Green Building Materials Market-Growth, Trend and Opportunity: South Asian Perspective

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***Abstract*—Selection of building material is an important issue in building design and construction decision-making and environmental issues need to be incorporated into the evaluation process. Prices vary for different types of green building materials. South Asian Green Building material market has lots of challenges and opportunities ahead. The future prospects are bright, but the South Asian (particularly Indian) customers are yet to get through the Rubicon of opting for Green Building instead of conventional buildings. Greener building standards and the rising energy costs are the market's main propellants. Unfortunately, enforcement of energy standards is uneven and customers are highly price sensitive. There is tremendous potential for construction of Green Building in India. The main objective to concentrate in Green Building is that, green building has a potential to save 30%-40% energy with reduction of operating cost and enhance good health. Through this report, authors studied the Green Building material market in relation to embodied energy and CO_2 emission from building material and analyzed the growth and trend of the materials in South Asian perspective over a period. For analysis authors have considered the city of Ahmedabad in India.**

***Index Terms*—Cost analysis, CO_2 emission, embodied Energy, energy efficient and green material.**

I. Introduction

A green building is one which uses less water, optimizes energy efficiency, conserves natural resources, generates less waste and provides healthier spaces for occupants, as compared to a conventional building. Green building is the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle from sitting to design, construction, operation, maintenance, renovation and deconstruction. This practice expands and complements the classical building design concerns of economy, utility, durability, and comfort. Green building is also known as a sustainable or high performance building.

Materials such as cellulose, cotton, fiberglass and mineral wool are capturing the market for insulations due to their excellent properties. Development of green roofs with eco-friendly materials from various manufacturers has also driven the growth of the roofing application segment. Interior finishing materials including eco-friendly carpets, recycled tiles and VOC free glues & paints are being consumed rapidly due to regulations regarding indoor environment quality and health hazards [1]. Wooden structures, steel with recycle content, autoclaved aerated concrete, engineered lumber and structural insulated panels for framing applications are expected to replace conventional materials. Hence, interior finishing and framing applications are expected to grow with healthy growth numbers over a period.

Building material selection is an important issue in building design and construction decision-making and environmental issues need to be incorporated into the evaluation process.

II. Literature Review

In building construction, the requirement of energy is large. It is in various forms. Materials which are required for construction, there manufacturing, transportation, actual use in construction and after construction, large amount of energy utilized. That form of energy is called as Embodied Energy. Secondly, there is good trend to use various green building materials in building construction. It will definitely helpful to make our building as Green Building. Production of Green material generally involves these types of material which are conventional, recyclable, waste products. Researchers are always trying to produce new building material, keeping various mix proportions, various conventional and non-conventional in gradients and taking all appropriate tests on them and conclude that this material is suitable for construction work. But no one tried to calculate their embodied energy along with all tests.

Buildings have a significant and continuous impact on the environment since they are responsible for a large portion of carbon emissions and also use considerable number of resources [2]. Buildings account for one-sixth of the world's fresh water withdrawals, one quarter of its wood harvest, and two-fifths of its material and energy flows [3]. The construction sector consumes considerable amount of energy from the production of basic building materials, its transportation and assembling called embodied energy. Energy conscious and eco-friendly development hold the key potential to significantly reduce thermal loads and electricity use in commercial buildings. Low embodied energy materials conserve energy and limit Green House Gases (GHG) emissions thus limiting the impact on the environment [4]. The energy in buildings may be looked from two different perspectives [5]. Firstly the energy that goes into the construction of the building using a variety of materials. Secondly the energy that is required to create a comfortable environment within the building during its lifetime. Embodied Energy is the sum of all the energy required to produce any goods or services, considered as if that energy was incorporated or 'embodied' in the product itself [5]. The

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DOI: 10.7763/IJESD.2016.V7.784

concept can be useful in determining the effectiveness of energy-producing or energy-saving devices, or the "real" replacement cost of a building [6], and, because energy-inputs usually entail greenhouse gas emissions, in deciding whether a product contributes to or mitigates global warming. One fundamental purpose for measuring this quantity is to compare the amount of energy produced or saved by the product in question to the amount of energy consumed in producing it.

III. Gap Identification

So far going through various research papers in the Green Building sector, it is clear that Indian Green Building material market have lots of challenges and opportunities ahead. The future prospects are bright, but the Indian customers are yet to get through the Rubicon of opting for Green Building instead of conventional buildings. Also, the general awareness on Green Buildings in India is scare and scattered. The main objective and need to concentrate for Green Building is that, green Building has a potential to save 30%-40% energy with reduction of operating cost and enhance good health. Moreover, the embodied energy of building materials and the CO_2 emission by them is of importance during the research [7]-[10].

Authors have analyzed the Indian market/industry on the basis of normal cement produced and consumed for construction in the last ten years and how much energy and CO_2 emission could have been saved and reduced by using Fly Ash, which is a post-consumer waste and Sandfree cement (Green material) instead of conventional cement. Energy saved can be directly related to monetary benefits [11]-[14].

IV. Research Methodology

This is a descriptive research undertaken, pertaining to factors taken into account during analysing green building materials market. The data used in this project are the production and consumption figures of cement which is in million tonnes and related embodied energy and CO_2 emission which are in MJ/Kg and Kg/Kg respectively.

The research is an applied research as it uses the research theories and methods for a commercially driven purpose of getting to know the green building material overall demand and supply. The research type is descriptive because the data description is factual, accurate and systematic, but it cannot describe what caused a situation. Variation in the embodied energy (MJ) and CO_2 emission are checked for normal cement mortar and cement mortar with 20%, 35% and 55% fly ash.

A. Data Collection

Both Primary and secondary data are collected from various sources as a basic instrument or tool for the purpose of this research.

B. Data Source

Various data sources for the research are as follows: Green Building construction companies, Green Building materials supplier, research works on Green building, etc.

V. Data Analysis

A. Methodology

A quantitative analysis of the data collected has been done using inferential statistics. Authors have done the linear regression. Scenario writing has been done which consists of developing a conceptual scenario of the future based on a well-defined set of assumptions. Different set of assumptions lead to different scenarios. Data analysis has been divided into four segments:

1) Linear regression is used to analyse the month wise production and consumption data of Cement in India from 2005 to 2014. Same analysis is carried out for cement concrete, cement concrete with 80% cement+20%Flyash, 65%cement+35%Flyash and 45%cement+55%Flyash. Consumption of cement is replaced by 10%, 20% and 30% of Sandfree cement which is a green building material and data is analysed using linear regression over a period of ten years from 2005 to 2015.
2) Embodied energy and CO_2 emission by cement concrete is checked and compared with that of cement concrete with 80% cement+20%Flyash, 65%cement+35%Flyash and 45%cement+55%Flyash.
3) Similarly, scenario analysis has been done by replacing the consumption of cement with Green building material, i.e., Sandfree cement. 10%, 20% and 30% replacement are done and the embodied energy and CO_2 emission are compared for the given situations.
4) Financial analysis is done by calculating the cost incurred in using normal cement for construction instead of green cement (Sandfree cement). Comparison done by finding the amount saved in the process over a span of five years.

B. Data Used

Embodied energy and CO_2 emission mentioned in Table I, are the amount released during the production of the particular material. Moreover, prices of normal cement and sandfree cement (which is greener than normal cement) are given in Table II. The prices taken are for the city of Ahmedabad in India over a period of ten years (2005-2014). The data from Table I and Table II are used for carrying out the analysis.

C. Analysis I: Correlation, Variability and Significance Check of Cement Production and Consumption with Time (Month)

The data shows the mean, correlation, adjusted R square and significance of all the items mentioned in Table III, month wise. It shows the fluctuation in demand and supply of cement industry in India. We took the data of 10 years or 120 months.

Correlation column shows the Pearson correlation coefficient which shows the correlation between the items mentioned in Table III and the number of months or time. A very strong positive correlation is seen here for every case as the value is well above 0.95. It means the items in reference will grow with the time or months.

Adjusted R Square shows percentage of variability. It basically talks about the perfect positive correlation or perfect negative correlation. It shows all items depicts 95% and above of variability and showing the strong positive correlation between the items in reference and months.

TABLE I: EMBODIED ENERGY AND CO_2 EMISSION OF SOME MATERIALS (SOURCE: CANNON DESIGN, 2013)

Items	Embodied Energy (MJ/Kg)	CO_2 emission (Kg/Kg)
Cement	5.8	0.9368
Cement Mortar (1:3)	1.33	0.1311
80% Cement + 20% Fly Ash	0.509	0.107
65% Cement + 35% Fly Ash	0.367	0.0755
45% Cement + 55% Fly Ash	0.34	0.0693
Sandfree Cement	5.2	0.843

TABLE II: PRICE OF NORMAL CEMENT AND SANDFREE CEMENT PRICE IN INDIA (SOURCE: EMKAY RESEARCH, INDUSTRY, PERLCON)

Year	Cement (Rs)/50 Kg bag	Sandfree Cement (Green building material) (Rs)/40 Kg bag
2005	Rs. 203.00	NA
2006	Rs. 212.50	NA
2007	Rs. 222.50	NA
2008	Rs. 233.00	NA
2009	Rs. 244.00	NA
2010	Rs. 255.50	NA
2011	Rs. 267.50	NA
2012	Rs. 280.00	NA
2013	Rs. 293.00	NA
2014	Rs. 308.00	Rs. 500.00
2015	Rs. 320.00	Rs. 500.00

TABLE III: VALUES OBTAINED FROM LINEAR REGRESSION ON VARIOUS PARAMETERS (2005-2014)

Sr No.	Parameter	Mean	Correlation	Adjusted R Square	Significance (Anova)
1	Production of cement	16.7709 million tonnes	.978	.957	0.000
2	Consumption of cement	16.5420 million tonnes	.989	.978	0.000
3	Embodied energy of cement	97271316666.6 MJ/Kg	.978	.957	0.000
4	CO_2 emission of cement	15710994.73 Kg/Kg	.978	.957	0.000
5	Embodied energy of cement mortar	72043440000 MJ/Kg	.989	.978	0.000
6	CO_2 emission of cement mortar	7101424800 Kg/Kg	.989	.978	0.000
7	Embodied energy of 80% cement+20% fly ash	27571512000 MJ/Kg	.989	.978	0.000
8	CO_2 emission of 80% cement+20% fly ash	5795976000 Kg/Kg	.989	.978	0.000
9	Embodied energy of 65% cement+35% fly ash	19879656000 MJ/Kg	.989	.978	0.000
10	CO_2 emission of 65% cement+35% fly ash	4089684000 Kg/Kg	.989	.978	0.000
11	Embodied energy of 45% cement+55% fly ash	18417120000 MJ/Kg	.989	.978	0.000
12	CO_2 emission of 45% cement+55% fly ash	3753842400 Kg/Kg	.989	.978	0.000
13	10% check embodied energy	94951080000 MJ/Kg	.989	.978	0.000
14	10% check CO_2 emission	15341381640 Kg/Kg	.989	.978	0.000
15	20% check embodied energy	93958560000 MJ/Kg	.989	.978	0.000
16	20% check CO_2 emission	15186217680 Kg/Kg	.989	.978	0.000
17	30% check embodied energy	92966040000 MJ/Kg	.989	.978	0.000
18	30% check CO_2 emission	15031053720 Kg/Kg	.989	.978	0.000

Significance (Anova) column explains that the correlation we got in previous column is statistically significant or not. Here, 0.000 value explains that the correlation between the items in reference in Table III and monthly are strongly significant.

Term ‘Unstandardized Coefficients’ in Table IV explains what will be the consumption of cement if we increase the number of months by 1. For example: the value of months is .124 means if we increase the number of month by 1 than the production of cement will increase by .124 million tone. Which depict the increased production of cement is possible in India as we move forward with time. The term ‘Constant’ means intercept here. It means the value of production will be 9.278 if the number of month is 0, which don’t make any sense in this context. Same can be inferred for other items in Table IV.

For example: If we take the case of production of cement in Table IV with 95% confidence interval for correlation. The confidence interval for intercept is in the range of 8.94 to 9.61. It means that at month 0, the production of cement will be in the range of 8.94 to 9.61 million tonne. For the months, the range is .119 to .129, it means by the increment of 1 month the production of cement will increase in the range of .119 to .129. The same follows for all the items in Table IV.

D. Analysis II: Embodied Energy and CO_2 Emission by Mixture of Different Proportion of Cement and Post-consumer Waste (Flyash)

In this analysis, Embodied energy and CO_2 emission by cement concrete is checked and compared with that of cement concrete with 80% cement+20% Flyash, 65% cement+35% Flyash and 45% cement+55% Flyash. The following results are obtained:

The embodied energy of three different mixtures of cement and fly ash has been calculated from 2005 to 2014. The three mixtures have specific ratio between cement and fly ash which are as follows such as mixture 1 (8:2), mixture 2 (6.5:3.5) and mixture 3 (4.5:5.5) respectively. The slope of mixture 1, mixture 2 and mixture 3 are 259779403.6, 187306564.1 and 173526517.1 respectively as shown in Fig. 1. This clearly signifies that the rate at which embodied energy is increasing with time is maximum and minimum for mixture 1 and mixture 3 respectively. This is due to disparity in embodied energy of cement and fly ash (less embodied energy per kilogram as compared to cement).

TABLE IV: VALUES OBTAINED FROM LINEAR REGRESSION ON VARIOUS PARAMETERS (2005-2014)

Sr No.	Parameter	Unstandardized Co-efficients		Co-efficients (95.0% Confidence Interval for B)			
		B (Constant)	B (Month)	Constant		Month	
				L.B	U.B	L.B	U.B
1	Production of cement	9.278	0.124	8.945	9.61	0.119	0.129
2	Consumption of cement	8.823	0.128	8.58	9.065	0.124	0.131
3	Embodied energy of cement	53810612885	718358740.1	51880717067	55740508703	690676050.5	746041429.8
4	CO_2 emission of cement	8691341.75	116027.32	8379630.301	9003053.199	111556.09	120498.554
5	Embodied energy of cement mortar	30976348235	678794905.2	29686987909	32265708561	660300144.2	697289666.1
6	CO_2 emission of cement mortar	3053382897	66909783.51	2926288808	3180476987	65086728.51	68732838.52
7	Embodied energy of 80% cement+20% fly ash	11854858084	259779403.6	11361411162	12348305006	252701333.4	266857473.7
8	CO_2 emission of 80% cement+20% fly ash	2492082151	54609815.6	2388351659	2595812644	53121891.3	56097740
9	Embodied energy of 65% cement+35% fly ash	8547608874	187306564.1	8191822979	8903394768	182203122.5	192410005.6
10	CO_2 emission of 65% cement+35% fly ash	1758431798	38533094.24	1685238787	1831624809	37483203.68	39582984.81
11	Embodied energy of 45% cement+55% fly ash	7918765714	173526517.1	7589154804	8248376625	168798533.1	178254501.1
12	CO_2 emission of 45% cement+55% fly ash	1614030776	35368787.17	1546848317	1681213236	34405112.78	36332461.5
13	10% check embodied energy	50641849412	732383976.7	49250697481	52033001342	712429103	752338850.3
14	10% check CO_2 emission	8182275955	118332325.4	7957505550	8407046360	115108187.9	121556462.8
15	20% check embodied energy	50112492101	724728395	48735881828	51489102374	704982108.9	744474681.1
16	20% check CO_2 emission	8099519762	117135502.8	7877022703	8322016821	113943974.5	120327031
17	30% check embodied energy	49583134790	717072813.4	48221066175	50945203405	697535114.8	736610511.9
18	30% check CO_2 emission	8016763569	115938680.18	7796539856	8236987282	112779761.1	119097599.3

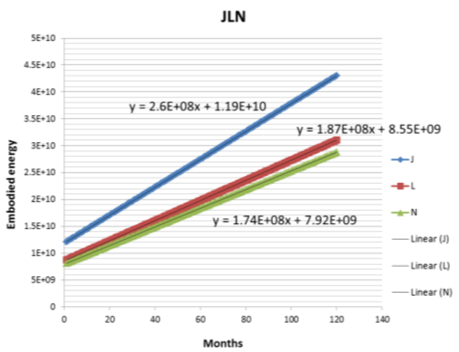

Fig. 1. Embodied energy from 2005 to 2014, J: Embodied energy of 80% Cement + 20% Fly Ash (MJ); L: Embodied energy of 65% Cement + 35% Fly Ash (MJ); N: Embodied energy of 45% Cement + 55% Fly Ash (MJ).

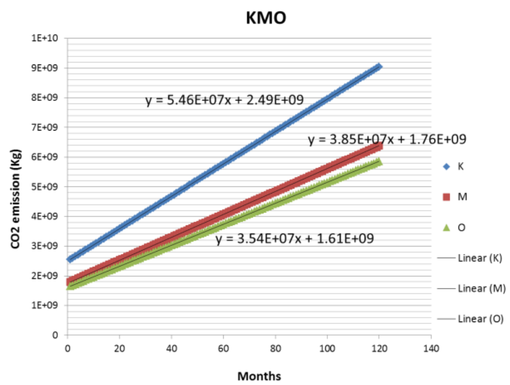

Fig. 2. CO_2 emission from 2005 to 2014, K: 80% Cement + 20% Fly Ash CO2 emission (Kg); M: 65% Cement + 35% Fly Ash CO_2 emission (Kg); O: 45% Cement + 55% Fly Ash CO_2 emission (Kg).

The CO_2 emission of three different mixtures of cement and fly ash has been calculated from 2005 to 2014. The three mixtures have specific ratio between cement and fly ash which are as follows such as mixture 1 (8:2), mixture 2 (6.5:3.5) and mixture 3 (4.5:5.5) respectively. The slope of mixture 1, mixture 2 and mixture 3 are 54609815.6, 38533094.24 and 35368787.17 respectively as shown in Fig. 2. This clearly signifies that the rate at which CO_2 emission is increasing with time and is maximum and minimum for mixture 1 and mixture 3 respectively. This is due to disparity in CO_2 emission of cement and fly ash (less CO_2 emission per kilogram as compared to cement).

E. Analysis III: Embodied Energy and CO_2 Emission When Cement Consumption in Replaced by Sandfree Cement in Different Proportion

In this analysis, scenario check has been done by replacing the consumption of cement with Green building material, i.e., Sandfree cement. 10%, 20% and 30% replacement are done and the embodied energy and CO_2 emission are compared for the given situations. The embodied energy of three combinations of cement and green building material replacement of cement in India has been calculated from 2005 to 2014. The three mixtures having specific ratio of cement and green building replacement are as follows: Combination 1 (9:1), Combination 2 (8:2) and Combination 3 (7:3) respectively. The slope of mixture 1, mixture 2 and mixture 3 are 732383976.7, 724728395 and 717072813.4 respectively as shown in Fig. 3. This clearly signifies that the rate at which embodied energy is increasing with time is maximum and minimum for mixture 1 and mixture 3 respectively. The minimum rate at which embodied energy is increasing with time is almost similar for combinations 2 and 3. But in the longer run, the differences between them can be clearly identified. This is due to disparity in embodied energy of cement and its green building replacement (less embodied energy per kilogram as compared to cement).

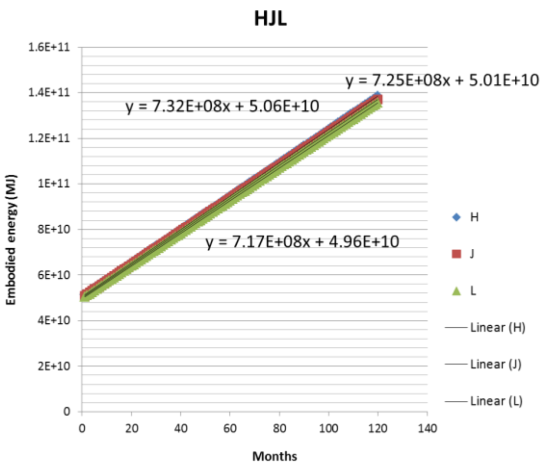

Fig. 3. Embodied energy from 2005 to 2014, H: 10% of cement consumption replaced by Green cement; J: 20% of cement consumption replaced by Green cement; L: 30% of cement consumption replaced by Green cement.

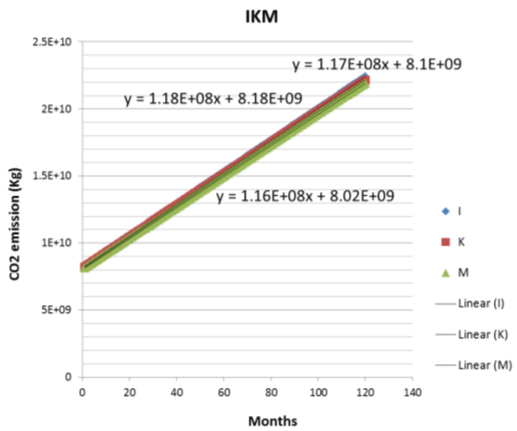

Fig. 4. CO_2 emission from 2005 to 2014, I: 10% of cement consumption replaced by Green cement; K: 20% of cement consumption replaced by Green cement; M: 30% of cement consumption replaced by Green cement.

The CO_2 emission of three combinations of cement and green building material replacement of cement in India has been calculated from 2005 to 2014. The three mixtures having specific ratio of cement and green building replacement are as follows: Combination 1 (9:1), Combination 2 (8:2) and Combination 3 (7:3) respectively. The slope of mixture 1, mixture 2 and mixture 3 are 118332325.4, 117135502.8 and 115938680.18 respectively as shown in Fig. 4. This clearly signifies that the rate at which CO_2 emission is increasing with time is maximum and minimum for mixture 1 and mixture 3 respectively. This is due to disparity in CO_2 emission of cement and its green building replacement (less CO_2 emission per kilogram as compared to cement).

F. Analysis IV: Financial Analysis

Here, financial analysis is done by calculating the cost incurred in using normal cement for construction instead of green cement (Sandfree cement). Comparison is done by finding the amount saved in the process over a span of five years.

1) Data used

TABLE V: CITYWISE TONNAGE CALCULATOR (SOURCE: BIJLIBACHAO)

Citywise Tonnage Calculator (Inverter AC)					
		Daytime Summer Temp		Multiplier	
Sr No.	CITY	Avg Temp (°C)	Max Temp (°C)	Non Sunny Room, Ground Floor	Sunny Room Top Floor
1	Panaji	34	37	750	950
2	Ahmedabad	42	46	950	1250
3	Mumbai	33	37	650	850
4	Nagpur	39	43	850	1150
5	Pune	36	40	750	950
6	Baroda	39	43	850	1150
7	Surat	41	45	950	1250

2) Assumptions

- Room Height Max 10Ft
- Room considered is 100 sq. ft.
- 2-4 persons
- 01 TV in room
- Curtains on Glass windows
- Coverage area of both normal cement and Sandfree cement is same.
- Using Split Air Conditioner.
- AC consumption for the whole year.
- Electricity consumption will not reduce in 70:30 ratio. We have assumed the reduction in 50:50 ratio because the use of cement will be uniform on the walls.
- The power input for AC is 1350 Watt-hour.
- Reduction in consumption of electricity will be 25-30 percent by using Sandfree cement which is greener than normal cement.

TABLE VI: TONNAGE REQUIRED IN AHMEDABAD (SOURCE: BIJLIBACHAO)

Room Size			Tonnage Reqd	
Length (mt)	Breadth (Mt)	Area (Sq Feet)	(2-4 people) Non-sunny room, Ground Floor	(2-4 people) Sunny room, Top Floor
2	2	43	0.32	0.42
2	2.5	54	0.4	0.52
2.5	2.5	67	0.49	0.65
2.5	3	81	0.59	0.78
3	3	97	0.71	0.94
3	3.5	113	0.83	1.09
3.5	3.5	132	0.97	1.28
3.5	4	151	1.11	1.46
4	4	172	1.27	1.67
4	4.5	194	1.43	1.88

Considering 1000 sq ft home and the calculations in Table VII and Table VIII are carried out using data from Table V and Table VI. Table V provides the multiplier value required for calculation of tonnage of air conditioner for a particular city. Table VI gives the tonnage in the city of Ahmedabad for different room sizes. Cost incurred by using normal cement, sandfree cement and mix proportion of both for construction over a period of five years is calculated as shown in Table VII and in Table VIII, cost comparison is done under three different conditions: 1) Replacing the use of normal cement by sandfree cement, 2) Replacing normal cement by (70% cement+30% sandfree) and, 3) Replacing Sandfree cement by (70% cement+30% sandfree).

TABLE VII: COST INCURRED OVER A SPAN OF FIVE YEARS USING NORMAL CEMENT, SANDFREE CEMENT AND MIX PROPORTION

Items	Normal Cement	Sandfree cement	70% Cement+30% Sandfree		
Requirement of cement	**20 kg/sq.ft**	**20 kg/sq.ft**	**0.7**	**0.3**	**Total**
	20*100 =2000 kg	20*100 = 2000 kg	2000*0.7 = 1400kg	2000*0.3 = 600kg	2000kg
No. of bags (1bag = 50 kg)	2000/50=40 bags	2000/50 = 40 bags	1400/50 = 28	600/50 = 12	40 bags
Total cost of cement and sandfree cement	40*320= Rs.12800	40*500= Rs.20000	28*320= Rs.8960	12*500= Rs 6000	Rs 14960
Calculated AC tonnage	0.83(we are taking it 1)	0.83(we are taking it 1)	0.83	0.83	0.83
Consumption electricity unit by AC per hour	1.35 units/hour	1 unit/hour	1.35*0.5= 0.675	1*.5 =0 .50	1.175 units/hour
Daily usage (10 hour)	1.35*10 = 13.5 units	1*10 = 10 units	.675*10 = 6.75 units	.50*10 = 5 units	11.75units
cost of 1 unit=Rs 5/unit	13.5*5 = Rs.67.5/day	10*5 = Rs 50/day	6.75*5 = Rs.33.75/day	5*5 = Rs.25/day	Rs.58.75/day
Yearly cost of AC	67.5*30*12= Rs.24300	50*30* 12= Rs.18000	33.75*30*12=Rs.12150	25*30*12= Rs.9000	Rs.21150
Cost for 5 years	24300*5= Rs.121500	18000*5= Rs.90000	12150*5= Rs.60750	9000*5= Rs.45000	Rs.105750

Note: Rs = Indian Rupees, Rs 1 = 0.0138 Euro as of 17th May, 2015

TABLE VIII: COST COMPARISON UNDER THREE DIFFERENT CONDITIONS

	I. Replacing Cement by Sandfree	II. Replace normal cement by (70% cement+30% sandfree)	III. Replace Sandfree cement by (70% cement+30% sandfree)
Total cost savings in electricity after 1 year	24300-18000 = Rs 6300	24300-21150 = Rs 3150	18000-21150 = Rs (3150)
Extra cost paid for construction	20000-12800 = Rs 7200	14960-12800 = Rs 2160	14960-20000 = Rs (5040)
Net loss or profit	6300-7200 = Rs (900)	3150-2160 = Rs 990	(3150)+5040 = Rs 1890
Remarks	NA	Future value of 990 at 10% rate and for 5 years is 1595	Future value of 1890 at 10% rate of interest and 5 years is 3045

It is seen that complete replacement of normal cement by Sandfree cement is not feasible under our assumed conditions in terms of monetary benefit. But, by replacing normal cement and Sandfree Cement with (70% Cement + 30% Sandfree cement), monetary benefit can be achieved as derived from the calculations.

VI. CONCLUSION

Generally, researchers are always trying to find out new building material which relates with recycle of material, use of waste material as in-gradients etc. This study helps to determine the embodied energy and CO_2 emission for construction material such as cement. Post-consumer wastes like glasses, plastics, tyres, fly ash, etc., can be used with cement concrete to make the building material greener. After analysis, it is seen that increasing the quantity of cement in concrete automatically increase the Embodied energy value. Same is the case with CO_2 emission.

Financial benefits as per the study very well depict the need of using Green Building material in construction sector.

ACKNOWLEDGMENT

Authors expresses their warm thanks to Prof. Dr. Akash Patel and Prof. Dr. Pramod Paliwal, School of Petroleum Management; Prof. Dr. Ravi Gor, Director - Dr. Babasaheb Ambedkar Open University, for their valuable support and guidance.

Also special thanks to Perlcon Premix Pvt. Ltd., Ahmedabad, India, which deals in Green Building materials supply for providing the required data during the study.

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