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"Life Cycle Assessment of a Construction phase Carbon footprint of a Building"

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Abstract

This research quantifies the Green House Gas (GHG) emissions of Khanduja's located at Banga road, Phagwara, Punjab. The methodology involves quantifying both primary energy consumption as well as GHG emissions in construction phase. A comprehensive Life Cycle Assessment is intended to carry manually to determine environmental effects of the structure. LCA is a very important tool to support civil, structural and environmental engineers realize how they can be a part to reduce the GHG emissions and embodied energy of any building. It provides us with huge potential of improving and lessons learned from LCA are significant. Construction materials like steel are highly recyclable but come with high energy requirements. In this study, the materials contributing to the overall GHG emissions have been estimated and productive alternative solutions have been prepared. The replaceable materials have been identified and a comparative analysis has been conducted to understand the materials that can reduce the overall GHG emissions in Khanduja's. Further, the scope of this thesis lies in discussing Energy saving techniques for reduction of Carbon Footprint during both Operation and maintenance phase along with Construction phase.

1. Introduction

Construction sector has now become a major source of Global GHG emissions and therefore a reduction in these emissions are required so as to minimize overall global GHG emissions. Hence there is an absolute need to change and revise the construction materials and processes for reducing the impact on environment. The building sector consumes 40% of the primary energy and 36% of the energy related to CO_2 emissions in the countries with more industries (IPCC, 2011b).

ISSN:0971-1260
Vol-22-Issue-37-December -2019

Building utilizes the energy throughout its construction phase and operation phase. Therefore, while selecting the materials in construction phase, comparison can be done on various available materials and the materials that tend to contribute to less use of energy can be chosen. The concepts of embodied energy and LCA (Life Cycle assessment) can be the useful tools in decision making when it comes to selection of materials

1.1 The concept of Life Cycle assessment (LCA)

Due to the Urbanization and rapid development of countries in the world, the resources are becoming insufficient for the demand and in addition to that, it is giving rise to environmental issues. Hence it has become very important to generate new ideas to tackle and reduce these issues. LCA is therefore a useful tool to analyze buildings from the point of view of the environment (Baumann et al., 2004).

The knowledge that is produced from these studies can assist the architects and civil engineers to make choice for the most appropriate constructive ideas from the point of sustainability (Antonio Garcia Martinez et al., 2011).

2.Methodology

LCA is one of the most reliable idea for any material and environmental impacts' quantitative assessment . It uses a step by step method to determine the effect of each material.

Primarily,there are three types of LCA methodology that is LCA based on process, LCA based on input–output and hybrid LCA **(** In LCA based on process, the end user enlightened all the processes associated with all life-cycle phases of a product, and relates inputs and outputs with each process, by which total environmental load energy can be determined. There are four stages of Life Cycle Assessment. The methodology of the study is illustrated in Figure2.1

ISSN:0971-1260
Vol-22-Issue-37-December -2019

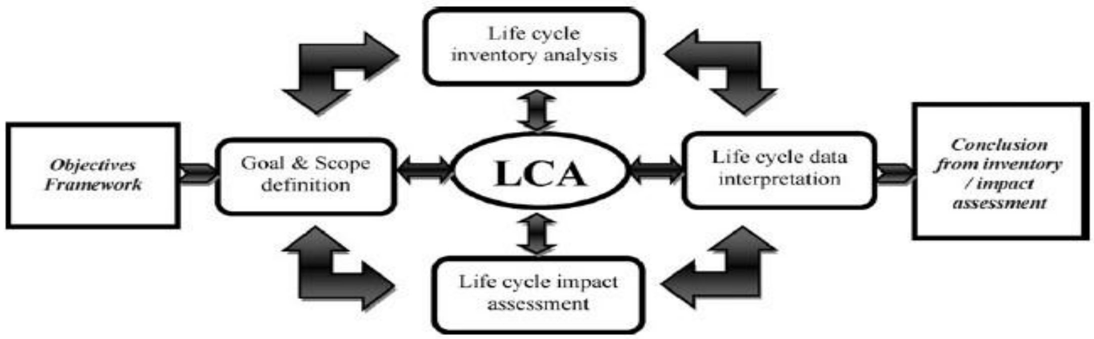


Fig 2.1: Methodology of LCA analysis (Source: Varun et al., 2012)

3. Description of Building:

3.1 Location:

The building that has been chosen for the study is a relatively new building known as 'Khanduja's' which is located in Banga road, opposite to old vegetable market, Phagwara. The building was planned as well as built in single phase and the structure has a floor area of nearly 175 m2. It is a three storey commercial building with a semi-basement. The semi-basement and the first storey is being utilized for selling garments and accessories. The second storey is kept vacant to let for renting and the third storey is still under construction.

3.2 Structural Features

The structure is aesthetically appealing due to vitrified tile floor work along with marble and granite stone tiling at some minor places. The main construction components used are considered and it is evident that cement mortar, reinforced concrete cement framework, glass, timber, brick masonry, aluminum, steel, anti-skid tiles, gypsum ceiling and vitrified tiles are main components employed in the construction.

Other significant specifications of building are: Structure: Reinforced Cement Concrete Framework Masonry: Brick masonry

Flooring: Cement concrete flooring with vitrified tiles (mainly), marble and anti-skid tiles used at various locations. Door and Windows: Aluminum shutters have been used for doors (washroom) and Glazed doors have been used for main entry since it is a garment showroom.

ISSN:0971-1260
Vol-22-Issue-37-December -2019

The interior portion is mainly constructed of commercial plywood, teak wood, and timber for stacking garments and for furniture.

Fig 3.1 Front View of Khanduja's

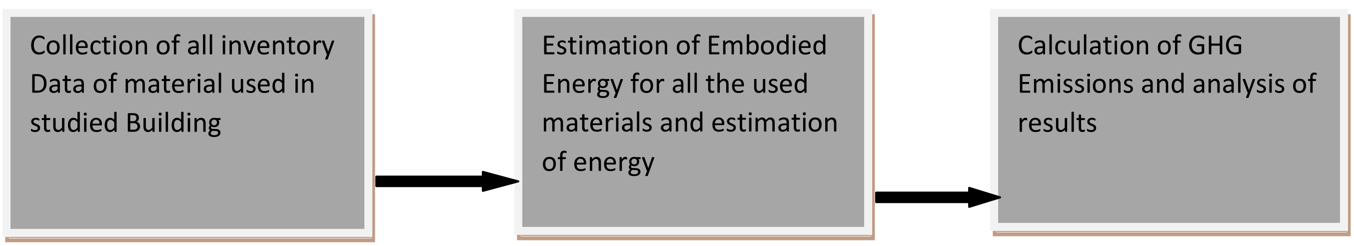


Fig 3.1: Methodology followed for Khanduja's

4. Results and Discussion:

4.1 GHG Emissions during Construction Phase

Table 4.1.1 GHG emissions from Construction Phase

1.	**Basic Materials used for various construction purposes**	**Final Value**	**GHG emissions Coefficient (Kg CO_2 equivalents/ Kg)**	**GHG Emissions (Kg CO_2 equivalents)**
	Bricks	348000	**0.24**	83520
	Cement	166650	**0.95**	158317.5

ISSN:0971-1260
Vol-22-Issue-37-December -2019

	Sand(fine aggregate)	425500.2	**0.0051**	2170.05102
	Bajri(coarse aggregate)(20MM)	607040	**0.0052**	3156.608
2.	**Stone usage and Tile Work**			
	P.O.P covering(10mm) to protect tiles	8947.5	**0.12**	1073.7
	Bitumen on roofs	Nil	**0.55**	Nil
	parking Tiles25mm thick	2345.84		2345.84
	Coloured Granite stone tiles(20mm)	1985.77	**0.48**	953.1696
	Vitrified floor tiles of Size 600 x 600 mm	7158	**0.55**	3936.9
	Anti-skid tiles10 mm	1310.32	**0.32**	419.3024
	Gypsum/lafarz false ceiling(12.5mm)	11184.37	**0.13**	1453.9681
	Marble stone flooring with 18 mm	2342.52	**0.187**	438.05124

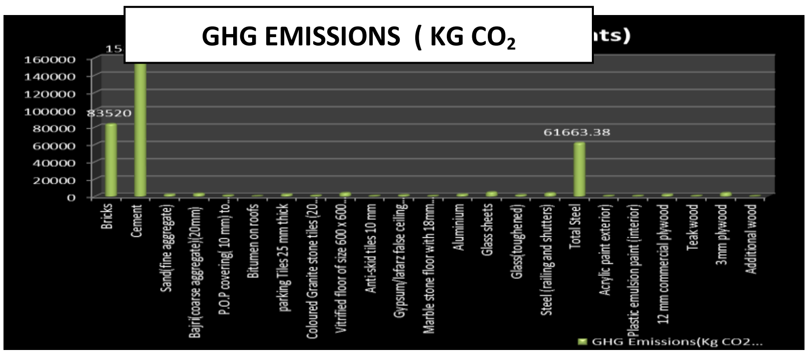
3.	**Metal & other material used**			
	Aluminum	179.41	**12.79**	2294.65
	Steel (reinforcement)	20035	**2.89**	57901.15
	Glass sheets	5198.87	**0.91**	4730.972
	Glass(toughened)	1655.5	**0.91**	1506.505
	Steel (railing and shutters)	1301.81	**2.89**	3762.231
	Total Steel	21336.81	**2.89**	61663.38
4.	**Paints(Sqm)**			
	Acrylic	266.6	**2.1**	559.86
	Plastic emulsion	222.6	**2.3**	511.98

ISSN:0971-1260
Vol-22-Issue-37-December -2019

5.	**Wood used**			
	12 mm commercial	1936.87	**1.0788**	2089.495356
	Teak wood	314.17	**1.56**	490.1052
	3mm plywood	3710.016	**1.08**	4006.81728
	Additional wood	112	**0.75**	84

4.2 Graphical Analysis for GHG EMISSIONS

Fig 4.1 Overall Graphical Analysis of **GHG Emissions(Kg CO_2 equivalents) for Khanduja's**



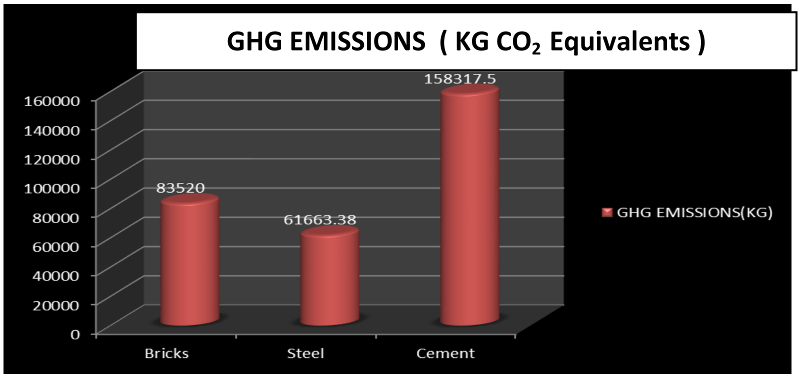
4.3 POTENTIAL REDUCTIONS

4.3.1 Table for potential reductions

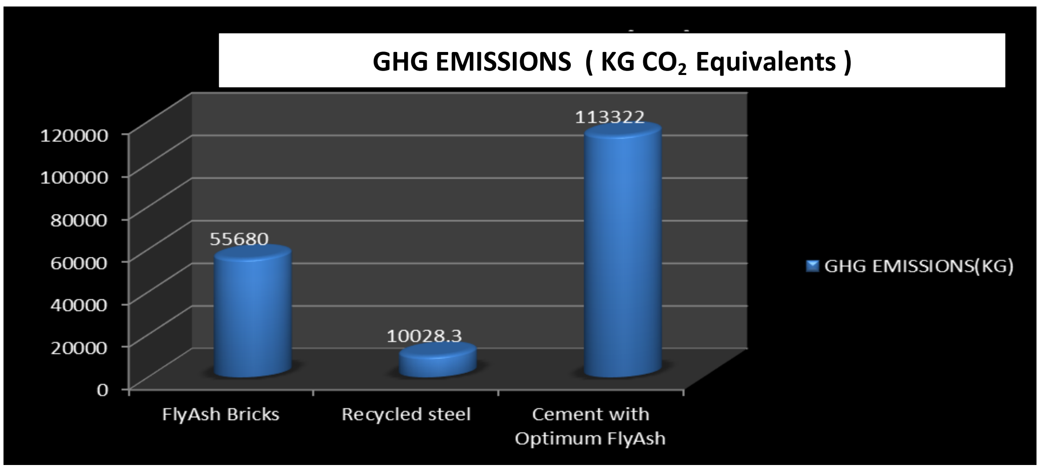
S.No.	1	2	3
Material Used	Bricks	Steel	Cement
GHG	83520	61663.38	158317.5
Material Replaced	Fly Ash bricks	Recycled Steel	Cement with Optimum Fly ash
GHG	55680	10028.30	113322
% Reduction	**33.33%**	**83.73%**	**28.42%**

4.2-Graphical Analysis of GHG Emissions for **Existing major GHG contributors**

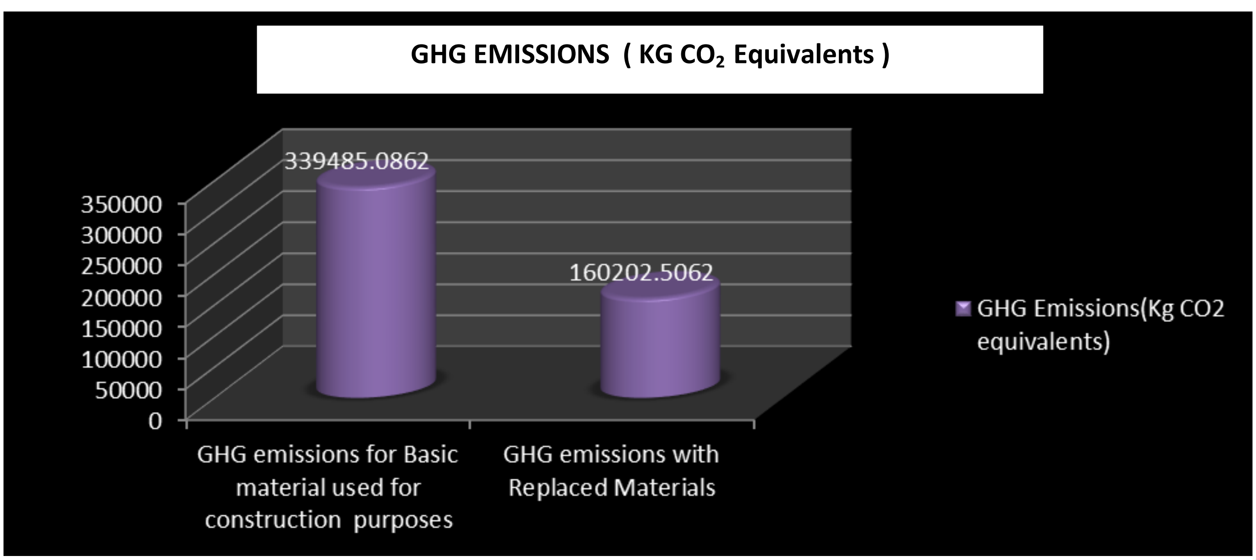
ISSN:0971-1260
Vol-22-Issue-37-December -2019



4.3-Graphical Analysis of GHG Emissions for **proposed Replaced materials**

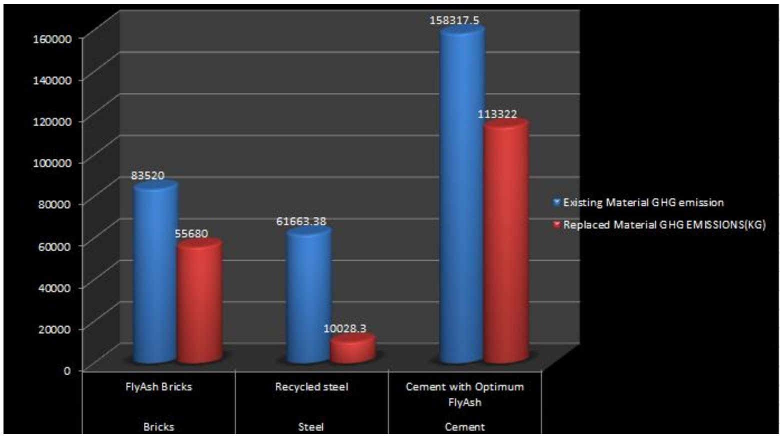


4.4-Graphical Analysis showing overall **reduction in GHG emissions for Khanduja's after the replaced materials are put instead of normal conventional materials**



4.5-Graphical Analysis of GHG Emissions for **Existing Vs Replaced Materials**

ISSN:0971-1260
Vol-22-Issue-37-December -2019



4.4 Potential Savings

Recycled steel, Fly ash bricks and Cement containing fly ash can be used to minimize construction phase GHG Emissions up to 52.8%.therefore, such materials can be replaced in existing Khanduja's for reducing the GHG emissions.

5. Conclusion :

It is clear from the study that steel, cement and Brickwork are the main contributors to GHG emissions during construction phase with glass and tiles playing a minor role. The GHG emissions can be reduced up to 52.8% during construction phase by replacing certain materials by more environmental friendly materials. The environmental friendly materials for Khanduja's could have been Fly ash bricks, Recycled steel and optimum fly ash bricks instead of normal conventional materials. Further Low-e-glass can be preferred over normal glass to reduce electricity bill and the overall carbon footprint. There is also a scope to minimize the carbon foot print in operation and maintenance phase for Khanduja's

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