The International Journal Of Engineering And Science (IJES)
||Volume||2 ||Issue|| 7 ||Pages|| 19-24||2013||
ISSN(e): 2319 – 1813 ISSN(p): 2319 – 1805

Inherent Energy In Demolition Debris: Re-Use Or Recyle? (A Case Study Of Roads Construction Led Demolition In Gombe Metropolis)

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ABSTRACT
The pressure from over exploitation of the natural resources by human on the environment is always in the increase and becoming more apparent every now and then, especially in the construction sector. There is the need for information on which to base sound solutions to the problems protecting the environment and the future planet as a whole. This paper is aimed at discussing that energy that is inherent in the demolition debris (inherent energy) littering around the environment whenever a demolition is carried out, and in many cases inappropriately disposed off. The study reviewed literatures, reports and texts, and drew advantages from within. This study outlined benefits associated with re-use and recycles and offered its recommendations on the premise of benefits found to have been more environmentally profitable.

KEY WORDS: *Inherent energy, demolition debris, re-use and recycling*

Date of Submission:18 July 2013 Date of Publication:7 ,Aug ,2013

I. STUDY BACKGROUND

Sustainable construction refers construction as a broad process/mechanism for the realization of human settlement and the creation of infrastructure that support development. This includes the extraction and beneficiation of raw materials, the manufacturing of construction materials and components, the construction project cycle from feasibility and design to demolition, and the management and operation of the built environment (Plessis, 2002). Thus, construction industry and its activities are responsible for a substantial amount of global resource use and waste emissions (Plessis, 2001). Consequently, it was realized that every activity involved in extraction, processing and delivery of construction materials result in energy consumption, pollution and waste; making the industry often referred to as 40% industry due to its responsibility for roughly consuming of 40% of all global resources and 40% of all waste production including greenhouse gas emission (Plessis, 2002).

In a global scene, researchers have established that the resources are being used up at an alarming rate through human over exploitation which led to the assumption of when these resources could be exhausted. Ogunsote, et al. (2011) opined that, the world is being threatened with diminishing energy resources and if consumption of energy continuous at the current rate, the life will be threatened in the future. In this regard, the world is therefore faced with looking for alternatives, which are important to businesses, government and other energy consumers, beside the search by scientist and engineers for replacement of fossil fuels with other alternatives that are clean, abundant, safe and in-expensive. Other alternatives require finding ways to reduce energy use, using energy more wisely and efficiently and increasing the public concern over ecological sustainability.

II. METHODOLOGY

For the purpose of fulfilling the requirement, the study adopted to reviewing literatures as well as using real life data obtained from the project file 2012 0f payment of compensation's report for the construction of roads in Gombe metropolis. However, it choose to work on the limited number of roads with the view just to creating awareness of the volume of resources involved, its contribution and usage as component in the project. The study delimited itself to the basic materials for walling such as sandcrete/concrete material, mud and bricks.

III. LITRETURE REVIEW

Inherent energy refers to energy embedded in material i.e. the energy content of the raw material. Against this back drop, demolition materials contained shared/built-in energy from its initial production. Henceforth in this study referred to as raw material whose energy is embodied, whose recycling and source reduction is directly related to the energy that could be saved through reuse or recycling. In fact the link between the use of energy in buildings, construction and the energy used is well established in Europe and America (UNCHS, 1991). However, the link between energy production, use; and local and global environment is causing increasing concern worldwide. Thus, there are good reasons seeking to reduce the energy in buildings and constructions. In the developed countries, there is growing demand for environmental impact assessment for all construction and building projects which include consideration of embodied energy (Becket, 1986).Many buildings and construction materials are manufactured involving high-temperature Kiln technologies, and crushing and grinding operations which are inherently energy-intensive. According to Ebohon (1992), the intensity of consumption of global resources particularly at the processing stage can be seen from the following: Zinc, Tin, Aluminum, Cement, Tiles, Bricks, Glass and Paint. It was established that (Economy Watch, 2000) construction industry is the largest sector in the consumption of energy and resource utilization in the industry amounts to half of the total resource consumed all over the world. Corroborating this assertion, Edward (2002) deduced that the construction industry is responsible for 50% of all energy consumed in the world making it one of the least sustainable global industries.

3.1.INERPRETATION OF EMBODIED ENERGY OF MATERIALS

Buildings are constructed with a variety of materials that consume energy throughout their stages of manufacture, use and demolition. These stages consist of raw materials extraction, transport, manufacture, assembly, as well as disassembly and demolition. Crowther (1999), defines embodied energy as "the total energy required in the creation of building, including the direct energy used in the construction and assembly process, and the indirect energy that is required to manufacture the materials component of the building". According to Treolar, et al. (2001) embodied energy (EE), "is that energy required providing a product (both directly and indirectly) through all processes, upstream (i.e. traceable backwards from the finished product to consideration of raw materials)". Likewise, a more comprehensive definition provided by (Baird (1994), Edward and Stewart (1994), Lawson (1996), Cole and Keman (1996), as (cited in Ding, 2004) proposed that "embodied energy comprises the energy consumed during the extraction and processing of raw materials and components, and the energy used in various processes during the construction and demolition of the building".

However, according to Dixit, et al. (2009), "embodied energy, is the direct energy consumed in various onsite and offsite operations, like construction, prefabrication, transportation and administration; this include, energy in construction and assembly on site, prefabrication of building components offsite and transportation, including various onsite and offsite processes." While the direct energy is the energy used in manufacturing the building materials, in renovation, refurbishment, and demolition processes of buildings. It includes initial embodied, recurrent embodied energy and demolition energy." Initial embodied is consumed during production of materials and component and include raw materials procurement, building initial manufacturing facilities and finished product delivery to the construction site. Embodied energy is just one of the environmental impacts associated with a building product's life cycle; the embodied energy of a typical building product is derived from the energy associated with other steps in its lifecycle from extraction of materials through processing and manufacture, to transportation and construction, and in some cases its eventual disposal and reuse/recycle.

The center of building performance research (CBPR) in New Zealand established that for a kilogram of aggregate to be produced a corresponding 0.10MJ of energy is required; so for 1 kg of aluminum to be produced the corresponding energy required is 191MJ (Alcon,1996). According to Gordon (2004), in order to produce one ton of steel, bricks, or of cement; it is necessary to invest 60, 6, and 4GJ of energy respectively. Through which a considerable amount of pollutants (co_2, SO_2, No_2, etc) are discharged. Shafii, et al. (2006) opined that, the biggest sector influencing climate change is cement and steel. Cement production is the biggest contributor of greenhouse gas emissions. Although cement makes up 12-14% 0f the final concrete mix further embodied energy comes from transportation and production of aggregate and in the case of reinforced concrete the manufacturing of steel. To this end it has been realized that, where a building is demolished, all the non-renewable energy used to create the building were lost and many more is needed to rebuild.

Table, 1. Embodied Energy Coefficients

Material	MJ/Kg	MJ/Kg3	MJ/Kg^2
Aggregate general	0.10	150	
Virgin rock	o.o4	63	
Concrete block	0.94	2780	
Concrete brick	0.97		
Precast	2.0	2780	
Earth raw			
Adobe block, straw stabilized	0.47	750	
Adobe bitumen stabilized	0.29	490	
Adobe, cement stabilized	0.42	710	
Pressed block	0.42		

Source: Center for Building Performance Research (2007)

A recovery of old materials saves the energy to extract, transport and create new materials and keeps more green space from development. It is imperative to note that, since the energy used in creating the original structure has already created pollution, especially with materials such as concrete, which is responsible for large amount of CO_2 during production, tearing the old building/structure means that all the pollution and energy used in creating the structure will be followed by more in the creation of the new building (Kibert, 1994).

3.2.CONCEPT OF DEMOLITION DEBRIS

The term “Debris” is of French origin (wikinary) that refers to: rubble, wreckage, scattered remain of something destroyed; litter and scattered refuse; ruins of broken-down structure etc. in line with this reference, the dictionary.com defines debris “as remain of anything broken-down or destroyed. Demolition debris can therefore mean, “An act or process of wrecking or tearing down of buildings and other structures through which rubbles or ruins of broken-down structure is generated”.

Building related construction and demolition debris are commonly grouped as a single type of material, though these two material streams come from different sources (ASTSWMO, 2007). Construction materials originate from construction, repair, or remolding activities; this material stream typically consists of a variety of building products (such as concrete, roofing, gypsum wallboard, wood products, plastics, insulation, tiles and metals) as well as packaging materials, that building materials arrived in (such as cupboard and plastics). Construction materials are usually generated as a result of cutting a material down to size for installation or purchasing material in excess of what is needed. While demolition materials are generated from razing or wrecking of building to reduce it to rubble, typical of this components include concrete rubble, blocks rubble, stone, wood, scrap metals, insulations, Brocken glass and other building materials.

IV. THE ISSUES

Demolition of building produces significant amount of materials that are for most part land filled (Wokekoro, 2007). Heavy consumption of resources for inputs to production of virgin components, most of which (cement, glass, clay bricks, steel, etc) involved high level of embodied energy through their production and distribution; absence of re-use and recycling of these materials mean that such most precious resources end-up in dumps and landfills after demolition of buildings, in spite of the declining life span of properties (Irurah and Holm, 1999; cited in Irura, 2001). These resources could be reused or recycled because of the energy embedded in them from its initial production through demolition.Currently, this development has become a very critical issue, as it poses enormous risk not only to the environment but to health and economy (Wahab and Lawal, 2011). It has been revealed that the effects of this situation in Nigeria are low level of technological, economic and social development (Bashir, 2012). According to Shuaibu (2011), huge amount of this waste is always generated, but its disposal has become a severe social and environmental problem.

Table 2: Area of Walls Demolished and Demolition Waste Generated by Construction Material

S/N	sandcrete block buildings (m^2)	Ave. Vol. Generated (m^3)	% of Total Waste	mud buildings (m^2)	Ave. Vol. Generated (m^3)	% of Total Waste	combined mud/sandcrete (m^2)	Ave. Vol. Generated (m^3)	% of Total Waste
1	320.00	60.00	33.47	261.00	78.30	27.30	375.00	126.56	39.23
2	727.00	136.31	38.53	641.00	192.30	33.97	519.00	175.16	27.50
3	1532.00	287.25	57.68	820.00	246.00	30.87	302.00	101.93	11.37
4	587.00	110.06	59.59	23.00	6.90	2.34	375.00	126.56	38.07
5	356.00	66.75	33.63	479.00	143.70	46.60	164.00	55.35	15.95
6	147.00	27.56	25.00	287.00	86.10	48.80	154.00	51.98	26.19
TOTAL		**687.93**			**753.3**			**727.63**	

Source: Project Files (2012)

The geographer Zimmermann stated in 1933 that, 'Resources are not anything static, but something as dynamic as civilization itself'. This assertion gives no reason for optimism. With the accelerating rate of exploitation we are on the Verge of bankruptcy in raw materials. The volume of debris generated (table, 1) from the above study shows the level of ignorance of the economic, social and environmental impact of these resources if such not properly integrated in to the project stream. The total volumes produced from the activity…… 2168.86 m^3 of sandcrete, mud and combined sandcrete and mud multiplied by its corresponding energy requirement in joules……….. Considerable area will be covered; substantial amount will be saved both from transportation to land fill and transporting virgin material to construction site, reducing greenhouse emissions, pollution from noise, and conserving natural resources for the future (table,3).

Table 3: Volume of Waste Generated, Cost of Compensation and Cost of Disposal

Road	Length (km)	Ave. Vol. Generated from Sandcrete Buildings(m^3)	Ave. Vol. Generated from Mud Buildings(m^3)	Ave. Vol. Generated from Buildings with Combination of Sandcrete and Mud	Total Vol of Waste Generated/Road (m^3)	Cost of Disposal at ₦2500/m^3	Compensations Cost (₦)	Non-Contructional Costs=(cost of Disposal+Compensation cost)
1	2.3	60	78.30	126.56	264.86	662,156.30	14,828,023.00	15,490,179.00
2	1.2	136.31	192.30	175.16	503.77	1,259,438.00	200,000.00	1,459,438.00
3	1	287.25	246.00	101.92	635.17	1,587,938.00	73,411,933.00	7,4999,871.00
4	0.926	110.06	6.90	126.56	243.52	608,812.50	17,846,595.00	18,455,408.00
5	0.408	66.75	143.70	55.35	265.8	664,500.00	36,195,160.00	36,859,660.00
6	1.4	27.56	86.10	51.97	165.63	414,093.80	79,583,346.00	79,997,440.00
Total						**6,467,250.00**		**261,299,317.00**

Source: Project Files (2012)

4.2.MATERIAL RESOURCES AND CONCEPTS OF REUSE AND RECYCLING

The building industry is the largest consumer of raw materials in the world today after food production. A major guiding principle for the future should be a drastic reduction in the use of raw materials. This is best applied to the less common non-renewable resources. The re-use of materials following demolition should also be taken into account. Recycling processes should be developed so that materials can be taken care of at their original level of quality, rather than down cycled. Demolition of building structures produce significant amount of materials that can be reused or recycled, principally wood, concrete and other types of masonry and dry wall (CalDRRR, 2013). Reuse and recycle of construction and demolition materials is one of the larger holistic practice called sustainable or green construction, whose fundamental tenet is the efficient use of resources.

In these two phases there are the following possibilities for reducing the use of primary resources:
• To build with an economic use of materials
• To minimize loss and wastage of materials on site
• To use the materials in such a way as to ensure their durability
• To maximize re-use and recycling of materials from demolition.

Definition: reuse and recycle

According to patric, et al. (1999), reclamation of material from waste stream is not considered as recycling in and of itself. Recycling is a reprocessing of reclaimed material and converting it to a new material or use. While re use means the use in similar form or as it was produced. The concept behind reuse is that one should use the item as much as possible before completely replacing them.

V. BENEFITS OF REUSE AND RECYCLING

Reuse and recycling is hardly a new concept for construction industry. Concrete and paving materials have been reused as fill materials or road based for many years; the forms of concrete used by the Romans included recycled aggregate from older stone structures.Waste management: an aspect of waste management includes reducing the amount of waste on job site, reusing as many materials and recycling those items that cannot be reused in their present forms. For Best Practicable Options to be developed guidance is necessary for a given set of objectives. Reuse of construction and demolition debris has occurred for centuries in most cases, this has been in the form of salvaging the materials from one building to use in the other construction project. For road demolition waste can often be reused onsite or for other roadwork, this is because the use of virgin materials instead of materials from demolition or deconstructed material in many instance do not maintain the quality of materials, natural resources and energy (Roth and Eklund, 2001). Hence, improved practices that reused materials in place of virgin material significantly improve environmental performance of the construction sector. Other benefits of reuse include:

- Recovers the highest percentage of embodied energy resources in the materials or subsystems;
- It reduces cost of disposal;
- Cost saving of the material;
- Provide efficient and sustainable way of mitigating climate change;
- Provide employment opportunities etc.

Recycling; the method of recycling of demolition material is very crucial to the economic and practical feasibility of recovering the materials. However there are many benefits to the increased recycling of demolition and construction debris:

- Conserve resources by diverting them from land fill;
- Increase operating life for local landfills that result in associated environmental impacts such as ground contamination;
- With the development of market for debris ‘waste generators’ may potentially have new source of income etc.

VI. CONCLUSSION/RECOMMENDATIONS

In the existence of any material energy must be involved; in many cases the raw material itself comes from fuel and other energy related sources example plastic, aluminum and polycarbonates etc. While huge amount of fossil fuels is invested in the extraction and manufacturing of other materials; such as cements, are manufactured in high temperature kiln and its production is associated with hazardous gasses that are responsible for the formation of acid rain and other health and environmental impacts. Fuels and energy are limited and expensive resources, and it is increasingly important to examine the effects of our activities most especially waste management practices on energy and energy-influenced/derived resources.Waste reduction efforts, such as source reduction; reuse and recycling, can result in significant energy savings. Source reduction techniques, in most cases significantly lower energy consumption associated with raw material extraction, transportation and manufacturing processes. The energy effects of materials occur in each life-cycle stage—source reduction, recycling and reuse, —and knowledge of those effects can reduce the demand for raw materials and energy. The re-use of materials following demolition should be taken into account. Recycling processes should also be developed so that materials can be taken care of at their original level of quality, rather than down cycled; and finally priority should be given to the production methods that use less energy and more sustainable materials with reduced transport distance.

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