ROLE OF THE CONSTRUCTION AND BUILDING SECTOR IN CLIMATE CHANGE – WHAT SHOULD WE DO?

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Abstract

Climate change is one of the most worrying environmental issues nowadays and efforts should be made to mitigate it all over the world. Among the causes of this phenomenon there is an increasing degree of anthropogenic carbon dioxide emissions. While the world's CO_2 emissions have grown almost linearly, CO_2 emissions have dropped in Hungary: from 58,019 in 2005 to 42,086 kt in 2014. (Source: WB, 2018), but it increased in the construction sector (IEA, 2017).

Nearly 60% of the world's total carbon dioxide emissions are linked to the energy sector and 10% to buildings. Recently global cement production is the third largest source of carbon dioxide due to the use of fossil resources and change in land use, it is growing rapidly. According to statistical data, cement production is responsible for 8% of total CO_2 emissions in the world. So the responsibility of building sector in climate change is great.

In this paper we review the global situation of cement and insulating materials production, it's impact on climate change, and also investigate the domestic environmental impact of construction and building sector. This article highlights the main challenges and tries to give some proposals what we should do towards future sustainable construction and building sector.

Keywords: climate change, cement production, carbon dioxide emissions, energy quakes, zero emission, sustainability, life cycle approach

Introduction

Construction and buildings have a significant impact on the environment through several sectors of the industry. Interference with the natural environment also affects the resources of the raw material mining and the exhausted resources. Looking at a life cycle approach, one of the greatest environmental burdens is the production of building materials, in particular due to the high energy demand and carbon dioxide emissions of cement production, but also the production of clay masonry and the environmental load associated with plastics. In the maintenance of buildings, demand for cooling and heating energy and the related direct and indirect carbon dioxide emission is decisive. At the end of the life-cycle, the energy demand associated with demolition is significant. With regard to climate change, reducing wood resources is not negligible, which plays an important role in the absorption of carbon dioxide when wood is used in architecture. Due to the role of CO_2 in climate change, the article focuses primarily on cement and thermal insulating material.

Experimental

The method used in the research is to study and synthesize literature, to analyse statistics and to compare the environmental impact of individual building materials based on the life cycle software database.

Global cement production and its impact to climate

Cement production in all countries is closely related to the construction industry and economic development. Cement production has increased more than fourfold in the world over the past 40 years and is particularly significant in emerging economies. China has half of the world cement production capacity, followed by India. Producing cement requires energy intensive technology and also emits significant carbon dioxide as a result of clinker production, which is the main component of cement, due to calcination of limestone. Different types of cement (CEM I – CEM V) are commercially available, which differ in particle size, alkali content and clinker content and consequently behave differently when used. Standard Portland cement (CEM I) contains 95% clinker.

One of the key issues in the development of innovative technology for cement production is how to reduce CO_2 emissions during clinker production. Habert et al. (2010), based on Factor 4's eco-efficiency, aimed at reducing the 1990's loads by 2050. However, according to the research results so far, this can only be achieved by factor 2. Efforts to reduce emissions were aimed at decreasing the amount of heat needed to produce unit clinker and to reduce the amount of clinker needed to produce a unit of cement. The carbon emission associated with cement production is equivalent to 470-540 kg / t cement (Andrew 2017) based on various estimates. Baxter and Walton have 470 kg of CO_2 estimated at 1 ton of cement, Keeling (1973) emissivity is 0.50 t CO2 / 1 t cement, Marland and Rotty (1984) and Olivier et al. (1999) also came to the same conclusion. The China emission factor is 0.5383 tCO_2 (t clinker)-1. India's Emission factor is 0.52 t CO_2 t /clinker. Intergovernmental Panel for Climate Change (IPCC) guide proposes less clinker content of cement to decrease the emission. According to the IPCC's more recent 2006 guidelines (Hanle et al., 2006), when using cement production data adjusted for clinker trade, the formula should be

$$E\text{cem} = f\text{cem clink } f\text{clinkCaO } \frac{M\text{rCO2}}{M\text{CaO}}$$

where *f*cem clink is the clinker ratio, and *f*clink CaO is the fraction of CaO in clinker. $M\text{r}CO_2$ is the molecular weight of CO_2 (44.01), and *M*rCaO is the molecular weight of CaO (56.08). ((Andrew, 2017) Total emissions from the cement industry could therefore contribute as much as 8 % of global CO_2 emissions. (Le Quéré et al., 2016, 2017; IPCC, 2006).

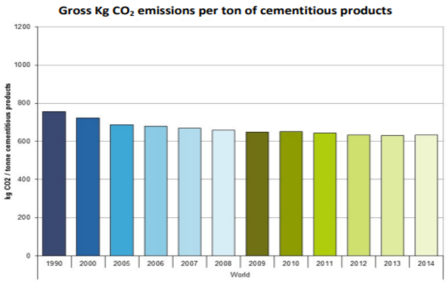

Figure 1.. Gross kg CO_2 per ton of cementitious products
Source:WBCSD, 2018

The environmental impacts of Hungarian construction sector

The impact of the construction sector on the environment and especially on the greenhouse effect could be exactly determined by material flow analysis, tracking each component of flows from cradle to grave / cradle and aggregating environmental impacts. It is a fact that from the raw material extraction to the decomposition of waste, each phase of the life cycle requires energy and is associated with carbon dioxide emissions. As detailed mass balances for the sector are not available, our analysis is confined to two main types of material in the sector and we can rely on estimated values. Building emissions based on the data of the OKIR database for 2016 are shown in the following figure. What surprising is that the CO_2 emissions of the Hungarian cement factories are not displayed in the database. It is true that

the energy needed for cement production comes from 60% of waste (car tire and tired oil, paper). (Lafarge, 2015; DDC, 2015)
According to data from the HCSO, the building industry's greenhouse gas emissions are increasing.

Table 1. CO_2 eq. emission of Construction sector 1990 - 2015 ktons

1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
579,5	329,9	505,6	700,6	793,2	724,5	682,5	832,0	961,4	1 039,1

Source: KSH, 2018

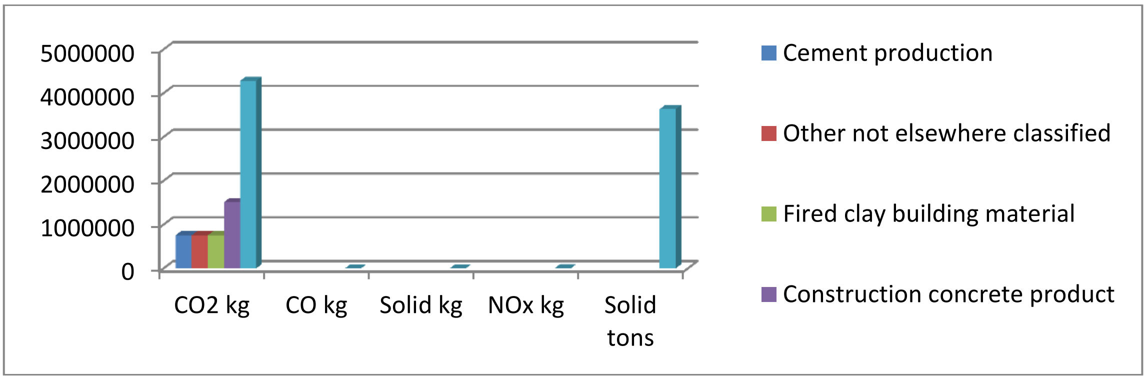

Figure 2. Emissions of Construction sector (2016)
Source: Own editing based on OKIR database (2016)

Plastic in the construction and building sector

Construction is the second largest area for the use of plastic materials. Beyond traditional applications (window frames, pipes, etc.) thermal insulating materials and composites are also applied. The volume of plastics used in construction has declined in the years of crisis, but it is growing steadily today, reaching 20 million tons in Europe. Usage of insulation materials (PUR, PS, composites) is increasing because the energy efficiency requirements of buildings have been much more. Materials utilized for thermal insulation include mineral wool, glass foam, plastic foam made of polystyrene and polyurethane. The insulating material can also be applied as a solid panel or injectable foaming fluid, which enables filling of difficult-to-reach gaps and angles. The European Association of Plastic Manufacturers of Plastic Foams are ecologically more favourable than competing materials because their production requires 16% less energy while releasing 9% less greenhouse gases. The insulation capacity of PS and PUR foams, in addition to the same thickness, is better than the competitor. The composites are mainly used to replace steel and concrete based on their excellent mechanical properties.

Life cycle approach in construction sector

A *life cycle assessment* (*LCA*) is an internationally accepted and useful tool to assess the environmental impact of products. The LCA methodology is based on a series of international standards and procedures, standards of environmental management called ISO 14040. LCA is a technique that aims to enable a correct assessment of the environmental aspects and potential impacts associated with a product, consisting of four distinct analysis steps (Definition of goal and scope; Establishment of life cycle inventory (LCI); Valuation of the impact of the life cycle; Interpretation of results). Most of LCA studies focused mainly for construction materials and building (Alejandro et al.,2016), does not cover all sectors. A life cycle approach can help us to make choices. It implies that everyone in the whole chain of a product's life cycle, from cradle to grave, has a responsibility and play a role taking into account all the relevant impacts on the economy, the environment and the society.

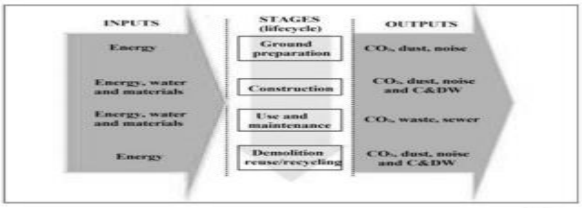

Figure 3. Environmental flows in the life cycle of a building
Source: Silva, 2003

In this paper we compare the Global Warming Potential (GWP) of different cement types and insulation materials on the base of LCA data. The used database was the construction data of SimaPro and GaBi software (CML 2001 method). The function unit is 1 kg of material and/or 1 m^2 wall surface. Greenhouse effect depends on clinker content, and substitute raw materials.

Table 2 Global Warming Potential [kgCO_2 eq/kg] of different concrete and cement types (CML 2001, Normalisation), GaBi Construction database

	Concrete C12_15	Ready_mix concrete C12_15	Concrete C20_25	Concrete C30_37	Ready_mix concrete C30_37	Concrete C8_10*	Ready_mix concrete C8_10*	Cement _CEM I 32_5_	Cement _CEM I 42_5_	Cement _CEM I 52_5_	Cement _CEM III 32_5_
GWP 100	0,08631	0,09074	0,09810	0,11175	0,11254	0,00014	0,00013	0,82402	0,79675	0,81889	0,30306

*It contents construction waste

Insulation materials

Rock wool and glass wool are durable, resistant, refractory and do not require maintenance. EPS and XPS based insulators are extremely sensitive to Ultra-Violet Radiation, while EPS is sensitive to condensation. Compared to their environmental effects, it can be stated that the most suitable type of insulating material per unit of mass is rock wool. But if we choose other function unit - 1 m^2 surface wall and that same thickness – the expanded Polystyrene has the smallest GWP.

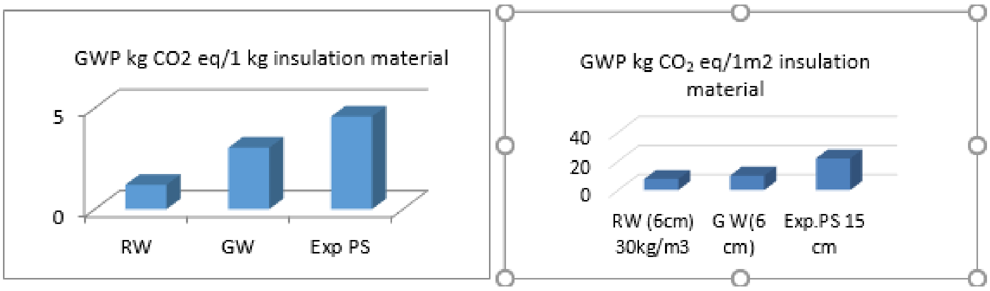

Figure 4 Comparative analysis of the environmental impact between insulation materials

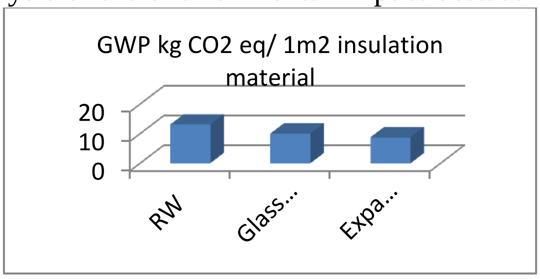

Figure 5 GWP impact of insulation (that same thickness 6 cm, Rock wool 180kg/m3)
Source: Own editing based on SimaPro 7.0 demo database

The estimated CO_2 emission of domestic plastic usage in construction sector is about 30 - 40 thousand tons.

Conclusion

Regarding the role of construction and building materials industry, also its environmental impacts on climate change, the way is to develop and follow-up a strategy that promotes the sector towards sustainability. However reliable data and material flow based life-cycle analysis can be the starting point to determine the correct target values. There is still uncertainty in the material balance of products used in the sector, in terms of inputs, but even more in terms of outputs regarding environment. The primary interest of the economy is to gather information on the supply of building materials (domestic / import), and to map the quality and environmental load characteristics of building materials available on the market. Having these data, the environmental impact of constructions in life-cycle considerations could be optimized at the design stage. These impacts include the use of resources and the contribution to the various environmental problems, such as climate change, acid rain, destruction of the ozone layer, human toxicity or depletion of resources. Increasing energy efficiency, reducing energy demand and emissions are primary sustainability aims at all stages of the life cycle. The advantage of the life-cycle method is that with detailed data analysis and evaluation loads can be more precisely defined in the different life-stages, so arising problems can be more consciously responded.

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