LIFE CYCLE ASSESSMENT: GAS EMISSIONS OF GREENHOUSE MATERIAL FLOWS FOR TWO TYPES OF CONSTRUCTION

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Abstract

The life cycle assessment (LCA) of the series of ISO 14040 standards [1], allows to estimate the environmental impacts of a product, from the extraction of raw materials to the end of life. In the building industry, this method enables to provide quantitative indicators of environmental impacts of the products and materials used.

This study provides a new tool for environmental evaluation on the carbon footprint that applies to buildings of any kind. Five types of material are identified at a first level of description: structural work products (PGO), Second work products (PSO), equipment products (PE), activity products (PA) and current consumption products (PCC). Several descriptive and analytic parameters are associated with these materials.

In this study we intend to assess the environmental impacts of the buildings of a holiday cottage, based on two methods of construction (mineral materials and organic type).

We will illustrate the methodological aspects related to the realization of this tool, based on a systemic and typological approach.

Keywords

ALC, carbon footprint, systemic approach, materials, material flows.

1. INTRODUCTION

Throughout its life cycle a building has a significant environmental impact (23% of CO_2 emissions and 75 % of the total mass of waste [2]). To address this concern, a practice known as eco-design has developed. It is the integration of environmental aspects into product design and product development [3].

This concept proposes to take into account a number of principles, methods and technical to reduce environmental impacts at each stage of the implementation of the construction.

In the context described above, the aim of this article is directly related to the proposal of an environmental impact assessment methodology, applied to buildings in an analytical and global approach.

2. COMPARATIVE ANALYSIS OF LIFE CYCLE OF BUILDING MATERIALS

The comparative study is carried out on the materials used for two types of construction (mineral and organic). The construction of the inorganic type is essentially composed of stone. The building is made of concrete block, mortar and steel. As regards the construction of the organic type, the frame and the structure are made of wood.

The different treatments of products such as the steps of manufacturing, transportation, their implementation and the end of service life are examined and analyzed. Their study allows to determine the importance of each type of material, and propose selection criteria based on environmental footprint.

The concept of the tool is a systemic and typological approach, which makes it possible to assess the problems and developments of a system. Several scales are identified and analyzed:

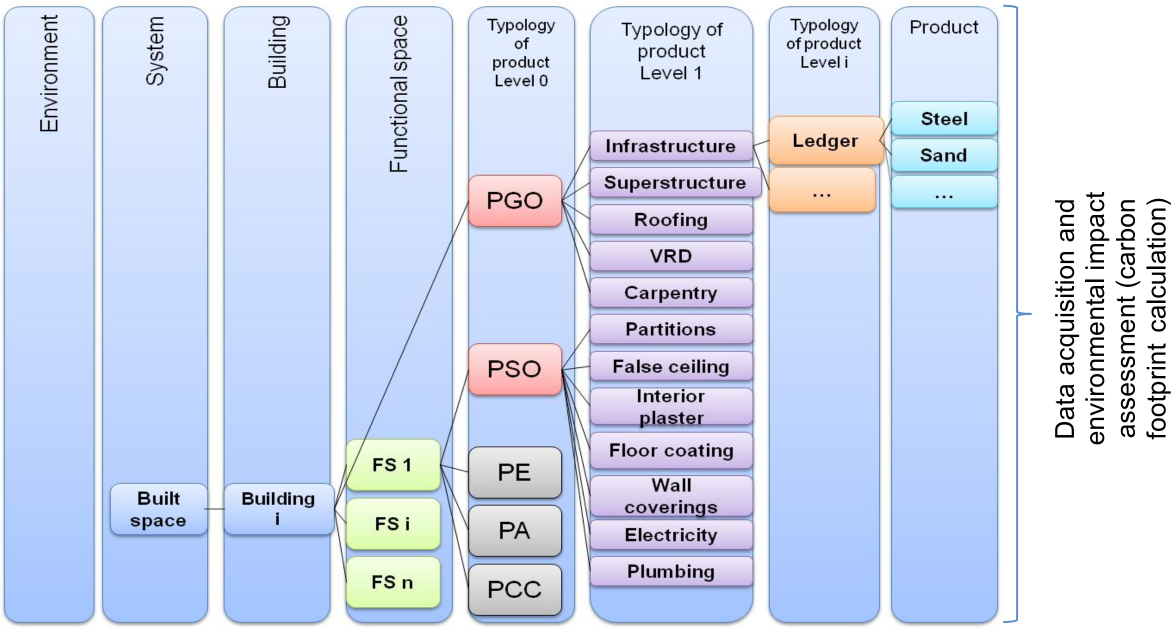

Figure 1: Diagram of systemic and typological approch

The idea is to identify, target and analyze all entities of the largest to the smallest scale. It is from this method is that it establishes the acquisition of data and calculations of carbon footprint.

The data acquisition is done in the form of a table as shown in Figure 2. This is the main draw for data acquisition products by type level. From this table, we input the product, unit, quantity and country of origin. The scope of application covers the manufacturing of products, transportation, packaging, and end of life as show below. However, given the difficulties in collecting data, we do not consider the maintenance and waste treatment, but make the assumption of a scenario of end of life for each material.

During data acquisition, the emission factors must be informed. For manufacturing carbon footprint, it is calculated either from the emission factor of the product (if it is specified) or from emission factors of the materials that compose it. The same applies to the transportation carbon footprint: the calculation is based on the emission factors of different modes of transport of the product (air, sea, river, road and rail).

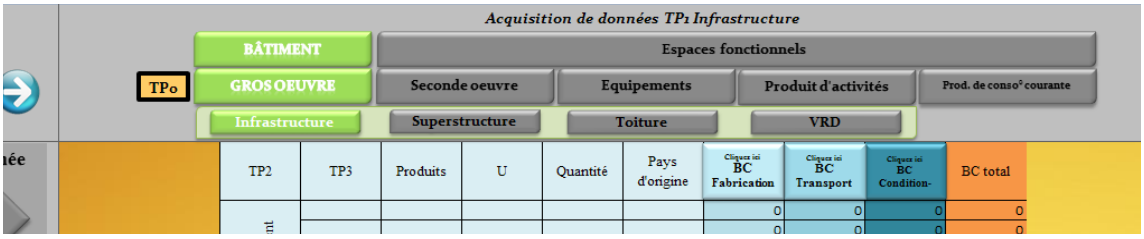

Figure 2: Architecture of the scope and data acquisition

The reason why one should consider the types of products is that they facilitate the interpretation of the results for the building as well as the functional spaces. They make it possible to visualize the environmental footprints by type of product, and to provide assistance on the choice of materials.

3. ASSESSMENT OF THE ENVIRONMENTAL FOOTPRINT

The carbon footprint simulation was performed by the creation of a new Excel tool and the use databases INIES [4] and Carbon data [5]. The environmental impacts were calculated according to the method described in ISO 14040. This method ISO 14 040 is used to connect the inventory data for the environmental damage they create. The results obtained in this study show that some building materials contribute very significantly to the generation of the environmental impact of a construction.

It is interesting to note here (Figure 3) that the carbon emissions are significantly variable depending on the type of product considered and the type of construction.

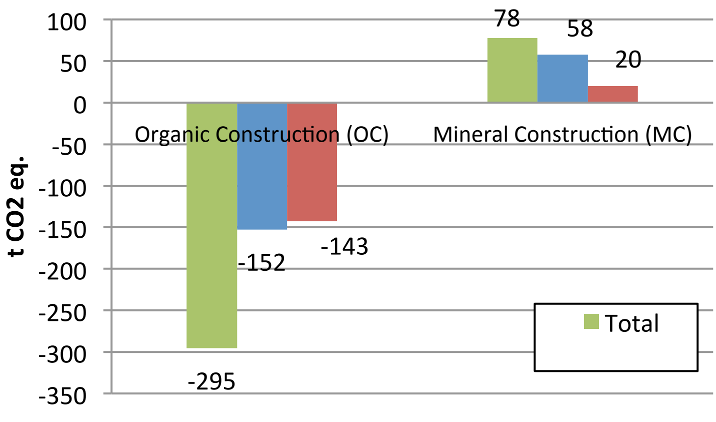

Figure 3: Comparative analysis of emissions of carbon for two types of construction

It is also interesting to observe the influence of the sub-types of level (Figure 4). The carbon emissions of the organic building are considerably reduced compared to the mineral construction. The largest variances noted are related to the superstructure and bulkheads. Indeed, as for the evaluation of the carbon footprint of the structural work and second work, only the materials that relate to the frame and the structure of the building will have a significantly different value. Emissions of other product types are similar (such as electricity and plumbing), since they are the same regardless of the construction materials considered. In this sense, it is important to consider all types of product level 0 (Structural work and second work) and level 1 (Infrastructure, superstructure...) to be able to target the environmental impact of buildings.

		OC	MC
PGO	1	2,40	1,78
	2	197,35	-7,38
	3	-147,42	-147,42
	4	5,19	0,57
PSO	5	4,08	7,62
	6	2,00	-154,44
	7	2,41	-0,52
	8	1,37	0,00
	9	3,92	-2,03
	10	1,41	1,41
	11	4,46	4,46
	12	0,48	0,48

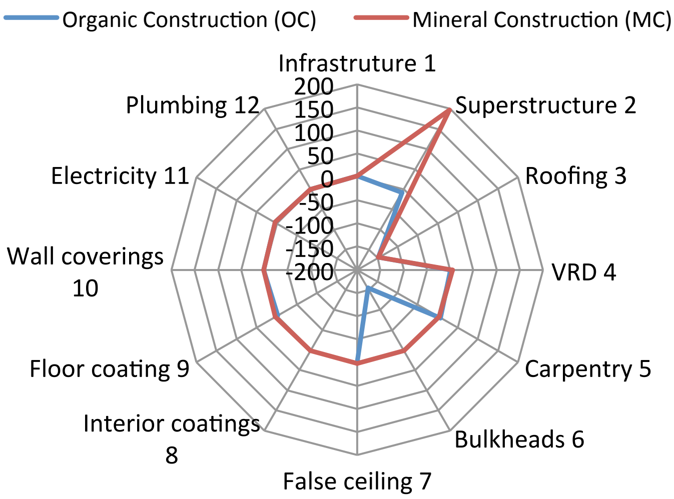

Figure 4: Comparative analysis of carbon emissions (t CO2 eq.) of big work and second work for two types of construction

4. CONCLUSIONS

Based on a selection criterion taking into account the environmental impact, a significant reduction of the carbon pollutants is possible. According to this study, the organic building type construction would have less impact than mineral construction with a gap of 373 t CO_2 eq. (Either -295 t CO_2 eq. for organic construction and 77 t CO_2 eq. for mineral construction). More precisely it is when considering the emissions of materials for the structure and the frame, that one can note a difference between the two types of construction.

In this sense, the study not only highlights the influence of the choice of materials, but mainly showed the point of the LCA approach to assess the environmental impact of a building. Indeed, this methodology allows both to have a synthetic and analytical approach.

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SYNTHESES

Le bâtiment tout au long de son cycle de vie, contribue aux émissions de gaz à effet de serre. Face à l'enjeu d'anticiper les impacts environnementaux des activités humaines, une pratique s'est développée : l'éco-conception. Ce concept propose de prendre en compte un certain nombre de principes, de méthodes, et de techniques pour limiter les impacts futurs des produits à chaque étape de la mise en œuvre de la construction.

La méthode d'analyse du cycle de vie (ACV) décrite par la série des normes ISO 14040 est un outil répandu pour l'évaluation de l'impact environnemental d'un produit. Cette méthodologie peut s'appliquer aux procédés et aux services.

Dans le cadre de cet article, le but est de comparer les divers matériaux entrant dans la composition de deux types de construction, pour utiliser comme critère de choix leur empreinte environnementale.

La présente étude est consacrée à la présentation d'une méthodologie d'ACV selon une approche systémique et typologique, appliquée à deux types de construction : minéral (béton) et organique (bois). Cinq typologies de matériau sont identifiées à un premier niveau de description : Produits Gros Œuvre (PGO), Produits Second Œuvre (PSO), Produits d'Equipement (PE), Produits d'activité (PA) et Produits de Consommation Courante (PCC). Les simulations pour cet article, ont été effectuées pour les émissions de gaz à effet de serre (CO_2) des Produits Gros Œuvre (PGO) et des Produits Second Œuvre (PSO).

Pour considérer tous ces paramètres, l'analyse a été réalisée à partir de la création d'un outil sous Excel et en s'appuyant sur les bases de données existantes (INIES et Carbone). Le champ d'application couvre la fabrication des produits, le transport, l'emballage et la fin de vie. Le bilan carbone pour chaque étape de traitement du produit est calculé à partir des facteurs d'émission, de l'unité fonctionnelle et des quantités.

Les résultats obtenus montrent d'une part quel est la construction la plus impactant et d'autre part ciblent les typologies de produit majoritairement contributrices. En effet, d'après les simulations effectuées, la construction de type organique aurait moins d'impact qu'une construction minérale, avec un écart de 373 t CO_2 eq. (Soit -295 t CO_2 eq. pour la construction organique et 77 t CO_2 eq. pour la construction minérale). Plus précisément c'est en considérant les émissions des matériaux pour la structure et l'ossature du bâti, qu'une différence est notable entre les deux types de construction.

En ce sens, l'étude a permis non seulement de mettre en évidence l'influence des choix des matériaux, mais a montré surtout l'intérêt de la démarche de l'ACV pour l'évaluation de l'empreinte environnementale d'une construction. En effet, cette méthodologie permet à la fois d'avoir une approche synthétique et analytique.

Par ailleurs, d'autres éléments d'analyse seront ajoutés à l'outil. Pour considérer l'ensemble des émissions carbones de l'espace bâti, les Produits d'Equipement, les Produits d'activités et les Produits de Consommation Courante, seront traités. Ce même outil permettra à terme d'effectuer d'autres analyses d'impacts environnementaux tels que l'utilisation des ressources ou encore l'acidification atmosphérique.