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Life Cycle Cost Assessment of Autoclaved Aerated Concrete Blocks

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Abstract: In the Development of construction materials Sustainable use of natural resources has become a necessity in India. In this project work, an LCA study is carry out for an AAC block production for environmental assessment. In addition to the LCA, the Life Cycle Cost (LCC) analysis is also applied for economic assessment. The LCA is performed according to ISO 14040. Firstly, a cradle to gate LCA method performed for one meter cube of Autoclaved Aerated Concrete Block. The LCCA method include in the OpenLCA software which is choose to calculate impact categories i.e. abiotic depletion, global warming potential, acidification potential, eutrophication potential, Eco toxicity, ozone depletion potential and photochemical oxidation potential. The last few decades, several approaches have been developed by agencies and institutions for Bricks Life Cycle Cost Analysis (LCCA). The LCC analysis was performed by developing a price model for internal and external cost categories within the software.
Keywords: Life-Cycle Cost Analysis (LCCA); Autoclaved Aerated Concrete (AAC); LCCA method; OpenLCA software.

I. INTRODUCTION

Autoclaved Aerated Concrete (AAC) bricks was first invented in mid1923 in Sweden by a Sweden Architect Dr. Johan Erikson. It is also known as Autoclaved Cellular Concrete (ACC) bricks or Autoclaved Lightweight Concrete (ALC) bricks. This AAC bricks are made with a Mixture of cement, fly ash, lime, aeration agents and water involving an aeration process that gives it a unique cellular structure.

For project developers it means ecofriendly cost of construction. For environmentally conscious it means ecofriendly product for those who occupy building build with AAC bricks it means better safety and lower energy costs for cooling or heating. At the end it all translates to be better world for future generation. The process of identifying and documenting all the costs involved over the life of an asset is known as Life Cycle Costing (LCC).Life cycle cost management includes the processes required to determine which resources (people, equipment, services, material etc.) and what quantities of each should be used to perform project/system activities, develop an estimate, of the associated cost and allocate them to individual work items.

These processes are aimed to estimate system life cycle cost for deciding and budget allocation and to make sure that the system activities are performed within the approved budget and according to the operational requirements fixed. The life cycle and cost of AAC brick as building material is analyzed in this project. Autoclaved Aerated Concrete (AAC) may be a noncombustible, lime based, cementations artifact that's expanding into new worldwide market. AAC has achieved acceptance in new markets throughout the planet.

II. LITERATURE REVIEW

Life cycle costing (LCC) as a contribution to sustainable construction – towards a common methodology", commissioned by the EU, in January 2006.

The literature review during this document concerning Life Cycle Costing (LCC) and Life Cycle Assessments (LCA) in construction has been assembled as a part of the research for the project. Üçer'e (2012) "Life cycle assessment of masonry wall types using simulation technique" in METU master thesis, the masonry walls; Blacked clay brick, aerated concrete blocks, natural stone and mud bricks were examined by their service life. In the end of life applications of LCA's of those materials, scenarios are produced as waste embedding, reuse and recycling.

The prepared data was transferred to the SimaPro, LCA software. Environmental impact scores of the alternatives identified through this software have been obtained and the results are discussed. Comparative life cycle assessment (LCA) and life cycle cost analysis (LCCA) of precast and cast-in-place buildings in United States commissioned by Tanmay Vasishta.

This document contains, Cradle-to-grave approach was used to develop a framework for assessing the environmental and economic impacts for precast and cast-in-place building systems constructed in United States through Open LCA software and NIST handbook for LCCA.

III. AIM

Aim: The aim of this paper is to find out the effects of environmental, total cost and energy Productivity of the material. Also remedies to reduce the environmental impact, saves a lot in terms of resources and long term cost. Accomplishing new sustainable material in India, which is considered as ecofriendly by stimulating its use around the country. It requires to acknowledge the contribution of raw materials, design, production/manufacturing process, transportation/delivery, use, end of life treatment and final disposal to assess environmental effects. The LCCA results can be used to pick out the opportunities to enhance the environmental performance of bricks at various stages in their life cycle. It also provides the information about the environmental effect and performance of AAC bricks.

IV. RESEARCH OBJECTIVES

A. Evaluate the economic and environmental sustainability effect and details of the AAC bricks by LCCA
B. Demonstrating LCCA approach of AAC bricks applications.
C. Determining total economic worth: Initial and final cost.
D. Leads to enable to speed up the construction process reducing environmental impact.

V. METHODOLOGY

A. Life cycle Cost Assessment Method

A life cycle perspective includes consideration of the environmental aspects of an organization activities, product and services that it can control or influence. Stages in life cycle include acquisition of raw materials, design, production, transportation/delivery, use, end of life treatment and final disposal with their cost analysis by the LCCA process. The LCCA process may be a systematic, phased approach and consists of 4 components: 1. Goal and scope definition 2. Inventory analysis 3. Impact assessment 4. Interpretation In this part of the work, LCC analysis of the AAC blocks production process was carried out in five steps (Figure 1). The functional unit was selected as “1 tone of Autoclaved Aerated Concrete Block” and the system boundaries were taken as LCA studies

Fig.1.Lcca Process

B. System Boundary

The system boundary covers the production of AAC Block from extraction of raw material to the production of finished packaged product at the factory gate. (Cradle to gate).

The system boundary specifically includes:
1) Manufacture of all materials employed (incl. pre-products e.g. cement)
2) Transport of raw materials and pre-products
3) Product manufacturing at plant
4) Packaged at Factory

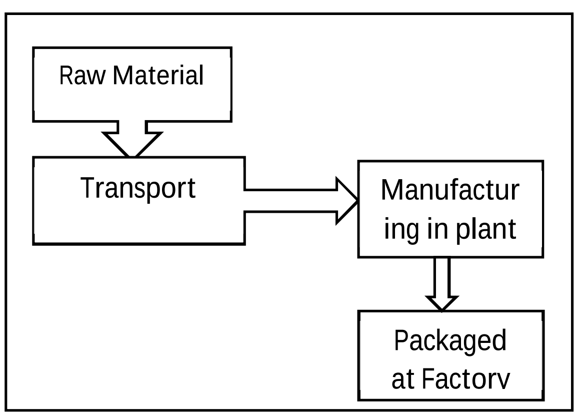

Fig.2. System Boundary

C. *Description of System Boundary*

1) *Raw Material Supply:* Production begins with raw materials. Supply includes staple extraction and pre treatment processes before production.
2) *Transportation:* Transport has relevancy for delivery of raw materials and other materials to the plant and therefore the transport of materials within the plant.
3) *Manufacturing:* Manufacturing begins with next processing raw materials needed for the production followed by mixing all raw materials with excess water at certain proportions, casting of the slurry formulation, expansion aeration, cutting to sizes, high pressure steam curing and packaging of the ultimate products.
4) *Packaged at Factory:* The Manufacture products are then packaged and transport to factory

D. *LCCA Information*

1) *Functional Unit* - The functional unit is 1 tone of Autoclaved Aerated Concrete unreinforced product
2) *Database and LCA software Used* – Aerated Concrete Block: Production mixes at plant, eco invent 3.5, Open LCA.

E. *Autoclaved Aerated Concrete Block Plant Specifications*

This plant of area has 4 acres in the Jalna region and the silo capacity of 100 tons as calculated in Table 1. In the silo, mix the fly ash slurry and uses Gypsum and cement mixes.

Table 1: Technical Specifications of AAC

Specifications	AAC Blocks
Strength	>3.5 N/mm^2 (150mm size cubes)
Shape & Size	Rectangular, 625 x 240 x 100
Water Absorption	22
Breakage / Wastage	0.5-0.8%
No. of Bricks in 1 Cubic meter	67
Density	500-600 kg/m^3
Fly ash Slurry density	1.48-1.52

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VI. RESULTS

A. Environmental Impact Results

Table 2: Environmental Impacts for 1 Tone AAC

PARAMETER	UNIT	RAW MATERIALS TO FACTORY GATE IMPACT AMOUNT
Global Warming Potentials	[Kg CO_2 eq.]	138
Ozone Layer Depletion Potential	[Kg CFC11 eq.]	6.01E-5
Acidification Potential	[Kg SO_2 eq.]	0.380
Eutrophication Potential	[Kg PO_4 eq.]	0.11
Photochemical OxidationPotential	[Kg C_2H_4 eq.]	0.017
Abiotic Depletion Potential	[Kg Sb eq.]	218E-6
Abiotic Depletion Potential (Fossil Resources)	[MJ]	1002

Table 3: Output Flows

PARAMETER	UNIT	RAW MATERIALS TO FACTORY GATE IMPACT AMOUNT
Material for reuse	[kg]	0
Materials for Recycling	[kg]	0
Exported Energy, Electricity	[MJ]	0

B. Quantity and Cost of the Materials

AAC blocks have some technical specifications which are tabulated in Table no 1. The quantity of all the Raw materials has been accountable in the unit of Tons. Description of land, other contingency and cost of all things are tabulated in Table 6.

Table 4: Quantity and Cost of the Materials for 1 Ton Material

SR. NO.	INGREDIENTS	DENSITY X ADDITION OF MATERIALS	TOTAL QUANTITY	RATE/MATER (INR/KG)	TOTAL COST (INR)
1.	Fly ash	2300 x 67	1541 kg	3	4623
2.	Cement	2300 x 18	414 kg	7	2898
3.	Lime	2300 x 8	184 kg	6.5	1196
4.	Gypsum	2300 x 1	230	2	460
5.	Al. Powder	2300 x .08	1.84	240	441.6
6.	Mould oil			40/Liter	40
Total Cost of Materials (a)					9658.6

Table 5: Description of land and other contingency

SR. NO.	DESCRIPTION	COST/MONTH
1.	Man Power	18-20 Lakh
2.	Electricity Bill	5-6 Lakh
3.	Diesel	4-5 Lakh
4.	Lease Rate of Land	5 Lakh
5.	Plant Setup	14 Crore
	Total Cost (b)	14 crore 35 lakh

Total Cost: (a) + (b) = 9658.6 + 14 crore 35 lakh =14crore 35 lakh, Nine thousand six hundred fifty eight (14, 35, 09658.60)

VII. CONCLUSION

A. LCA and LCC are useful tools to determine the environmental and economic performance of Autoclaved Aerated Concrete blocks.
B. LCC is one of the best tool for reducing energy costs and environmental impact.
C. This will allow them to minimize the initial costs.
D. The use of AAC blocks leads to savings in overall project cost; Enables to speed up the construction process reduced environmental and social impact.
E. Therefore we conclude that, the use of AAC blocks around country will save a lot in terms of resources and long term costs.

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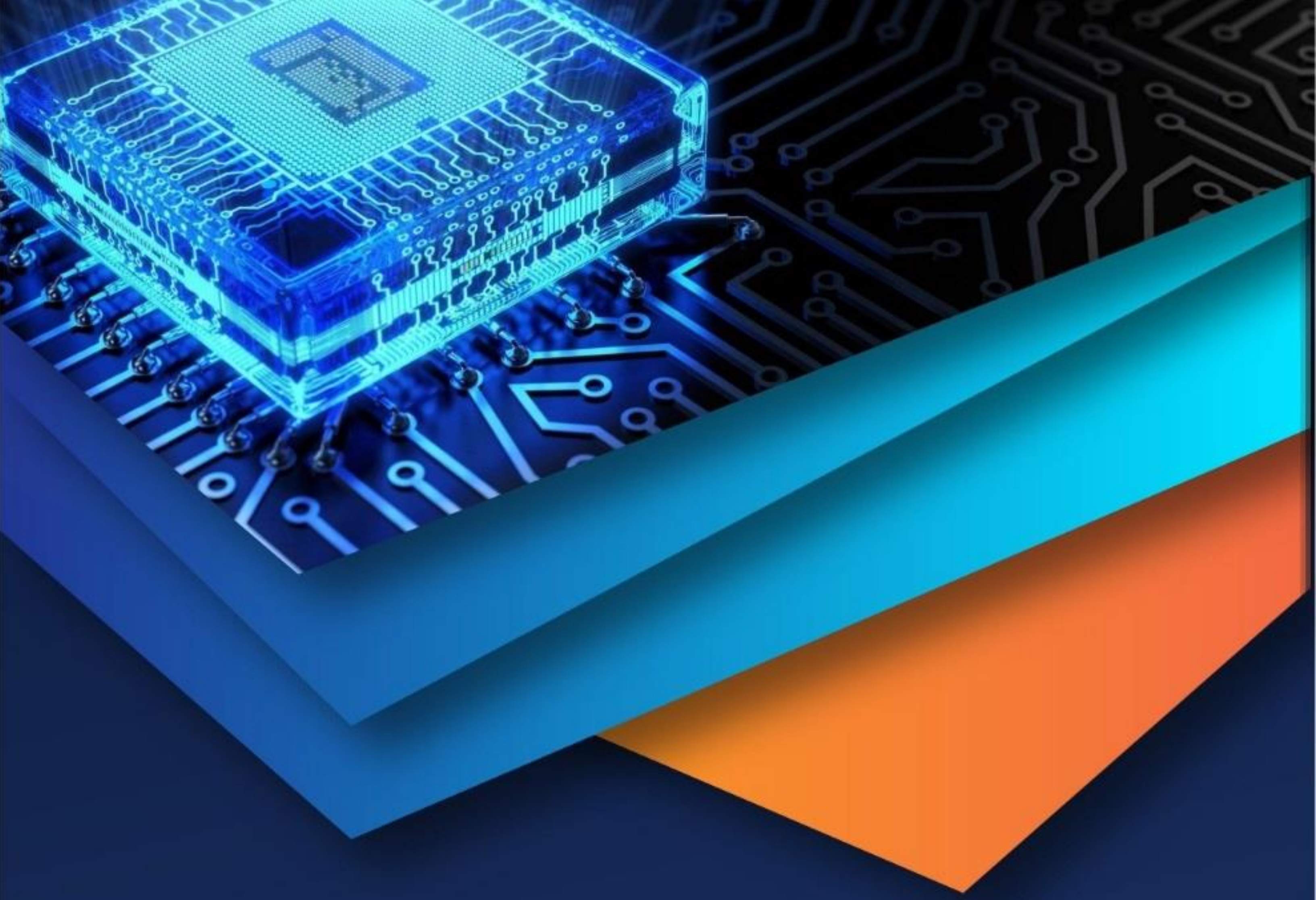

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