analytical or numerical model of the structure.

3. PIEZOELECTRIC MATERIALS AS DYNAMIC STRAIN SENSOR

The phenomenon of piezoelectricity occurs in certain classes of non-cento-symmetric crystals, such as quartz, in which electric dipoles (and hence surface charges) are generated due to mechanical deformations. The same crystals also exhibit the converse effect; that is, they undergo mechanical deformations when subjected to electric fields. The constitutive relations for piezoelectric materials for 1D interaction (Bhalla, 2004)[5], such as for a piezoelectric plate are shown in Equation (1) and (2).

$$D_3 = \in_{33}^{T} E_3 + d_{31} T_1 \quad (1)$$

$$S_1 = \frac{T_1}{Y^E} + d_{31} E_3 \quad (2)$$

where, d_{31} is Piezoelectric strain coefficient, S_1 is strain, D_3 is Electric charge density over PZT, Y^E is Young's modulus of the PZT patch at zero eclectic fields, $\in_{33}^{T}$ is Complex permittivity of the PZT at zero stress and E_3 is Electric field in direction 3. If a PZT patch surface bonded on a structure is desired to be used as a sensor only (with no external electric field across its terminals, i.e. $E_3 = 0$, its governing sensing Equation (2) can be reduced to Shankar et al., (2011)[2].

$$D_3 = d_{31} Y^E S_1 \quad (3)$$

where $Y^E S_1$ has been substituted for T_1 making use of the Hooke's law. From the theory of parallel place capacitors, the charge density can also be expressed as

$$D_3 = \frac{\in_{33}^{T} V}{h} \quad (4)$$

where V is the potential difference across the terminals of the PZT patch of thickness h. Using Equations (2) and (3), the strain in the PZT patch (and hence on the structure it is bonded to) can be expressed in terms of the voltage measured across its terminals as

$$S_1 = \left(\frac{\in_{33}^{T}}{d_{31} h Y^E} \right) V = K_p V \quad (5)$$

A Simply supported beam is chosen for the experiment as Curvature mode shape and displacement mode shapes are of same form and changes in the curvature mode shapes increases with the increase in the damage and hence amount of damage in the structure can be obtained.

4. EXPERIMENTAL PROCEDURE

The experiment is done on an aluminum beam (see figure.2b.) bonded with the PZT sensor under simply supported condition. It is divided into four equal parts such that each part is a nodes depicted in the figure 2 and PZT sensor is in the middle.

Fig. 2a. Simply supported beam mode (all dimensions in mm)

Fig. 2b. Actual experimental Aluminium strip

In this experiment force is applied at all four nodes as represented in the Figure.3. and output is obtained using PZT in Digital oscilloscope.

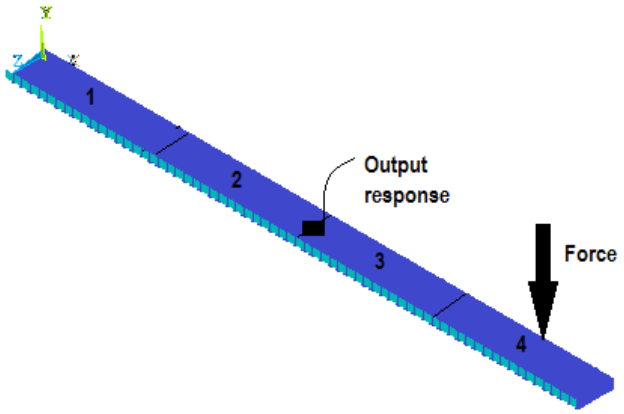


Fig. 3. Simple Plate excitation model

Output is obtained for both impact hammer and beam. The output is obtained in the time domain and it is converted into frequency domain by doing Fast Fourier Transformation This transformation gives complex values comprising of real and imaginary part. The frequency response function (FRF) can be calculated as

$$h(w) = \frac{\mu}{F} \qquad (6)$$

Experiment is done for damaged beam i.e. adding some additional mass in beam at two different locations. Natural Frequency of undamaged beam is at 28 Hz. In this method one PZT sensor was used to take response and impact was done at seven different locations.

One channel of oscilloscope was connected to PZT sensor and other channel was connected to force measuring device force sensor. FRF of each response and force was obtained by using MATLAB® program. Peak point at natural frequency at every node location was used to plot curvature mode shape.

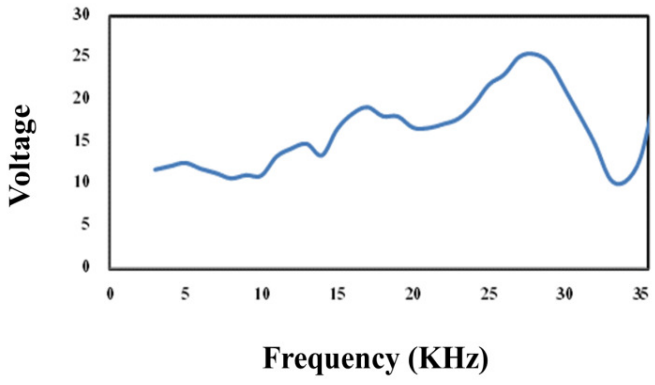


Fig. 4. Natural Frequency of aluminum Beam for undamaged condition

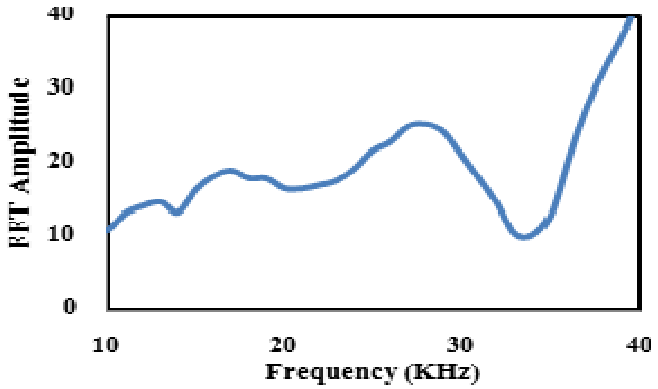


Fig. 5. Natural Frequency of aluminum Beam for damaged condition

To detect damage in specimen the comparison is done between the sensor responses for different node position where the excitation was given through force hammer. The following figures represent the piezo response for input force excitation in different node location of beam for both undamaged and damaged condition.

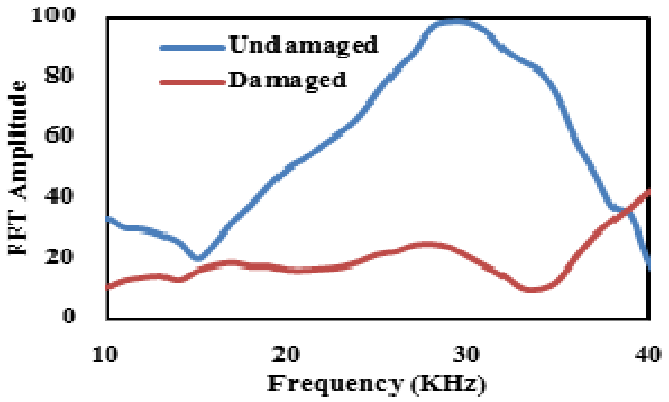


Fig. 6. Frequency response of sensor for force at node1

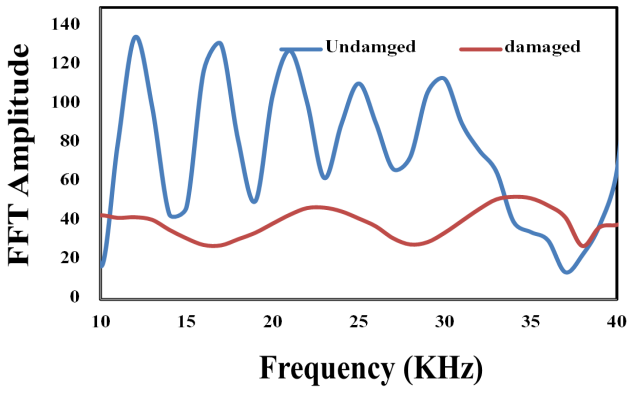


Fig. 7. Frequency response of sensor for force at node2

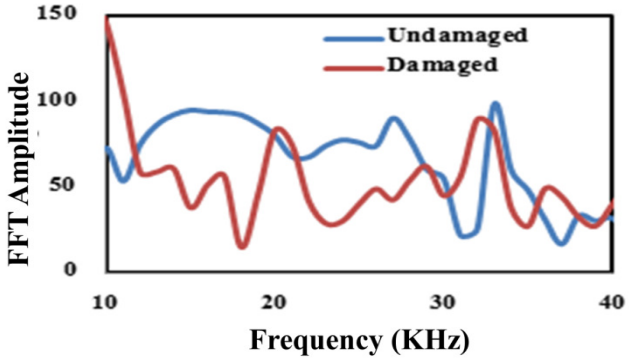


Fig. 8. Frequency response of sensor for force at node3

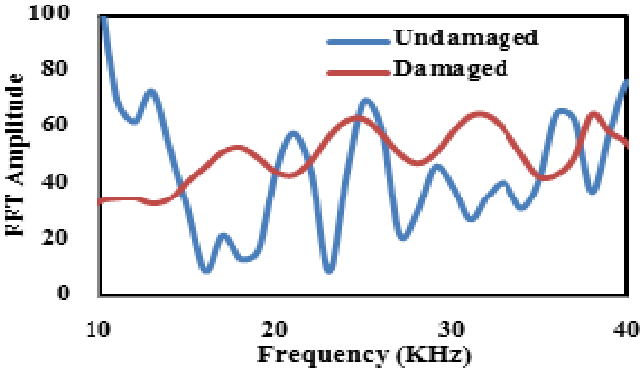


Fig. 9. Frequency response of sensor for force at node4

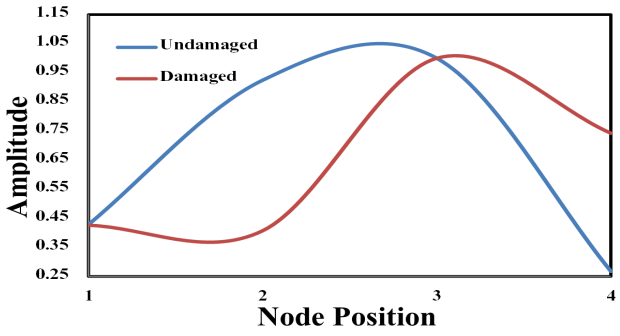


Fig. 10. Mode Shape of aluminum beam identified by piezo response for both damaged and undamaged condition

The mode shape is obtained by using frequency response function of piezo sensor. The Comparison of mode shape is done to localize the damage position in beam. Figure.10. represents the mode shape of beam for both damaged and undamaged condition. The variation in mode shape is significant at node position 2 and 3, where artificial damage is induced be adding mass in that location. Figure.10. represents the quantification of damage severity for the beam. The damage severity of beam can be evaluated by subtracting peak amplitude of Relative difference in peak values of undamaged and damaged beam.

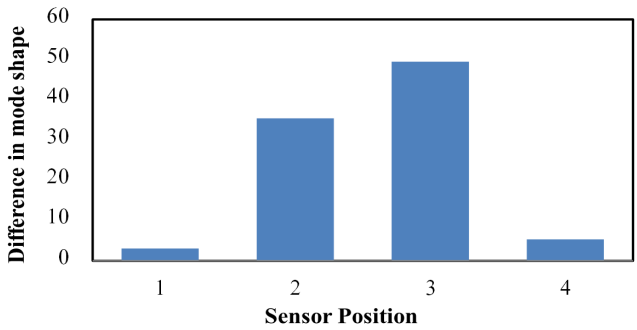


Fig. 11. Relative difference in peak values of undamaged and damaged beam

5. CONCLUSION

This paper is aimed to assess damage in one dimensional structure using curvature mode shape technique based on global vibration technique, operates on low frequency range (typically < 200Hz). The experiment has been done on an aluminum beam bonded with the PZT sensor under simply supported condition. Occurrence of the damage is determined using frequency response function (damaged and undamaged). Finally, damage severity was determined in terms of the experimental mode shapes directly obtained through response of piezoelectric sensor. It is found to be an efficient, cost effective technique for detecting damage in complex civil, mechanical and aerospace structures as it is free of complex analytical model and save time from large computational effort.

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Journal of Civil Engineering and Environmental Technology
Print ISSN: 2349-8404; Online ISSN: 2349-879X; Volume 1, Number 6; August, 2014 pp. 46-48

http://www.krishisanskriti.org/jceet.html

Use of Efficient Tools for Tying Rebar on Indian Construction Sites

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Abstract: **In construction of a RCC structure, there is an essential part of making a reinforcement cage, which can be made by tying different re-bars with the help of a tie wire as per the design requirements. There are different tools for tying of re-bars like – conventional hook, hand twister and automatic tying machine. In India, there is a huge lack of skilled workmen force and hence use of conventional hook is most prominent at construction site which indirectly hamper the project productivity and hence increases the cost of construction. It is very important to introduce new better tools in Indian construction industry which are already in practice in other countries. This paper deals with the use of new innovative tools for tying of steel re-bars at construction site and the comparison of these different tools on basis of various criterions like time consume in tying one knot, cost of tools, productivity measurement and health problems related to workmen while using different tools for tying of re-bars.**

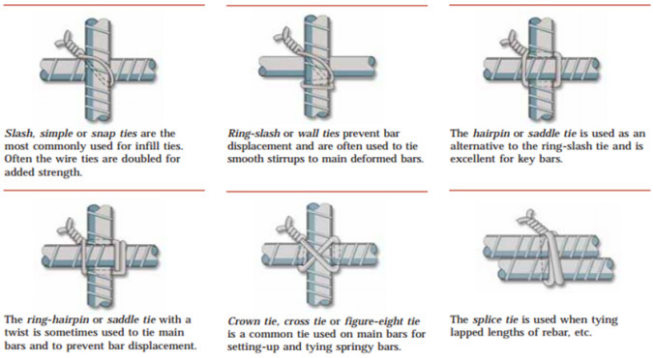
1. INTRODUCTION

India is a country where world's second largest amount of concrete is produced with an average of 280 million tonnes and 20,000 metric tonnes of steel re-bars per year. This data show that how extensively India is investing in construction sector which directly pronouncing the use of new and innovative techniques at construction site which increase the productivity and hence reducing the cost of construction. In all RCC structures, use of steel re-bars, formwork and concrete are three essential parts which required higher cost, time and labor inputs. Out of which, tying of re-bar is one of the process in making of steel re-bar cage before pouring concrete which consumes higher time and labor as per current work scenario in India. Due to lack to skilled labor, and huge difference between the demand and supply of technology, new tools and techniques are not implemented directly on construction sites. In this manuscript, three different tools are examined at construction site to calculate the productivity rate and time consumption required to tie re-bar knot.

2. THEORY

2.1. Definition

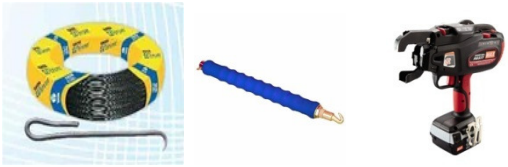
"Tying of re-bar" is the process of connecting re-bars together with the help of tying wire. There are different types of tie wires [3-4] – Regular steel wire, electro – galvanized wire and polyester coated wire that are used in construction industry depend upon the type of and value of structure. There are generally five different types of ties that are in practice at construction sites in India – slash tie, crown tie, hairpin tie, ring – slash tie and ring – hairpin tie. Figure 1 shows different types of ties.



Φιγυρε 1. Διφφερεντ τψπε οφ τιεσ υσε ιν χονστρυχτιον σιτε.

2.2. Tying tools

There are three types of tools for tying steel re-bars at site – conventional hook, hand twister and automatic tying machine. Figure 2 shows three different ways for tying steel re-bars.



Φιγυρε 2. Διφφερεντ τψπεσ οφ τψινγ τοολσ χονϖεντιον αλ ηοοκ, ηανδ τωιστερ ανδ αυτοματιχ τψινγ μαχηινε.

2.2.1. Conventional hook

This is a very basic tool which is most common at Indian construction sites by which a workman ties the re-bars with the help of tie wire. Conventional hook is a re-bar which is

twisted and bended with the help of bending machine to make fit for tying purpose. This tool has many problems related to productivity of work as well as the health related issues for workmen. As, while using conventional hook tool, there is a requirement of twisting the tool again and again for each and every tie wire to tie re-bar which consumes more time and quality also hampers. Another problem is related to the productivity of the work, that is this tool is not cover with any grip which can protect hook to become hot during working hours, thus frequently, a workman has to drop it for a while and work hampers. Some issues related to the health problems of a workman are the musculoskeletal injuries to the back and upper limbs.

2.2.2. Hand twister

This tool is an up gradation over a conventional hook tool. Hand twister completely eliminates the twisting effort for tying of re-bar with the use of tie wire. It has a spring mechanism that allows a workman to just plug tie wire and pull backwards which allows twisting of a tie-wire. This tool is more convenient in comparison with conventional tool in many respects.

2.2.3. Automatic tying machine

This tool is most recent and is best in comparison to other two types of tools. This tool allows very fast working condition with minimal health problems to the workmen. Automatic tying machine is costly tool but it makes very efficient working conditions which increase the productivity tremendously and hence overall cost gets reduced.

3. TESTING

An experimental study has been conducted by the author of this manuscript. Conventional hook and hand twister are used and time is calculated. For Automatic tying machine, the time is taken from the other technical paper as mentioned in a reference. After observing the time taken for tying a re-bar with one tie wire, a hypothetical 10 storey building is taken and the total time in making reinforcement cage of floor and foundation up-to 10th storey is calculated and shown in Table1.

Ταβλε 1. Τιμε ρεθυιρεδ το τιε ονε ρεβαρ κνοτ βψ υσε οφ παρτιχ υλαρ τοολσ.

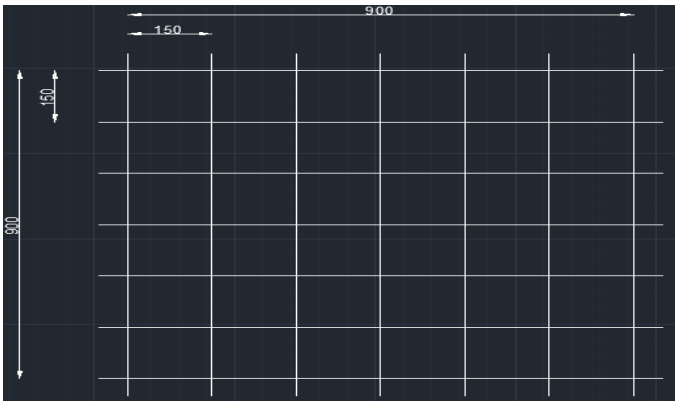
S. No.	Re-bar tying Tool	Time taken to tie one knot
1	Using Conventional hook	13 – 15 sec
2	Using hand Twister	9 – 10 sec
3	Using Automatic Tying Machine	4 – 5 sec

The time taken to tie one knot includes:-

A. Taking out one bending wire from the lot.
B. Shaping and Sizing of a bending wire by hand.
C. Placing of a bending wire at a correct position.
D. Tying of a bending wire with use of conventional hook / manual twister / tying machine.

4. ILLUSTRATION

For an illustration, we are taking a G + 10 storey building with an area of 15m x 30m, in which distance between each steel bar is 150 mm as shown in Figure 3.



Φιγυρε 3. 900μμ ξ 900μμ ρεινφορχεμεντ χαγε ηαϖινγ βαρ σπαχι νγ 150μμ.Σηοωινγ σπαχινγ βετωεεν τηε ρεινφορχεμεντ βαρσ.

For simplifying it, let's take a reinforcement cage of 900mm x 900mm, having 49 joints to be tied with tie wire. For a building area of 15m x 30m, there are 556 such segments of 900mm x 900mm that will accommodate in it and for a whole ten storey building, there are 24 such meshes of reinforcement will be required to tie. The calculations are shown in Table 2.

Ταβλε 2. Χαλχυλατιον οφ τοταλ δαψσ τηατ αρε ρεθυιρεδ το τι ε σλαβ κνοτσ οφ Γ+10 στορεψ βυιλδινγ ωιτη τηε ηελπ οφ ονε ω ορκμαν.

1	2	3	4	5	6
S. No.	Re-bar tying tool	Time taken to tie one knot	Time taken to tie 900 x 900 mm steel cage (3*49)	Time taken to tie 15m x 30m steel cage (4*556)	Time taken to tie whole building steel cages (5*24)
1	Conventional Hook	13 – 15 sec.	14*49 = 686 sec.	686*556 = 381416 sec. or, 106 hrs.	216 days

				or, 9 days	
2	Hand Twister	9 – 10 sec.	9.5*49 = 466 sec.	466*556 = 247976 sec. or, 69 hrs. or, 6 days	144 days
3	Automatic Tying Machine	4 – 5 sec.	4.5*49 = 221 sec.	221*556 = 122876 sec. or, 34 hrs. or, 3 days	72 days

Ταβλε 3. Ποιντ οφ διφφερενχε βετωεεν υσε οφ τηρεε τοολσ ι ν Ινδιαν χονδιτιονσ.

Point of Difference	Conventional Hook	Hand Twister	Automatic Tying Machine
Total time taken for tying steel with one tie wire	13 – 15 sec.	9 – 10 sec.	4 – 5 sec.
Productivit y	1	1.5	3
Health related problems to workmen	Very sever musculoskelet al injuries to the back and upper limbs.	Less sever musculoskelet al injuries to the back and upper limbs.	Very less musculoskelet al injuries to the back and upper limbs.
Work efficiency	Frequently drop out the tool because of overheating and absence of grip.	Fewer drops out of tool because of good grip and elimination of twisting effort.	Very few drops out of tool because of good handle ability and workability.
Cost	Rs. 10/- to Rs. 50/-	Rs. 1800/- onwards.	Rs. 12000/- onwards.

5. CONCLUSION

By above results it is clear that if in construction, automatic tying machine is use instead of conventional hook, productivity will increase tremendously by 300% and the cost of construction will reduce. Thus it is required to use such new tools and techniques at Indian construction sites which can enhance the productivity and quality of work [1-2-5]. In Table 3, the comparisons of all three tools are depicted.

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Journal of Civil Engineering and Environmental Technology
Print ISSN: 2349-8404; Online ISSN: 2349-879X; Volume 1, Number 6; August, 2014 pp. 49-53

http://www.krishisanskriti.org/jceet.html

A Study on Critical Success Factors for the Effective Program Management in Multiple Project Environments in Indian Retail Construction

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Abstract: **In the Indian Retail construction industry, multiple project environments (MPE) exist where challenge are in handling more than one project simultaneously. The success of the implementation of MPEs lies in the success of the Program Management team by way of pragmatic allocation of resources and by identifying the Critical success factors (CSF). The current lack of clarity associated with the discipline and the practice of program management in this no one-knows-what-happens-next state of the global economy calls for a better understanding, insight and analysis of what is/are critical to successful construction programs.A total of 35 numbers of usable questionnaires were received and analysed, 3 semi-structured interviews were conducted with program management experts and critical literature review was conducted to establish, ascertain and document the factors that are critical to the success of implementation and the practice of program management in the construction environment. The findings in this research are based on a theoretical and pragmatic synthesis of literature review, questionnaire survey and semi-structured interviews with program management experts. The study seeks to provide a better understanding, insight and analysis of the factors critical that are critical to the success of any effective construction program and the way forward.**

Keywords: **Program management, Critical success factors (CSF), multiple project environments (MPE).**

1. INTRODUCTION

Organisations are taking management initiatives by shifting the paradigm of project management to the management of multiple projects (Blomquist and Müller, 2006, Pennypacker and Dye, 2002, Evaristo and van Fenema, 1999) as an efficient vehicle to successfully deliver improvements and changes due to the unpredictable economic climate (Shehu and Akintoye, 2010). For the construction industry, it needs to assimilate new steps to intervene with such uncertainties to survive. Thus managers are altering their strategic direction to expand opportunities and expand capacity for marketing, sourcing, introducing new infrastructure and taking advantage of distributed location (Dooley et al., 2005).

Studies on the management of multiple projects are dominated by the high technology industry (Caniëls and Bakens, 2011, Patanakul and Milosevic, 2009, Maylor et al., 2006) specifically on the new product development. Few studies have examined and little analytical attention has been paid to the management of multiple projects environment within the construction industry (Gholipour, 2006, Blismas et al., 2004, Dubois and Gadde, 2002).

Furthermore, most studies have demonstrated the existence of multiple projects environment from the context of developed country. Although studies on construction industry in the context of developing country has been acknowledged in the literature (Ngowi, 2002, Ofori, 2000), little recognition has been given to the multiple project environments within the construction industry.

It is important to recognise the management of multiple projects environment from the developing country because the construction industry among countries is different as presented in the cultural studies of the construction projects, firm and site by Baiden and Price (2011). Thus, the complexity of challenges will be different in the level of socio-economic stress, chronic resource shortages, institutional weaknesses and a general inability to deal with the key issues (Ofori, 2000).

2. BACKGROUND LITERATURE REVIEW

2.1 Multiple project environments

Initially, MPEs was referred to, "an organisational level environment in which multiple projects are managed concurrently" (Patanakul and Milosevic, 2009, p. 217). However, this definition needs to be extended not to focus only on more than one project managed simultaneously, but also at various locations (Evaristo and van Fenema, 1999), on the possibility of involvement from multiple organisations (Dubois and Gadde, 2002)

These two features of multiple projects at various locations and involves multiple organisations are important in defining MPEs. The first feature stressed on various locations because within the construction industry, projects are influenced by geographical location which includes international and domestic distribution whether in a local region or elsewhere.

Table 1:' summarise the discussion on the challenges in the MPE.

MPE / Challenges	Uncertainty	Interdependency
Organisational Input	Project selection (Patanakul and Milosevic, 2009) To understand the project priority, match between the ability of project managers and the project assignments Resource allocation (Elonen and Artto, 2003, Fricke and Shenbar, 2000)	
Management Processes	Lead group of projects (Patanakul and Milosevic, 2009,Patanakul and Milosevic, 2008) -Problem solving (Engwall and Jerbrant, 2003) -Information sharing (Elonen and Artto, 2003) -Multitasking (Patanakul and Milosevic, 2008) -Communication (Lycett et al., 2004)	Management of single projects (Shehu and Akintoye, 2010) -Project Management Process (Hashim and Chileshe, 2012) To adjust and link schedules to match available resources, and remove unnecessary variation in workloads of project managers Inter-project interactions (Milosevic, 2009, Fricke and Shenbar, 2000)
Project Output	Projectmanager's expectation (Patanakul and Milosevic, 2009, John et al., 2000) Project's benefit (Shehu and Akintoye, 2010)	

This distribution is due to the potential benefits of the physical location and where professionals are involved in the project operation location (Zavadskas et al., 2004). One project can be performed in several sites concurrently, as long as the correspondent actions share the same objectives (Evaristo and van Fenema, 1999). The management of these projects is assumed to be either centralised or distributed located in any of the sites or nodes. The challenge of project's location of multiple projects is related to the focus on the co-ordination mechanisms, with the option of either focusing on inter-site or boundary spanning across sites, or concentrate on intra-site or boundary spanning across projects (Hashim and Chileshe, 2012).

The second feature originated from the construction management which is complicated by several organisations involved in the supply chain. The organisations are also engaged in other projects in which they have to coordinate their activities and resources with different sets of organisations. This affiliation shows that an organisation is capable in managing more than one project simultaneously in the construction industry (Dubois and Gadde, 2002) and supports project-based structures (Söderlund, 2004). The increased use of project-based structures defines the nature of multiple project environments with the involvement of multi-project organisations.

From these features, the representation of challenges instigated from the complexity in managing multiple projects could be illustrated. For example, the projects located in multiple locations will focus on the co-ordination mechanisms, on single unit without segregating the projects into multiple units in sharing the projects goal and objectives even though they are widely distributed from each other (Desouza and Evaristo, 2004). On the other hand, projects which involves with multiple organisations will easily create conflict between the team mates, and impede the establishment of "organisation culture" of multiple projects environment particularly between different levels of management or between other projects, especially when competing after the same resources (Fricke and Shenbar, 2000, Olford, 2002). Therefore, these features illustrate the challenges in managing the MPE that will minimise the effectiveness in managing the projects.

3.2 Program Management and its benefits in managing MPE

Program management is not a synonym of project management (Pellegrinelli,1997), but an integrated approach that can streamline the effective delivery of projects (Gray, 1997); Lycett et al. (2004) observe that the former has its roots in the latter and according to Milosevic et al. (2007) the two concepts are often confused. Therefore, it has been observed that organisations use the terms 'project management' and 'program management' interchangeably (Ferns, 1991;

GAPPS, 2008), whereas the two are completely different but directly related to one another (Reiss, 2003). For program management to succeed there is need to define and differentiate its practices from those of project management to avoid leaving them to serendipity. Programs tend to be dynamic in nature with intense cross-discipline and cross-project integration (OGC, 2003), in which the actions of one functional project affects, supports and reinforces the other project teams involved in the programme (Milosevic et al., 2007; Thomsen 2008). On the other hand, program management involves management of a group of projects (Ferns, 1991; Lycett et al., 2004), while project management deals with the effective management of activities to deliver the project within the approved cost quality and time (Turner, 1993; Burke, 2003). The high level of synergy and integration in program management requires the identification of certain CSFs that will facilitate efficient delivery (OGC, 2003; Milosevic et al., 2007).

In program management, critical success factors are identified to enable tracking the value of program outputs; they should enable proper assessment of the few fundamental aspects of the program that must be done well to achieve the objectives of the program (Wren 2003). While the relationships project management and program management are observed to be synergistic (Milosevic et al., 2007), the CSFs for project management may be insufficient to those of program management (Reiss, 2003). In the same manner that program management emerges from project management (Ferns, 1991; Lycett et al., 2004), the CSFs of the former may also be related or emerged from the latter; therefore, based on the above established relationships between projects and program, this research reviews, establishes and analyses the CSFs for effective program management, which may have emanated from project management.

Rockart (1982) first used critical success factors (CSF) in the context of information systems and project management and a number of researches have been subsequently reported in this field. Rowlinson (1999) and Thomsen (2008) state that CSFs are those fundamental issues inherent in the project (s), which must be maintained in order for team working to take place in an efficient and effective manner. CSFs require day-today attention and operate throughout the life of the project. OGC (2007) believes that CSFs are limited in the number of areas that, if fully addressed, would ensure the successful completion of the program. Identifying and communicating the CSFs ensures that everyone in the program team is focused.

3.3. Critical Success factors for handling MPE projects by Program Managers

Below are some of the CSF factors that are found to be critical to the success of Retail construction MPE programmes:

Table 2 : Factors affecting the success of the construction projects (Chan, 2004)

Factors affecting project success	Variables
Project related	1. Type of project 2. Nature of project 3. Number of floors of the project 4. Complexity of the project 5. Size of the project
Procurement related	1. Procurement method 2. Tendering method
Project Management related	1. Communication System 2. Control mechanism. 3. Feedback capabilities. 4. Planning effort. 5. Developing an appropriate organisation structure. 6. Implementing an effective safety program 7. Control of contractors works. 8. Overall managerial actions.
Project Participant related (Client, contractors,sub contractors, manufacturers)	1. Client experience. 2. Nature of client. 3. Size of client organisation. 4. Clients emphasis on low construction cost. 5. Clients emphasis on high quality construction. 6. Clients emphasis on quick construction. 7. Clients ability to approve. 8. Clients ability to make decisions. 9. Clients ability to define roles. 10. Clients contribution to design. 11. Clients contribution to construction. 12. Project teams leaders experience. 13. Technical skills of project teams leaders. 14. Organising skills of project teams leaders. 15. Motivating skills of project teams leaders. 16. Project teams leaders commitment to meet cost, time and quality. 17. Project teams leaders early and continued involvement in the project. 18. Project teams leaders adaptability to changes in the project plan. 19. Project teams leaders working relationship with other stakeholders. 20. Support and provision of resources.

External Related	1. Economic environment. 2. Social environment. 3. Political environment. 4. Physical environment. 5. Industrial relations environment. 6. Technologically advanced.

1. Planning and establishing priorities.
2. Strategic review and approach.
3. Simplicity and easiness of techniques.
4. Learning and development.
5. Management infrastructure and understanding programme and its stakeholders.
6. Clarity/consistency of vision and benefits focus.
7. Coordination of projects and managing the transition/changes.

Having discussed the CSFs for effective programme management, these factors were listed into a Survey questionnaire to analyse and assess their effects on successful programme management practice.

To provide the exploratory and descriptive data analysis for CSFs for effective programme management, criticality, mean and Factor Analysis were employed in the statistical analyses.

3. RESEARCH METHODOLOGY

The findings in this research are through the triangulation of

1. Literature review,
2. Questionnaire survey and
3. Semi-structured interviews in the Retail construction industry.

In the survey, 250 postal questionnaires were sent using a convenience sampling; the sampling was conducted as the target (programme management organisations) population was not known by the researcher as highlighted by (Denscombe 2007; Fellows and Liu 1997; Bryman and Bell 2003). A total of 35 usable completed questionnaires were received and analysed, the number implies that approximately 14% of the total sample contacted has participated in this study.

Survey findings indicates the need for deeper understanding of the prerequisites of programme management, hence may justify the low response rate in this research. In the semi-structured interviews, to increase the depth and breadth of programme management knowledge, responses were also collected, analysed and synthesised from other non-construction programme management organisations. The sample of the population for the semi-structured interview was acquired by providing a column in the questionnaire for participants willing to be interviewed to provide their details; use of snowballing approach (Denscombe 2007) and referral by the programme management experts (Wisker 2008) were also employed to develop an adequate interview sample. At the end of the interview sessions, a total 3 interviews were conducted with programme management experts.

The results in the questionnaire survey were analysed using SPSS 17 and Microsoft Excel, the CSFs were analysed using Criticality Index and a comparison of the data was conducted using a t-test and Factor Analysis which reduced the CSFs into manageable groups.

3.1 Criticality Index for critical success factors

Abdul Kadir et al. (2005) used the Importance index to evaluate the factors affecting construction labour productivity for the Malaysian construction projects. Kometa et al. (1995) used a relative importance index to analyse the attributes of clients' organisations, which may influence project consultants' performance. Odeh and Bettaineh (2002) used importance to determine causes of construction delay in traditional contracts. Chan and Kumaraswamy (1997) also applied a relative importance index in their comparative study of the causes of time overruns in Hong Kong construction projects; Cheng (2002) used Importance Index in discussing technologyforesight. As a result of its popularity and accuracy, this research also adapts Criticality Index in ranking the CSFs for effective programme management.

To determine the relative importance index of the listed skills and competencies, this research uses Odeh andBettaineh's (2002) formula due to its clarity, simplicity of use, and the similarity between the data in this research and the data in their study. The analysis used the weighting used by Cheng (2002) as the values set for the Likert scale in this research aimed to add to a total of 1. Cheng used the weighting of the importance from 0.00, 0.25, 0.5, 0.75 and 1. In this approach, the weighting substitutes the position of the Likert scale. The maximum criticality index (**Equation 1**) of any of the skills factor should not be more than 1, and any skills and competencies with the highest value between 0 ≥ 1 are considered important.

$$C = \frac{\sum_{i=1}^{5} W_i X_i}{\sum_{i=1}^{5} X_i}$$

Equation 1: Criticality index

Where:

C = Criticality Index.

i= responses category index = 1,2,3,4 and 5 (position on the Likert scale).

W*i*= is the weight assigned to *i*th response = 0, 0.25, 0.5, 0.75 and 1 respectively (Cheng, 2002)

X*i* = frequency of the *i*th response given as percentage of the total responses (Odeh and Bettaineh, 2002).

The CSFs are ranked in ascending order of their criticality based on the rating in the responses.

Table 3: Presents the criticality analyses indices for the critical success factors for the successful practice of construction programme management in the Retail construction environment.

Critical Success factors	Total Responses
	Criticality Index
Effective planning	0.85
Understanding the stakeholders attitude	0.83
Establishing program priorities	0.79
Cross discipline coordination	0.79
Effective communication.	0.77
Proper coordination of projects	0.76
Effective risk management	0.739
Effective time management	0.725
Effective performance management	0.72
Strategic focus on programme	0.705
Effective budgeting	0.693
Cross project coordination	0.691
Clarity and consistency of vision.	0.678
Smooth handover to business operation on completion	0.672
Cross discipline problem solving	0.650
Clear benefits target	0.648
Effective change management	0.641
Management infrastructure	0.636
Simplicity of programme	0.629
Easiness of techniques used	0.627

According to Table 3, 'Effective planning' is the highest critical success factor with the Criticality Index of 0.850, then 'Understanding stakeholders attitude 0.83. Programme planning ie establishing program priorities is essential for the success of a programme (Bartlett, 2002; Reiss et al., 2006); as a result, it may be directly linked to the success of the implementation and practice of construction programme management.

4. CONCLUSION

The effective programme management though has its roots in the project management, but the two are not the same; hence the two though are related but their CSFs may also be related, but may never be the same. To successfully manage construction programmes, the programme management teams are expected to closely examine and establish those factors that are critical to the success of their programmes. The CSFs presented in the research on Retail construction are by no means the only ones that programme management organisations should pay attention to as the factors may differ from one organisation and programme to another.The reduction of the factors will provide the stakeholders, Academicians, Project Organisations and consultants with more clear and relevant groups, rather than being puzzled with a long list of factors. However, the organisations can adapt and generate other groups based on the nature and requirements for the critical success factors provided in this study, rather than a heuristic approach to the requirements.

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Journal of Civil Engineering and Environmental Technology
Print ISSN: 2349-8404; Online ISSN: 2349-879X; Volume 1, Number 6; August, 2014 pp. 54-59

http://www.krishisanskriti.org/jceet.html

Analysing and Rating Smart City Development in India

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Abstract: **India's recent stand on Smart City Development and involvement of various high income countries; initiates the talk of ideal variables for smart city evolution by our own standards. With a vision of Urban Governance for general livability, it becomes imperative to study these parameters and ensure the evolution of our own concept of a Smart City. Our spatial planning models based on unique factors such as Human Diversity, Physical-Social networks and ICT impact on urban fabric, City resilience, etc. make it all the more interesting to evolve a blueprint for Planning a Smart City.**

The paper centers the infrastructural developments for the Smart Urban Development in India. The research helps us arrive at a general line of action for Urban Planning implications catering to the Infrastructure Sector, amongst others; thus affecting environmental, social and economic structure significantly. The study further finds the scope of progress, encouraged from various government policies for successful implementation of Smart City Development. It also allows a peek into future scenario of improvements and deliberations particular to Indian standards in consideration with the scenario of other countries.

Keywords: **Human Capital, ICT based inclusive approach, Electronic Government, Smart Urban Development and Sustainability.**

1. INTRODUCTION

A city can be defined as 'smart' when investments in human and social capital and traditional and modern (ICT) communication infrastructure fuel sustainable economic development and a high quality of life, with a wise management of natural resources through participatory governance.

A "smart city" would describe the integrated management of information that creates value by applying advanced technologies to search, access, transfer, and process information. "Smartness" here is seen as an infrastructure quality. Cost and benefit optimization takes place when information sources are connected and information is shared in real time as that will have a profound impact on how cities are planned and managed for bettering the quality of life for citizens, provisioning water supply, transportation, entertainment, safety and security, delivery of government services etc.

At the beginning of urban studies and economic research of urban areas, cities were mostly seen as a 'by-product' of industrialization; currently however, they are rather treated as a catalyst of economic change with intensive correlation of urbanization and economic growth as well as increasing importance of high value added industries, mostly localized in cities. Increasing economic importance of cities is reflected in urban studies which transfers focus from social science (social relations in urban areas, segregation, social inclusion) increasingly towards economics (management, entrepreneurship, competitiveness). In context of economic research, cities are treated not only as a location for entrepreneurial activity, with institutional environment analysis, but also as an economic entity itself, capable of competing with other entities.

Urban development research points towards two pillars of urban growth, i.e. entrepreneurial environment and quality of life. Those two elements (represented by companies and people) are significant and necessary for a competitive city to develop [1]. Well elaborated in literature and implemented in urban practice concept of urban competitiveness gave grounds for the introduction of the idea of "smart city".

Papers objective is to analyse the country-wide movement for smart city development on policy level. Also we aim to rate this urbanization policy on smart service led development for future speculations of ICT inclusion for basing our conclusions.

1.1 India's Smart Urbanisation narrative

The reliance on western models of urban planning and containment has resulted in a catastrophic failure to manage the growth of cities in many low and middle income countries. The equity in Development of Indian cities relies largely on the resources allocation and ingenuity of Urban poor, leading

towards the sustainable urban development models which India seeks. Analysing the baffling numbers we understand that the measures to contain this is not an easy. Thus, out of necessity, the urbanisation policies of India are subjugated to ICT integrated governance systems.

JnNURM 1 had promoted e-governance focusing on eight areas, viz. B&D certification, property tax, payroll and personnel, e-procurement, building plan approval, water and utility payments, SWM, grievance system, trade licenses, project and ward works. Large scale investments in the urban sector were initiated. Soon it was realized that for improving services, reducing costs, process time, productivity gains, etc. i.e. bettering urban governance and service delivery, ICT revolution had to be capitalized. ICT synergizing with the emerging technologies is transforming businesses and societies in a significant way.

Phasewise evolution from good to smart cities;

- Inception (1990's): Information via cities' websites.
- Good Governance (2000's): City portals for Online information services.
- E-Governance (2005's): Intel-cities- Online web-based e-Learning system integrated & interoperable with other cities' platforms.
- Smart Governance (2010's): Smart cities- Having e-learning, participatory governance, support digitally inclusion, Intelligent buildings, Energy & environment efficient, Carbon emission & pollution controlled city development.

Now, with a vision of Indian cities of tomorrow as places of advanced social and environmental progress, while maintaining economic growth achieved by integrated approach, a need for including all aspects of sustainable development is being realized. Promotion of sustainable urban development while concentrating on issues of transport, mobility, energy for ICT implementation; various platforms of research to identify the tools for Smart development are being set up.

We are moving forward with a vision of regional development in Smart sustainable context for future India. It is thus imperative for us to list down and weigh the parameters as a means of comprehensive planning. Rating the cities will be the next step towards apprehending the pros and cons of such eccentric approach towards Smart Urban Development.

2. IMPORTANCE OF PARAMETERISING THE SMART CITY RATING: RESEARCH METHODOLOGY

Urbanisation and globalization, with trade liberalization measures and fast technological changes altering the relations of production, distribution and consumption, has very substantial effects on city development. As an important consequence, economies evolved with easier physical movement and globalized players made decisions with no regard to national boundaries [8]. Along with this progress private firms of the service sector and also of the production sector increasingly became footless and flexible in their location behavior. The ongoing reduction of differences and barriers between nations also made cities more similar in their preconditions. Thus, only a few out of many location-based characteristics gained importance for global actors [9-10] enforcing competition across cites by altering each city as potential competitor to improve its SMART Rating.

To enforce an endogenous development as per Indian standards, our urban centers have to aim on identifying their strengths and chances for positioning and ensure and extend comparative advantages in certain key resources against other cities as nodes of development. City rankings are a tool to identify these assets. Although they are quite common in recent time, rankings are very different in their approaches or methods. Due to different interests behind rankings and the indicators and methodological approaches used it is also normal that one city is ranked very different in different rankings.

We are thus establishing the following line of action or methodology for the research in our paper;

1. Analysing of major developments related to smart initiative in service delivery across India.
2. Establishment of elaborate sections for parameterising Smart City development, particular to Indian standards.
3. Deliberations or concise comparison of smart city development on Global scenario.
4. Basing the conclusions on general line of action for Smart Urban Planning.

3. SMART INITIATIVES IN URBAN MANAGEMENT ACROSS INDIA

Service delivery or City infrastructure can be broadly sub-divided into five sectors and further (refer figure 1). Although the concept of smart city goes beyond this narrow field of classification limited to ICT, it delivers infrastructure for social and economic initiatives concerning economic growth, social capital and higher resources efficiency.

In a broader approach, smart cities are treated as a new urban development paradigm, where we focus on phenomena such as human and social capitals, education and natural environment. Such models of urban development point to smart cities as areas which, on one hand, are a supporting factor for intellectual capital development and well-being growth by institutional system; at the other hand providing a knowledge transfer mechanism for system of innovation along with Sustainable development inclusions.

Following are the ideal smart services successfully implemented in various cities in India [7].

Figure 1: Smart service delivery areas through ICT for Urban Management [7]

Water Supply	Waste water	Solid Waste Management	Municipal Services	Revenue and Management
• Water Resource Management • Distribution Management • Internal Business Process • Water Quality Management • Billing & Collection • Grievances Handling	• Plant Management • Collection & Distribution • Billing and Collection • Internal Business Process • Grievance Handling	• Attendance Monitoring • Bin Tracking System • Vehicle tracking System • Waste collection & Transfer • Treatment and Disposal • Internal Business Processing	• Birth & Death Certificates • Building Plan Approval • Grievance Management • Utility Bills • Licenses • Traffic • Street Lights • Flooding	• Property Tax • E-Procurement • Accounting System • Personnel Management

Funding for these projects are being propagandized in various Central and State development policies. It has been established that investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance.

3.1 Water Supply

Distribution and monitoring system thru GIS, Hydraulic modeling, Online water quality monitoring, Sustainable operations- metering and online billing, etc. are some of the successful systems implemented in Indian cities which can be listed under smart water supply services.

A lot of 24/7 water supply programs in urban and rural sectors were implemented across India. GIS based mapping integrated with the hydraulic modeling, Metering with analyzers and online billing systems, centralized real time web based monitoring of water supply services improved water availability due monitoring of input and output points and checking of water distribution losses.

3.2 Waste water

Integration and automation of water treatment plant and sewerage systems, Enterprise resource planning (Oracle) system and grievance management funded under state projects and many local bodies.

Generation of database for sewerage services and grievance management services along with the grievance management services led to improvement in service delivery, bill collection and procurement leading to efficiency and transparency in waste water sector.

3.3 Solid Waste Management (SWM)

Off-site real time monitoring system, GIS and GPS enabled services, biometric attendance systems for sanitary workers, sensor based applications for smart solid waste management services.

GPS and GPRS technologies through cell phone images are taken and stamped with time and location and put in public domain for scrutiny on real time basis thus improving the SWM service delivery.

3.4 Municipal Services

Integration of all operations of municipal corporation through GIS (land based services), Computerised building plan scrutiny and approvals, Standardized online citizen administration (GIS based), Traffic information system initiative and many others as smart governance in Urban bodies. Land being the base of all operations for municipal services, GIS mapping and integration of various databases was initiated in JnNURM 1 for improving the services. Building Plan scrutiny and Approvals automation on a comprehensive level and its integration with GIS database accelerated the pace of development.

3.5 Revenue and Management

Municipal e-revenue systems using GIS linked property database, Tulana: online application for service level benchmarking, M-Governance, e-tendering, Dynamic

integration of property registration and land records administration system, Comprehensive Public Works Management Information and Management system for PWD's (State level) and many more advanced applications, catering to the smart service delivery in this sector.

Augmentation of municipal revenues for financing and maintenance of municipal services and infrastructure with focus on reforms in property tax using the GIS integrated with property database systems improved tax administration greatly. Submission of tenders, documents, EMD's, security deposits, tenders integrated with the accounting and ICT enabled services led to speed-up in service delivery of infrastructure through e-tendering and related smart services.

4. PARAMETERS FOR SMART CITY DEVELOPMENT

Summing up, smart city as a concept of urban development assumes it should include multiple spheres of growth: economy, people, urban governance, geographic mobility, natural environment, quality of life, etc. These areas should be further supported by information technology systems, provided they are a tool not a goal of development strategy. Smart strategy should also include not only multi-dimensional approach but also city's stakeholders, i.e. enterprise sector, inhabitants and local government.

Interesting approach to urban development determinants of a smart city is presented in P. Lombardi's paper [6]. Using Analytic Network Process (ANP) method, over 60 indices of urban development is analyzed. Indices are first grouped according to triple helix model, however helix is in this case extended to four dimensions, fourth dimension being civil society. ANP analysis, including relations between priorities (dimensions of the helix) and alternative solutions, gave grounds to grant following weights to particular determinants: (1) entrepreneurial city – 48 per cent, (2) innovative city – 20 per cent, (3) people friendly city – 17 per cent, (4) networked city – 13 per cent.

The criteria chosen for a analysis in OECD [2] should be significant for policy-making and application value; have good degree of analytical soundness and be quantifiable. Ever since the report was published, i.e. for over two decades, the state of urban research has changed significantly. The statement that: "It is still not common to study economic processes and products at the scale of cities" [2] is inadequate, however urban economics may not be considered leading concern of economists. Still, some challenges and recommendations presented by OECD remain current, e.g. still quantitative research in urban studies are rather fragmented and concern chosen spheres of economy (innovation or energy market), they are also territorially limited (regard few Western European cities or are a case study). Moreover, still quantitative analysis is biased by heterogeneity of statistical systems for local level. Therefore, OECD proposed best practices separately for different spheres of urban economy: natural environment protection, energy, economics, and sustainable development. Unfortunately, suggested by OECD "mission information" i.e. the need for data collection in urban areas in international dimension, is still valid. Lack of comparative (including international comparisons) and updated data is one of the challenges urban researchers and researchers have to overcome [3-4-5].

Many other elaborate smart city parameters for various cities worldwide can be found in the publishing's as noted below;

- "Quality of Living Survey" by Mercer Human Resource Consulting in 2007 (200 cities world-wide)
- "Canada's most Sustainable cities" by Corporate Knights: The Canadian magazine for responsible business in 2007 (Large Canadian urban centers)
- "How the world views its cities" by Anholt City Brands in 2006 (60 cities world-wide)
- "World-wide cost of living" by Economist Intelligence Unit in 2006 (130 cities world-wide)
- "Dritter Großstadtvergleich" by IW Consult GmbH / Institute of the German industry in 2006 (50 cities world-wide)

As discussed earlier the parameters can only help us in realizing the needs for a smart city. The key lies in location and regional approach.

4.1 Indian Smart City development

Understanding the comprehensive overview of the issues in smart city development in India, we can point out that;

- The population explosion has brought upon an urgent need to transform the Urban centers into ICT enabled smart cities for controlled service delivery systems.
- The twelfth Five Year Plan set out an approach for planned, inclusive, sustainable urban development and there is a need to consider the economic sustenance of the urban centers, if smart development is to be implemented.
- There are many organisations, Ministries and Government agencies with overlapping responsibilities some of whom support research, but it is not clear who has the main responsibility for supporting research on sustainable urbanization.
- Research on cities has been largely sectoral and lacks holistic focus combining society, economy, environment and technology.
- The idea of research on sustainable cities is gaining traction but needs to develop research on processes for

practice linking – policy plan, programs and projects to address rapid urbanisation.

- Whatever happens in the future, it is very likely that large scale informal development will continue in India and it was important to understand this and develop alternative pathways and theories to achieving sustainability and resilience.
- The economic restructuring, combined with the economic downturn, has raised levels of unemployment, particularly among young people, and so economic growth and building resilience to further change is a key priority for city authorities.
- The urban infrastructure has grown piecemeal and rising urban populations are putting pressure on housing and transport.
- Concerns about climate change, and the fact that 80% of the countries' population lives in cities, inevitably means that cities have a key role in improving energy efficiency and reducing carbon emissions, while promoting energy resilience in terms of security of supply and price.

How does the market penetrate informal cities and what are its impacts? What is the impact of peri-urban development on sustainability of cities? Which areas of research might prove useful of India when utilized as dealt with in other countries? The answers to these trigger the integration of smart notions of urban development on global scale. It can also be understood that we are in need to enforce our infrastructure management for service delivery realizing the above notions for a smart urban development.

Transformation of a city to Smart does not happen instantly. Strategy Development requires understanding of the issues and challenges for the particular city.

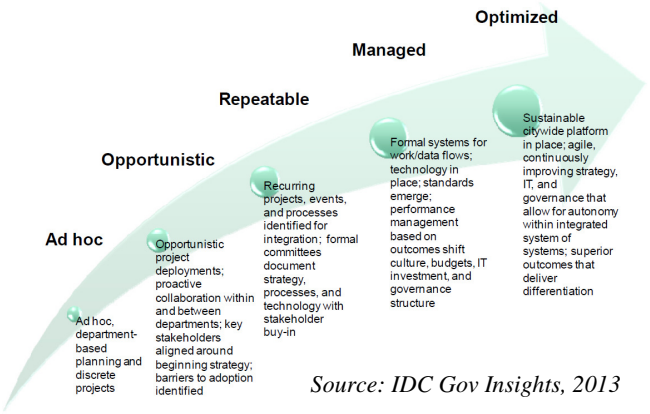

Fig. 2: Stages in Smart City Development

We need to develop a long term strategy for the city; prioritize on the projects; Integrate smartly; optimize the services and operations through the effective ICT and be ready to discover new opportunities for growth and optimization. The following generalized parameters can be considered for furthering a holistic approach towards smart city development;

Smart Governance (Participation): We need to inculcate public participation in decision-making, strengthen public and social services, have a certain level of transparency in governance, Evaluate political strategies & perspectives.

Smart People (Social and Human Capital): The level of qualification, affinity to life-long learning, Social and ethnic plurality, flexibility, creativity, open-mindedness and Participation in public life should be necessitated.

Smart Economy (Competitiveness): The innovative spirit, Entrepreneurship, Economic image & trademarks, Productivity, Flexibility of labour market, Ability to transform or respond to change are the requisites.

Smart Mobility: Local accessibility; availability of infrastructure (ICT); Sustainable, innovative and safe, transport systems.

Smart Environment (Natural resources): Attractive natural conditions, Pollution free environments, Environmental protection, Sustainable resource management are necessary for sustainable conditions.

Smart Living (Quality of life): The availability of Cultural facilities, Health conditions, Individual safety, Housing quality, Education facilities, Tourist attractions, and Social cohesion can contribute greatly towards our goal.

5. DELIBERATIONS AND COMPARISONS OF CITY DEVELOPMENT GLOBAL FRONT: CHINA STUDY

India has the complexities and issues of a developing, middle income country; our base concern being population explosion. Comparing the urban development approach of China we can realize the concerns and deliberations for India for a smart city approach. The scale and speed of urbanization for both countries are almost proportionate. However, China's urban expansion has clearly outpaced India's despite the fact that China had started with a lower proportion of population living in cities than India. The most significant difference between the urbanization paths of India and China has been China's deliberate and systematic effort to manage its urbanization, to ensure the sustainability of rapid economic growth and improvement in quality of life. While India has barely paid attention to its urban transformation, China has developed a set of internally consistent and effective practices across every element of the urbanization operating model: funding, governance, planning, sectoral policies, and shape.

Where India has underinvested in its cities, China has invested ahead of demand and given its cities the freedom to raise substantial investment resources by monetizing land assets and retaining a 25 percent share of value added and income taxes. While Indian cities have devolved little real power and accountability to the cities, China's major cities have powerful and empowered political appointees as mayors. While India still runs services in Indian cities out of city government departments, China has experimented with innovative delivery models including the use of corporatized agencies and special-purpose vehicles. While India's urban planning system has failed to address competing demands for space, China has a mature urban planning regime that emphasizes the systematic redevelopment of run-down areas consistent with long-range plans for land use and transportation. Where India has paid little attention to shaping its overall portfolio of cities, China's urbanization had a early focus on the dynamic coastal cities, with the result that these cities now deliver higher than national growth averages. This is the starkest contrast between the two countries: China, that has embraced and shaped urbanization, and India, which is still waking up to its urban reality and its inherent opportunities.

Fig. 3: World concentration of Urban centers

Both India and China will need to expand and build infrastructure on a grand scale to meet the needs of their surging urban populations. This is a significant market opportunity for international firms. From 2002 to 2007, India invested about 5.7 percent of its GDP on infrastructure to China's 9.3 percent. Over the next 20 years, both countries will need to at least maintain, and, most likely, materially increase this level of infrastructure spending to meet the challenge of urbanization. In 2007, India made urban capital investments of only $17 in per capita terms compared with $116 in China. Take impending demand for residential and nonresidential space. Depending on which urbanization planning scenarios each country pursues, India could potentially need to build 700 million to 900 million square meters of new residential and commercial space every year for the next 20 years, compared with 1.6 billion to 1.9 billion square meters per year for China. Or take metro railways and subways as an example. India could potentially have to construct nearly 350 to 400 kilometers of new metro railways and subways per year, while China may need to construct nearly 800 to 1,500 kilometers per year. Investors and businesses should prepare themselves to address the dynamic new opportunities that this massive transformation of the two most populous countries in the world will unlock.

6. INFERENCES

The smart city development is more concerned with making progress as concerns the smart indicators rather than rating a city, which inevitably is a snapshot in time. Consideration of different characteristics, factors and parameters in a non-weighted way expresses that the Urban Development is a complex process in different dimensions and evaluation, finally depends on the actors, their preferences and individual objectives. Perhaps it would not be an exaggeration to say that truly smart city may use the parameters and rating as a tool to benchmark with other cities, and draw lessons from better performing cities, perhaps resulting in policy transfer.

Smart city concept and parameterising presented in this paper requires further research, alterations and improvements.

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Journal of Civil Engineering and Environmental Technology
Print ISSN: 2349-8404; Online ISSN: 2349-879X; Volume 1, Number 6; August, 2014 pp. 60-60

http://www.krishisanskriti.org/jceet.html

Effect of Silane Coupling Agent on Structural and Mechanical Behaviour of Biomass Ash Reinforced Recycled Polypropylene Composites

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ABSTRACT

This research focuses on reusability and sustainability by developing low cost composites based on recycled polypropylene (PP) matrix and filler biomass ash particles. These lead to change in structural, processability, morphology and physical properties of the raw thermoplastic. Biomass ash (BMA) and automobile polypropylene (APP) are industrial wastes which highly affect the environment. Biomass ash is one of the most inexpensive & low density reinforcement available in large quantities as waste product during gasification process of biomass in thermal power plant and recycled polypropylene is left as scrap in automobile industry. A Proper management and commercial utilization of biomass ashes and automobile polypropylene will provide alternative value added products and also reduction of environmental and economic impacts from the cost of its disposal. APP/ BMA composite were prepared by extrusion followed by injection moulding. Concentration of biomass is varied from 0, 10, 15, 20, to 40% by weight in recycled polypropylene. The performance of filled polymers is determined on the basis of the interface attraction of different concentration and varying particle sizes of the filler. The incorporation of a Silane coupling agent into APP/BMA composite brought about beneficial changes in morphology, rheology and mechanical properties related with improved dispersion of ash particles and increased filler matrix interaction .Recycled polypropylene composite with biomass ash having varied physical & mechanical properties can be used in the commercial usable boards in uses like furniture making office partitions.

Keywords: Composites, Biomass ash, Recycled polypropylene, Silane Coupling Agent, Mechanical Analysis.