International Symposium on Life Cycle Assessment and Construction

Case Studies for Buildings

COMPARATIVE LIFE CYCLE ASSESSMENT: STRUCTURAL MASONRY OF CONCRETE AND CLAY BLOCKS

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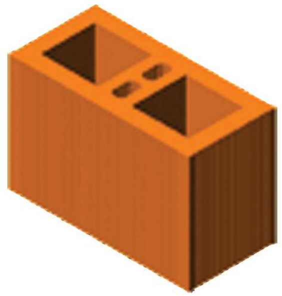

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INTRODUCTION

LCA and the certification systems

Existing systems for the environmental certification of buildings: prevalence of the recognition of product attributes, such as cost, durability, renewability and recycled content

Attributes are dealt separately and missing the global notion of the impact.

The availability of data of Life Cycle Assessment of major building systems, according to their function would encourage the use of LCA by the environmental certification systems.

OBJECTIVE

The objective of this research is the development of a comparative LCA study for structural masonry of concrete blocks and structural masonry of clay blocks.

In addition, it is intended to contribute to the development of a life cycle database of major building systems which could be used by environmental certification systems of buildings, to enable a quantitative environmental assessment of building systems.

METODOLOGY

Application of a complete LCA methodology for comparative purposes to be disclosed to the public.

The methodology will be guided by ISO 14040 and ISO 14044 through the application of the guidelines proposed by ILCD Handbook, and should consist of four phases:

- Definition of Objective and Scope;
- Life Cycle Inventory Analysis (LCI)
- Life Cycle Impact Assessment (LCIA);
- Interpretation.

CASE STUDY

OBJECTIVE: Intended Application and Target Audience

- **Comparison** between structural sealing systems
- Structural masonry of **clay blocks** vs. structural masonry of **concrete blocks**
- Aims to **support the decision making** of designers in the **selection of building components and systems**.
- Scientific study, intended for publication to the academy for areas related to construction.
- **Target Audience: technical and external** audience.
- This study is a **comparative assertion** and is expected to **be disclosed to the public**.

CASE STUDY

SCOPE: Functional Unit and Reference Flow

The **functional unit** adopted is **1.00m² of external structural masonry**, which provides **structural, thermal and acoustic performance**, as required by the relevant standards, for the application in the bio-climatic zone 3, related to the **city of Sao Paulo**, for a period of **40 years** (minimum durability fixed by NBR 15575-1 for external walls building systems).

The **reference flow** for the functional unit of 1m² of structural masonry consists of:

- 16,67 clay blocks, 0.0126m³ of sitting mortar and 0.028m³ of mortar coating = **158,558kg**
- 16.67 concrete blocks, 0.0126m³ of sitting mortar and 0,04m³ of mortar coating = **269,8565kg**

CASE STUDY

SCOPE: Data Sources and Cutoff Criteria

Sources of secondary data:

a) **ELCD database 2.0**;

b) **GaBi4 Database**;

c) **Athena Renewable Materials Institute.**

Cutoff criteria

The cutoff will be applied on **inflows** of significance **lower than 0.1%**.

Emissions those **contributes to EDIP 97 impact categories will be considered**, regardless to their magnitude.

CASE STUDY

SCOPE: Requirements of Systems Comparability

Adopted alternatives:

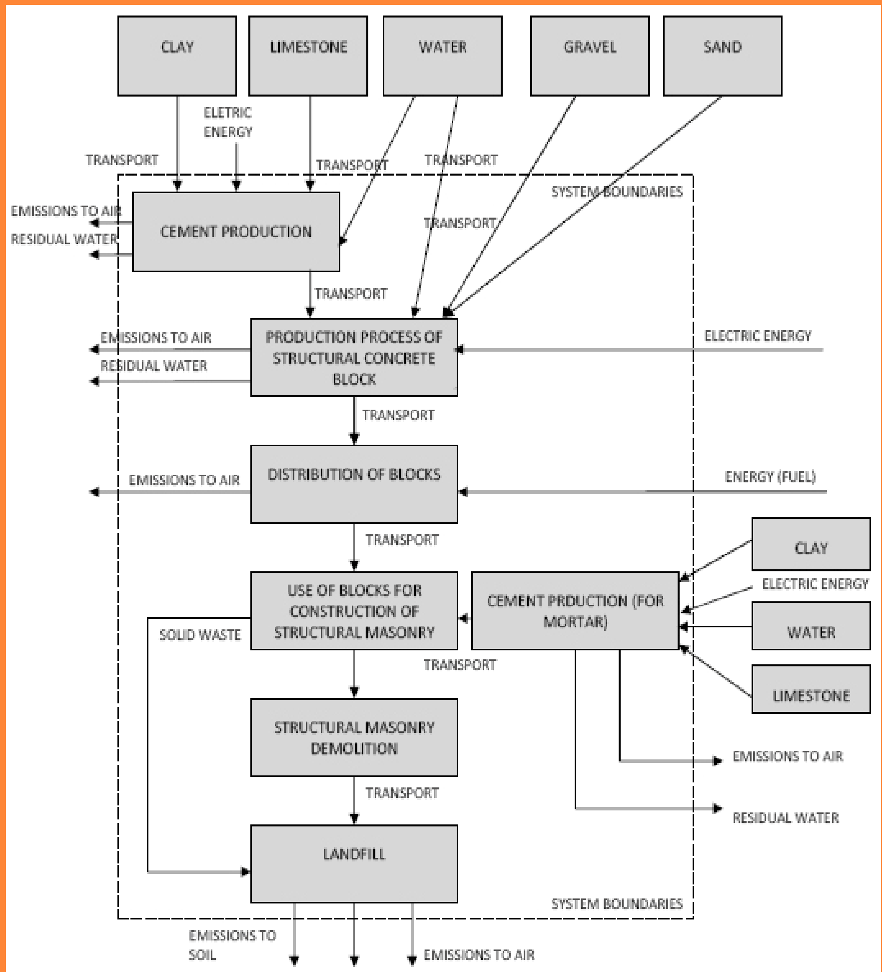
Structural masonry of hollow clay blocks, made by blocks of two holes, 14 cm thick, with external plaster coating of 2 cm and internal plaster coating of 0.8 cm;

Structural masonry of hollow concrete blocks, made by blocks of two holes, 14 cm thick, with external and internal plaster coating of 2 cm.

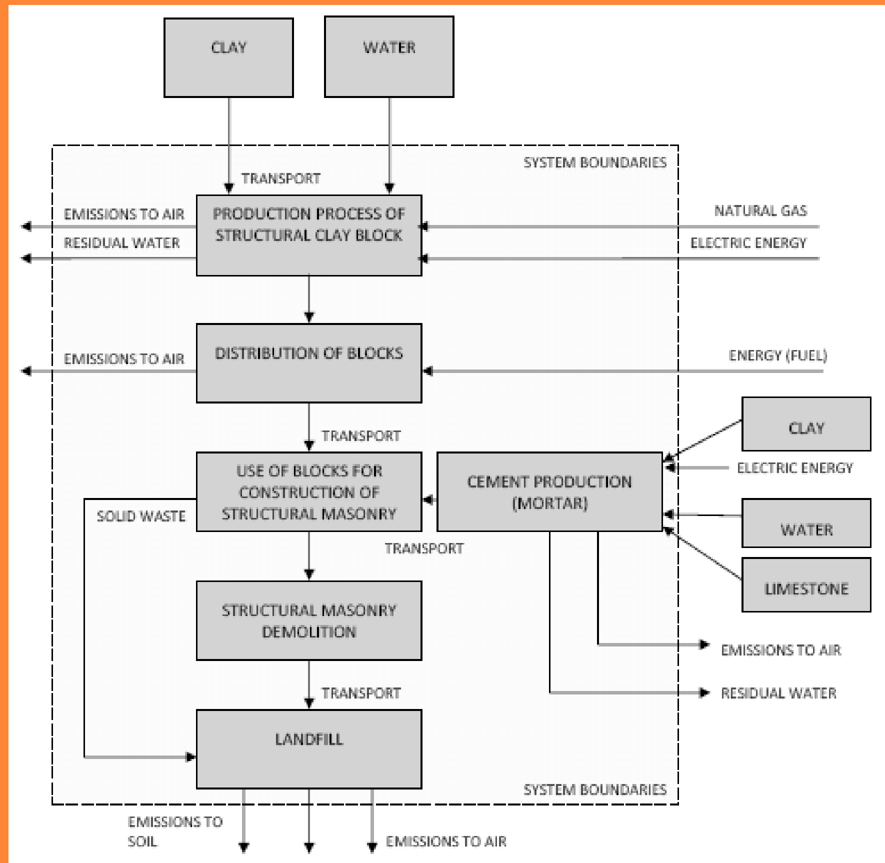
Alternatives equivalence: based on recent scientific publications of Sacht and Rossignolo (2009) and on the relevant standards as NBR 15575-1 (ABNT, 2008), NBR 15220 (ABNT, 2005), NBR 15151 (ABNT, 2000), NBR 15152 (ABNT, 1987) e NBR 8681 (ABNT, 2003).

CASE STUDY

LIFE CYCLE INVENTORY ANALYSIS (LCI): Processes Identification



Structural Masonry of Concrete Blocks



Structural Masonry of Clay Blocks

CASE STUDY

LCI: Organization of processes for data collection

1. **Processes in the life cycle of structural masonry of concrete blocks**:

   1.1. **Portland cement production** process (ELCD Database 2.0);

   1.2. **Production of structural concrete blocks** (ELCD Database 2.0);

   1.3. **Distribution** of concrete blocks (GaBi4 Database);

   1.4. **Use** of structural concrete blocks for construction, including mortar production (ELCD Database 2.0);

   1.5. **Demolition** of structural masonry of concrete blocks and transport to landfill (GaBi4 Database);

   1.6. **Landfill** (ELCD Database 2.0).

2. **Processes in the life cycle of structural masonry of clay blocks:**

   2.1. **Production of structural clay blocks** (Athena Renewable Materials Institute);

   2.2. **Distribution** of clay blocks (GaBi 4 Database);

   2.3. **Use** of structural clay blocks for construction, including mortar production (ELCD Database 2.0);

   2.4. **Demolition** of structural masonry of clay blocks and transport to landfill (GaBi4 Database);

   2.5. **Landfill** (ELCD Database 2.0).

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LIFE CYCLE IMPACT ACESSMENT (LCIA)

EDIP 97 methodology, which covers the following impact categories (Wenzel et al. 1997, Hauschild e Wenzel, 1998):

- **Resource Comsumption**
- **Global Warming**
- **Stratospheric Ozone Depletion**
- **Photochemical Ozone Formation**
- **Acidification**
- **Nutrient Enrichment**
- **Ecotoxicity**
- **Human Toxicity**
- **Solid Waste to be landfilled**.

The category related to impacts in the work environment was not addressed in this paper.

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LCIA: Resources Consumption

Concrete structural blocks		
Consumption	**Reference unit**	**1m² of structural masonry**
Consumption of non-renewable resources	Kg	3,41E+02
Consumption of renewable resources	Kg	5,39E+01
Consumption of energy from non-renewable sources	MJ	2,05E+02
Consumption of energy from renewable sources	MJ	1,25E+01
Clay structural blocks		
Consumption	**Reference unit**	**1m² of structural masonry**
Consumption of non-renewable resources	Kg	1,82E+02
Consumption of renewable resources	Kg	4,51E+01
Consumption of energy from non-renewable sources	MJ	2,98E+02
Consumption of energy from renewable sources	MJ	1,88E+02

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LCIA: Potencial Impacts from Emissions

Global Warming Category	
Structural Masonry System	**Kg CO2-eq/m² of structural masonry**
Concrete blocks	3,66E+01
Clay blocks	2,58E+02
Stratospheric Ozone Depletion Category	
Structural Masonry System	**Kg CFC11-eq/ m² of structural masonry**
Concrete blocks	4,20E-03
Clay blocks	8,85E-04
Photochemical Ozone Formation Category	
Structural Masonry System	**Kg C2H4-eq/ m² of structural masonry**
Concrete blocks	3,56E-03
Clay blocks	4,12E+00
Acidification Category	
Structural Masonry System	**Kg SO2-eq/ m² of structural masonry**
Concrete blocks	6,16E-02
Clay blocks	8,16E+01

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LCIA: Potencial Impacts from Emissions

Nutrient Enrichment Category			
Structural Masonry System	**Kg NO_3^--eq/ m² of structural masonry**		
Concrete blocks	8,92E-01		
Clay blocks	3,74E+01		
Ecotoxicity Category			
Structural Masonry System	**Chronic in soil - m³ of soil/m² of structural masonry**	**Chronic in water - m³ of water/m² of structural masonry**	**Acute in water - m³ of water/m² of structural masonry**
Concrete blocks	4,46E-02	8,80E-01	8,63E-02
Clay blocks	9,00E-03	2,33E-01	2,30E-02
Human Toxicity (via exposure to the environment) Category			
Structural Masonry System	**From air - m³ of air/m² of structural masonry**	**From water - m³ of water/m² of structural masonry**	**From soil - m³ of soil/m² of structural masonry**
Concrete blocks	1,71E+03	1,16E-01	9,55E-04
Clay blocks	3,27E+05	1,64E-02	5,01E-04

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LCIA: Solid Waste

Waste to be dumped or landfilled	
Structural Masonry System	**Kg / m² of structural masonry**
Concrete blocks	3,00E+02
Clay blocks	1,67E+02

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INTERPRETATION: Conclusions

- **Resource consumption**: the **structural masonry of concrete blocks** has shown a **higher consumption of renewable and non-renewable resources**, and also generating **more solid waste**. The **masonry of clay blocks** has shown **higher energy consumption** of both types of sources.

- Larger contribution from emissions of the **structural masonry of clay blocks** for the categories **Global Warming, Photochemical Ozone Formation, Acidification, Nutrient Enrichment and Human Toxicity in the air**.

- The emissions from the **structural masonry of concrete blocks** showed a larger contribution for **Stratospheric Ozone Depletion**, for all types of **Ecotoxicity** and for **Human Toxicity in water and soil**.

CASE STUDY

INTERPRETATION: Conclusions

- The **analysis of the results** in this paper required the observation of **each category of impact in isolation**.

- The **results were presented aggregated** for the whole product systems for the two studied alternatives.

- The authors intend, in a **future work**, to:

  1. Present a more detailed **impact assessment for each elementary process** in order to allow the **identification of processes** **with larger contribution.**

  2. Apply the **Normalization and Grouping** to the LCIA categories results, in order to have a better **overview of the potential impacts**.

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THANK YOU!

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