International Journal of Civil and Structural Engineering– IJCSE
Volume 2 : Issue 1 *[ISSN : 2372-3971]*
Publication Date: 30 April, 2015

Comparative Environmental Impact Assessment of Clay Brick and Stone Aggregate Concrete Building

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***Abstract*— Due to scarcity of natural stone, a large number of residential building in Bangladesh are constructed using crushed clay brick aggregate. Since production of brick aggregate consume large amount of energy and hence emit higher quantity of CO_2, environmental impact from brick aggregate would justifiably be different from concrete made from natural stone aggregate. It is, therefore, of interest to know how choosing either of the two types of aggregate affects the overall CO_2 emission in a building construction project. To this end, in this paper, a comparative study is conducted between CO_2 emission of identical brick and stone aggregate concrete six storied residential building located in Dhaka, Bangladesh. For this, the construction materials, their quantities and respective CO_2 emission are estimated and tallied. All the processes involved from production, transportation to the site, installation etc are considered while estimating CO_2 emission from each construction material. Total CO_2 emission from the two different types of concrete building is later compared. Comparison shows that brick aggregate concrete building emit approximately 28% higher CO_2 than natural stone aggregate concrete building.**

***Keywords*— carbon dioxide (CO_2) emission, energy consumption, brick aggregate, stone aggregate, concrete production.**

I. Introduction

Concrete is the main ingredient of ever growing construction industry of Bangladesh. Production and use of constituents of concrete like cement, aggregate, sand etc involve energy consumption and subsequently CO_2 emission. Moreover, production and use of essential building materials like deformed rebar and some decorative elements like tiles, glasses, false ceiling elements etc. also require energy and result in the emission of greenhouse gasses [1]. Since there is scarcity of natural stone aggregate, crushed clay brick aggregate are widely used as coarse aggregate for concrete production in Bangladesh. However, clay brick and subsequent production of aggregate from it consumes great amount of energy and emit large amount of CO_2. Alternately, acquiring and producing stone aggregate from natural stone bolder is an entirely different process and hence, CO_2 emission and energy consumption is different. It is, therefore, of interest to know how use of these two types of aggregate affects amount of CO_2 emission in an overall project construction. To understand this, in this paper, two identical buildings are analyzed for their CO_2 emission. One of them is constructed using natural stone aggregate while other one is constructed using crushed clay brick aggregate. Total CO_2 emission from these two building during their construction phase are compared to see how using brick aggregate concrete adversely affects the overall CO_2 emission scenario.

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II. Methodology

In this research, detail construction data are collected and analyzed from two different residential building projects situated in Dhaka, Bangladesh. The buildings under consideration are approximately 5400 square feet in plan area and each of them is six storey high. Concrete used in Building-1 is of stone aggregate and that used in Building-2 is crushed clay brick aggregate. Apart from coarse aggregate all other construction materials and their respective volume are considered as identical for the two building. The different construction materials that are considered in the computation of CO_2 emission are listed in Table 1. These include cement, brick, stone, sand, rebar, glass and lime. Table1 also shows the actual amount of each materials required for both projects. Standard values [2,3] for computing CO_2 emission and energy consumption for each of the building materials are, again, included in Table 1. These values are taken as guideline while evaluating CO_2 emission from each of the construction materials. Local conditions are also incorporated while evaluating these values. Especially, local transportation, brick kiln related CO_2 emission data are taken from local sources [4]. Since brick production and brick aggregate is the prime concern CO_2 emission special attention was given to its production process. Amount of CO_2 emission from a single brick depends on the type of kiln used to produce it. Several activities from both Government of Bangladesh and International donor agencies are underway to reduce CO_2 emission from the brick kilns of this country. New concepts like Hybrid Hoffman kiln are also introduced. Nevertheless, brick production in Bangladesh still largely depends on kiln technologies that were developed decades ago. Mostly, there are four types of kilns prevailing in Brick industry of Bangladesh. Of these, 75.8% are Fixed Chimney kiln (FCK), 16.1% are Bull's Trench Kiln (BTK) and 5.7% are of ZigZag type kiln. A small portion of 2.4% is of Hoffmann kiln type [5]. Amount of CO2 emission from these kilns per 100000

TABLE 1: CONSTRUCTION MATERIALS CONSIDERED IN CO_2 EMISSION

Sl. No.	Item Description	Project-1	Project -2	Standard Value Per Unit		CO_2 Emission (Ton)		Energy Consumption (GJ)	
				CO2 Emission (Ton)	Energy Consumption (GJ)	Building-1	Building-2	Building-1	Building-2
1	Cement(Bags)	12440	7398	0.0194	0.0935	241.34	143.53	1163.2	691.71
2	Brick (Nos.)	-	845222	0.00054	0.00575	-	456.8	-	4870.6
3	Stone (Cft)	57258	-	0.00356	0.00483	203.8	-	2765.5	-
4	Sand (Cft)	28580	18174	0.00138	0.02346	39.5	25	670.5	426.36
5	Rebar(Kg)	133000	133000	0.0000624	0.001365	8.3	8.3	181.545	181.545
6	Glass (Kg)	3500	3500	0.0013	0.0184	4.55	4.55	64.4	64.4
7	Lime(Ton)	3	3	0.47	5.69	1.41	1.41	17.1	17.1
					Total =	498.9	639.59	4,862.25	6,251.72

TABLE 2: REASONS OF CO_2 EMISSION & ENERGY CONSUMPTION

Sl. No.	Description of Construction Items	Sources of CO_2 Emission & Energy Consumption				
		Wood Cutting	Burning of Wood/Gas/Coal	Electricity for Machine Operation	Plant Operation	Fuel Burning for Transportation
1	**Cement**					
i)	Clinker Import					√
ii)	Gypsum Import					√
iii)	Mixing of Ingredients			√		
iv)	Packing & Processing for Sale				√	
v)	Transportation of Cement bags					√
2	**Brick**					
i)	Cutting, Carrying & Mixing of Earth			√		√
ii)	Molding Works				√	
iii)	Burning Sources:					
	Wood	√	√			
	Gas		√			
	Coal		√			
iv)	Kiln Operation & Maintenance				√	
v)	Transportation to Construction Site					√
3	**Stone**					
i)	Collection of Boulder/Stone Sources					√
ii)	Crushing of Boulder			√		
iii)	Transportation to Construction Site					√
4	**Sand**					
i)	Collection of Sand from River Side			√		
ii)	Transportation to Construction Site					√
5	**Rebar**					
i)	Milling process				√	
ii)	Remolding			√		
iii)	Transportation to Construction Site					√
6	**Glass**					
i)	Milling process				√	
iii)	Transportation to Construction Site					√
7	**Lime Coat**					
iii)	Transportation to Construction Site					√

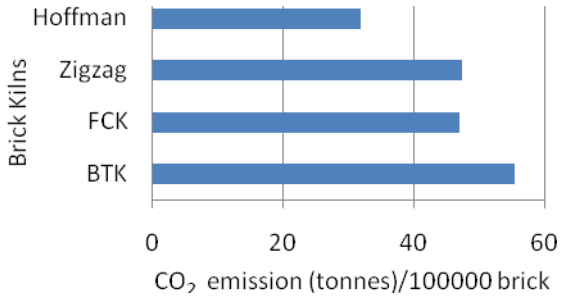

Figure 1 CO_2 emission from different kiln types

brick is shown in Figure 1. In this work brick is considered as produced from fixed chimney kiln. Apart from concrete production, bricks are used for construction of partition wall as well. That part is onsidered as identical for both the building.

III. Discussion on Results

Using these data computation of CO_2 emission and energy consumption can be done based on the unit area of the buildings. The last four column of Table 2 represents the such results. The CO_2 emission for building 1 and building 2 is 498 Ton and 639 Ton which is 0.015 and 0.019 Tons/sft respectively. The energy consumption for building 1 and building 2 is 4862 GJ and 6251 GJ which is 0.151 and 0.192 GJ/sft respectively. It is apparent from the outcomes that both CO_2 emission and energy consumption is lesser for building 1 than those for building 2. For a six storey building of this size, increase in CO_2 emission is approximately 28% when brick aggregate are usedf ro concrete production. Fig 2 and Fig 3 shows the detail contribution of construction materials in CO_2 emission for building 1 and building 2 respectively.

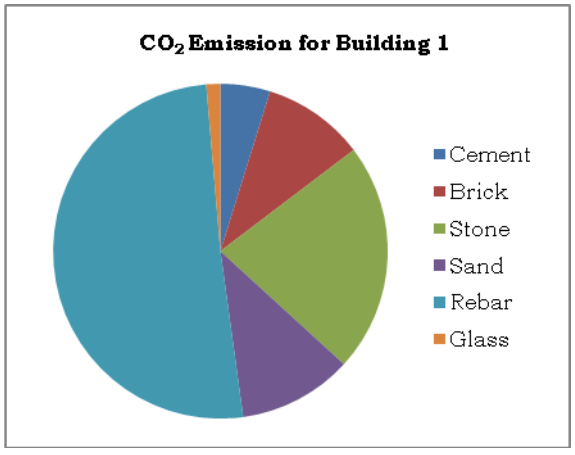

Figure 2 CO_2 emission from Building 1

For building 1 in terms of building materials are used, the most CO_2 emission and energy consumption is due to the use of steel rebar (36%) whereas for building 2, the significant emission is due to the use of bricks (39%). Although rebar quantity is same for both the buildings, increased CO_2 emission from brick changes the entire CO_2 emission scenario for Building 2. Contribution of brick for Building 1 is from the partition brick wall only as mentioned earlier.

If we consider concrete alone, i.e. if only cement, sand and brick or stone is considered, CO_2 emission is three times higher where brick aggregate is used instead of stone aggregate.

Since bricks are the major producer of CO_2, it is a concern for the construction industry to find alternative of using bricks. For concrete production, stones can be used as they are more environment friendly, though their prices are higher than bricks. In the overall scenario considering the effect of brick in environment, use of stone would be feasible. For external façade and internal partition wall, use of hollow blocks may be the suitable alternative.

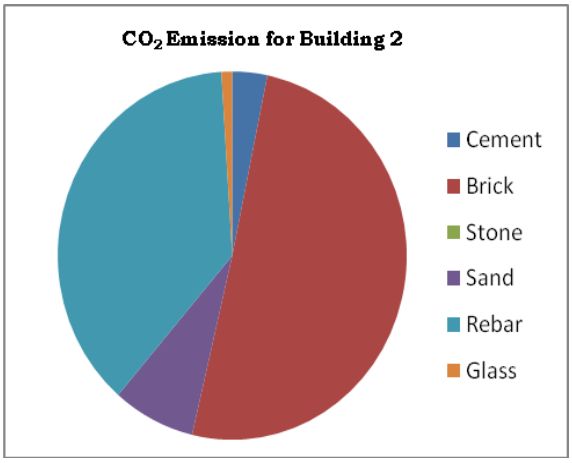

Figure 3 CO_2 emission from Building 2

IV. Conclusion

For a developing country like Bangladesh construction of buildings, bridges and other infrastructures are common. As shown in this paper, use of brick aggregate in concrete production increase the CO_2 emission by 28%. In a world which is getting more and more concerned about green houses gasses, efforts should be taken to minimze use of brick aggergate. The construction should go in such a way that it eliminates the items of materials i.e. bricks which cause more CO_2 emission and requires more energy during its production. It is the call of the time to go with green technology which in turn will be sustainable, feasible and safer for the earth we live in.

V. Acknowledgement

This paper has been prepared on the basis of ongoing M.Sc. Engg. research work conducted at the Department of Civil Engineering, Bangladesh University of Engineering and

Technology (BUET), Dhaka, Bangladesh. The authors are grateful to BUET for providing the financial support and necessary facilities for conducting the research.

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Brick and brick aggregate concrete produce three time more green house gasses than natural stone aggregate concrete.

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In the world yearly 4 billion tons of carbon dioxide produce for producing concrete .So it is high time for taking proper steps of reducing CO_2 emission.