JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

LIFE CYCLE ASSESSMENT OF CONCRETE

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Abstract : Concrete is a broad field and the most used building material in the world. The use of concrete is increasing day by day. However, the negative impact of the increased demand for concrete is its environmental impact. Concrete production, while encouraging development, pollutes the environment at an alarming rate. Cement production has many harmful emissions and the extraction of raw materials such as limestone, clay and aggregates destroys the terrain. Emissions into the atmosphere during the production of cement and concrete not only contribute to global warming, but also have a significant impact on the local environment. This paper describes all the environmental impacts associated with the production of concrete, along with the cement production process and purchase of aggregates. Since concrete is an integral product and its use cannot be stopped, there is a need to reduce the impact of concrete manufacturing that can be achieved by replacing some of the products used to manufacture concrete, thus reducing the impact of concrete on the environment. There are several alternatives to reduce the impact of I will briefly mention the specifics at the end.

IndexTerms - Ordinary Portland cement, Environmental impact, LCA, LCIA, Clinker production.

Introduction

A lifecycle approach helps with decision making. This means that everyone and everything involved in a product's lifecycle, from cradle to grave, has a responsibility and a role to play, taking into account all the economic, social and environmental impacts. To do. Agencies, businesses and governments must fully consider the impact of all product stages when making decisions about consumption, production, policy and control strategies. A life cycle approach enables product designers, service providers, government officials, and individuals to make long-term decisions and consider all relevant environmental media (air, water, land, etc.). increase. The lifecycle approach avoids transferring problems from one lifecycle stage to another, from one geographical area to another, or from one environmental medium to another.

In recent years, attention has focused on the environmental impact of cement production. Various publications make different statements about these environmental effects at different stages of production. This study evaluated ordinary Portland cement (OPC) by applying a life cycle analysis (LCA) assessment tool to determine the environmental impacts of cement production using the midpoint approach of the LCIA methodology. Did. The results of the assessment show that the clinker production stage is the largest contributor to global warming causing climate change due to his large CO2 emissions affecting both human health and ecosystems. Crude oil, coal and natural gas are maximally consumed, causing depletion of fossil resources and terrestrial toxicity that affects both humans and ecosystems. This is because most of the copper is deposited during the clinker production stage along with other production stages

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The need for an LCA:

1. Determine the environmental impact of your product.
2. Helps reduce environmental impact and waste.
3. Helps reduce costs by allowing in-depth product research.
4. Product development is possible.
5. It helps to substantiate your marketing claims, improve your product/company image, and identify the right performance metrics.

I. METHODOLOGY

LCA is an assessment tool used to analyze the environmental impacts of a process or product, considering the potential impacts of such process or product throughout its cycle chain. A good stance taken by LCA in Systems Researchis to state a holistic LCIA method, whose calculation (environmental impact) is based on specific factors. This allows theto speed up analysis and simplify systems under investigation. ReCiPe is an LCIA method that helps assess the impact categories using both endpoint and midpoint approaches.of the surveys take a process-oriented approach (the waypoint). Midpoint provides scientific assessments of the causes and consequences of various environmental impacts. In the midpoint approach, flows are classified according to their environmental impact. This approach includes approximately 18 impact categories: global warming, stratospheric ozone depletion, ionizing radiation, ozone formation, terrestrial acidification, freshwater eutrophication, ocean eutrophication, terrestrial ecotoxicity, and freshwater. ecotoxicity, etc. Streamlining to more general environmental impacts.

2.1 Clinker Assessment

Table 1. Inventory Data for 1kg Clinker production.

	Units	Input/Emission	
		Design Data	2011
RAW MATERIALS*			
Limestone (Milled & Loose)	Kg/Clinker Kg	1.18	-
Clay (At Mine)	Kg/Clinker Kg	0.35	-
Sand (At Mine)	Kg/Clinker Kg	0.07	-
Iron Ore (From Mine)	Kg/Clinker Kg	0.01	-
Water	Cum/Clinker Kg	1.4E-04	-
ENERGY**			
Electricity	kWh/ Clinker Kg	0.07	0.07
Petroleum Coke	Kg/Clinker Kg	0.09	0.09
Hard Coal	Kg/Clinker Kg	5.6E-09	-
Diesel	Kg/Clinker Kg	9.1E-07	-
Heavy Fuel Oil	Kg/Clinker Kg	1.7E-09	-
EMISSIONS			
CO2	Kg/Clinker Kg	0.80	0.82
NOX	Kg/Clinker Kg	7.7E-03	1.2E-03
SO2	Kg/Clinker Kg	3.2E-04	2.5E-04
Particulates	Kg/Clinker Kg	0.07	4.1E-4

III. LIFE CYCLE ASSESSMENT FACTOR

1. Impact of Global Warming: The contribution of concrete to its GWP (Global Warming Potential) over its life cycle is approximately 75-80%, with raw material extraction being the largest. Also, among raw materials, cement production is the single largest source of greenhouse gas emissions, and in cement plants, clinker accounts for approximately 69% of total emissions from cement production, with the remaining 31% for energy. due to consumption i.e., From fossil fuels.

2. Acidification: Acidification is primarily caused by SO2 and NOx emissions. The level of acidification depends on the type of plant construction, clinker construction and cement type. HCL and ammonia (NH3) are released in very small amounts during cement production and therefore usually have a very low or negligible impact on the environment. Manufacturing Industries, Brussels, 2001. SO2 is mainly released when clay is used as raw material. The amount of SO2 emitted varies between 0.2 and 7 kg per tonne of cement produced, while NOx is emitted at a rate of approximately 0.4 to 6 kg per tonne of cement produced.

3. Eutrophication: The main emission of NOx (Nitrogen Oxides) is the main cause of eutrophication. Clinker and cement production emits a large amount of NOx, "about 31-35%", but the main factor is transportation, about "59-65%".

Table 2. Characteristic factors used for Acidification & Eutrophication

Emission	Acidification	Eutrophication
Ammonia (NH_3)	1.88	0.33
HF (Hydrofluoric Acid)	1.6	-
HCL (Hydrochloric Acid)	0.88	-
NO_2 / $N0_x$	0.7	0.13
SO2/S02	1	-

4. Photochemical oxidation potential: Photochemical ozone production is the presence of volatile oxidizing compounds (VOCs) and carbon monoxide (CO) in the troposphere. The action of solar radiation on these substances causes reactions between oxidizing photochemical compounds and hydroxyl radicals (OH-) in the presence of nitrogen compounds (NOx), resulting in the formation of tropospheric ozone (O3). These emissions are released during clinker and cement kiln slag formation and depend on the type of fuel used and the type and design of the plant.

5. Greenhouse effect: The greenhouse-related gas emissions in the LCI analyzed were carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O), with corresponding characteristic factors of 1, 11, and 11, respectively. and 270. However, the combined impact of methane (CH4) and nitrous oxide (N2O) on the greenhouse effect is very small compared to the contribution of carbon dioxide (CO2), which ranges from 98.8% to 100%. This is because despite its low characteristic factor (1), it emits significantly more CO2 than other gases. It is important to recognize the significant quantitative impact of CO2 emissions. Depending on the type of cement, these values can reach up to 800 g CO2/kg cement.

Table 3. Characteristic Indicators

	Global Warming Potential	Eutrophication Potential	Acidification Potential	POCP
	gm CO_2 eq/gm	PO_4 eq/gm	gm SO_2 eq/gm	gm C_2H_2 eq/gm
Emissions to Air				
SOx	-		1	-
NOx	-	0.13	0.696	-
NH3	-	0.35	1.88	-
CO2	1	-	-	-
CO2	-	-	-	0.032
CH4	21	-	-	0.007
C2H2	-	-	-	1
CHCl3	5	-	0.803	0.004
CFC (Hard)	4000-17000	-	-	-
CGC (Soft)	93-2000	-	-	-
CGFC-11	4000	-	-	-
HC	11	-	-	0.416
Emissions to Water				
BOD/COD	-	0.022	-	-
SOx	-	-	1	-
NOx	-	0.13	0.696	-
NH3	-	0.349	1.88	-
PO4	-	1	-	-

6. Carcinogens and heavy metals: Metals heavier than the specific gravity of titanium (4.51 g/m³) are considered heavy metals. Heavy metals and carcinogens are found in trace amounts in raw materials such as crude oil, rocks and coal. Based on the inventories used, it can be inferred that these emissions primarily originate from power plants. This is because there is no evidence that they are included in the raw materials for cement production. The table below shows the heavy metals and carcinogens produced in cement and concrete production and their emission levels.

Table4 . Characterization factors affecting formation of Ozone, Heavy metals and Carconigens.

Chemical	Ozone Depletion	Heavy Metals	Carcinogens
Aldehydes	0.443	-	-
Arsenic	-	-	0.004
Benzene	0.189	-	0.0004
Benzopyrene	-	-	1
Cadmium	-	5	-
Chromium	-	0.2	-

Methane	0.007	-	-
C2H4	0.398	-	-
Ethylbenzene	-	-	0.000045
Phenol	0.761	-	-
Fluorobenzene	-	-	1
Silver	-	1	-
Nickel	-	-	0.045
PAH	0.761	-	1
Lead	-	1	-
VOC	0.398	-	-

7. Transportation: Energy usage and emissions in the transportation of cement, aggregates and concrete are as follows. Road transport by heavy trucks using diesel as an energy source is being considered. An average distance of 100 km (160 miles) is considered. This has been accepted by his ECCO members to study his LCI distance of concrete considering transport.

Table 5. Emissions during transportation.

Transportation of	Emission (kg/cum of concrete)
Cement	
Particulate Matter	0.002
CO_2	1.62
SO_2	0.003
NO_x	0.015
VOC	0.003
CO	0.015
CH_4	0
Aggregate	
Particulate Matter	0.009
CO_2	7.09
SO_2	0.001
NO_x	0.065
VOC	0.012
CO	0.065
CH_4	0.002
Total Material	
Particulate Matter	0.011
CO_2	8.71
SO_2	0.014
NO_x	0.08
VOC	0.014
CO	0.08
CH_4	0.002

IV. SUGGESTION

4.1. Suggested Alternatives to Reduce Environmental Impacts

There is no substitute for concrete in the construction and construction industry. There are various ways to reduce emissions and environmental impacts by altering or altering the various materials used in cement and concrete manufacturing, or even replacing some materials entirely.

1. Reduction of cement content: The use of fly ash has increased recently. Fly ash is produced as a by-product in coal-fired power plants used to generate electricity. Fly ash reduces the cement content, but since fly ash production comes from coal-fired power plants, using fly ash has about the same environmental impact as cement production.
2. Recycled Aggregate: This topic is under study and holds great promise as the precisely mined concrete traditionally used in the backfill process can be used as aggregate for concrete production. It seems. This greatly reduces the use of virgin aggregates, significantly reduces emissions to the atmosphere, and reduces land destruction. A recent study by A.R. Cotwal. YJ Kim and J.

3. Use of renewable source of energy: Although this idea seems logically great, but the capital requirement required to set up renewable sources of energy supply for the processed such as heating at a cement manufacturing unit are very high and are not practical as incorporating these types of energy.

V.CONCLUSION

We conducted a specific life cycle assessment of Cradle to Gate according to the guidelines of ISO14040.2 Draft: Life Cycle Assessment – Principles and Guidelines. A thorough and detailed analysis has been carried out to determine how the cement production process and transportation, including raw material to the cement plant, cement to the batching plant, and aggregate to the batching plant, affect the cement environment. Cement production mainly causes global warming due to very large amounts of CO2, and transportation leads to acidification and eutrophication. Carbon dioxide is the main emission leading to increased global warming, followed by sulfur oxides and nitrogen oxides. Some chlorofluorogases (CFCs) are also emitted along with volatile organic compounds (VOCs).

As global development has increased exponentially over the last 10-15 years, so has the demand for concrete. This ever-increasing demand for concrete is increasing pressure on the environment in the form of more and more quarries, crustal destruction and cement production, all of which have a significant impact on global warming (GW). According to one report, cement production or cement factories contribute up to 5% of global carbon emissions and are a major contributor to global warming.

Cement manufacturing energy input and emissions data were obtained from a 2002 publication of the Portland Cement Association, a leading organization in cement research. Here is an EU article that also helped me get data for cement production. There are four types of cement manufacturing methods, but only the dry method of clinker was considered in this study.

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