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A NEW BREED OF SUSTANIABLE ULTRA-LIGHT-WEIGHT AND ULTRASHALLOW STEEL-CONCRETE COMPOSITE FLOORING SYSTEM: LCA

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INTRODUCTION

In recent years, assessing and controlling carbon emissions have become a basic strategy to achieve sustainable developments. The European Community and 37 industrialized countries committed to reduce greenhouse gases (GHG) emissions by 18% lower than the 1990's level from 2013 to 2020 (Dong et al, 2015). The sustainability issue has taken an important attention in all industries. In particular, the construction industry is influenced by the higher use of materials and the larger amount of waste (Stroetmann and Podgorski, 2013). Buildings are significant contributors to carbon emissions, not only caused by the energy consumption in building maintenance and operation, but also due to the substantial material use and intensive onsite construction operations. It has been stated that buildings account 40% from the global material flow (Dong et al, 2015). Concrete is an essential reported construction material with the global annual consumption of 1 ton per capita. Concrete has been identified as a carbon intensive material, and cement being the key component of concrete is responsible for 5–7% of the world's carbon emission (Meyer, 2009). The on-site construction process is another source of carbon emission, mostly contributed from fuel consumption in material transportation and heavy equipment, waste treatment management and embodied carbon in temporary materials (Dong et al, 2015).

Prefabrication is considered as a sustainable construction process of enhanced quality control, enhanced environmental performance, enhanced site safety, reduction of labour work and construction time (Jaillon and Poon, 2008). The use of pre-casting technique can reduce the waste up to 52% and reduce the timber formwork up to 70% (Jaillon et al, 2009).

In this regard, this paper's contribution focuses on presenting a life cycle assessment of a new prefabricated ultra-lightweight and ultra-shallow flooring system which is characterised by using light materials and integrating thin-walled steel beams into the floor with the advantages of low construction height as well as quick erection due to its precast nature. A comparison between the new ultra-light ultra-shallow flooring system and existing shallow flooring system (CoSFB with Cofradal 260 mm) through the Life Cycle Assessment (LCA) is conducted.

Background

Sustainability is not merely related to the environmental nature such as climate changes, wastes (landfill), materials' consumption, energy consumption and recycling, but it is also related and assessed based on the economic aspects such as life cycle costs, maintenance, value conservation, flexibility, functionality and reusability, as well as the social demands such as comfort, health and safety, aesthetics and urban redevelopment. Consequently, sustainable floors require to fulfill the ecological, economical and social sustainability demands (Reddy and Jagadish, 2003). A floor slab should be designed according to today customer requests particularly for vibration comfort, sound and heat insulation in addition to other structural design requirements. However, the floor construction should be cost-effective in the construction stage due to rapid erection and availability/completion in short delivery time to carry one with building works. The high degree of prefabrication ensures the increase in safety on both the construction site during erection as well as in the final stage, due to the quality control in the shop. In addition, modern floor design should take into account its future use. As the designers are normally not capable to predict the future, the floor design and construction should be flexible and easily adaptable to customer anticipations, with the potential of reuse, thus the investment itself will become sustainable. Also, maintenance and alterations of installation services must be feasible and as easy as possible (Passer et al., 2007). These additional requirements demand the design of large spans with reduced number of columns in combination with smart flooring systems.

METHODOLOGY

In this study the life-cycle assessment of materials used in the new ultra-light shallow flooring system and CoSFB with Cofradal 260mm is presented and it considers the demolition and recycling of the building materials. It focuses on two impact categories only: (a) embodied carbon, and (b) embodied energy impacts. LCA has been applied to calculate the embodied energy and embodied carbon of the flooring systems for a grid of 8.10m×8.10m. The LCA study is conducted at three stages: (i) the influence of the materials used in the production of the flooring systems, (ii) the influence of the transportation of these materials, and (iii) the end of life of the materials of the flooring systems themselves. The grid is designed as such to cover the standard grid requested by today's market presented in Figure.1 and Figure.2. The LCA is presented in Table 1.

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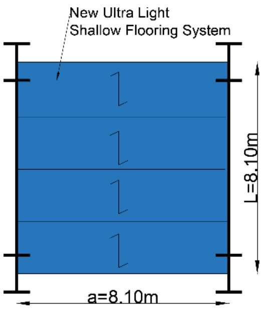

(a)

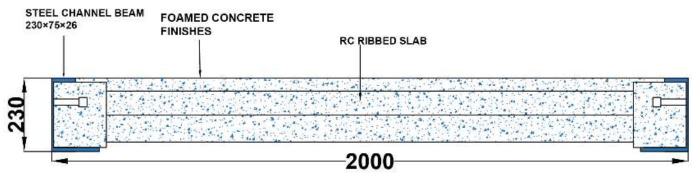

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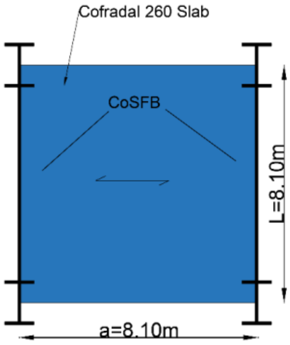
Figure 1: (a) Floor layout grid 8.10m×8.10m, (b) New ultra-light shallow flooring system section



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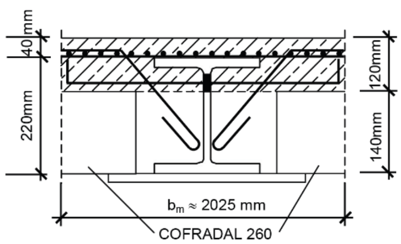

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Figure 2: (a) Floor layout grid 8.10m×8.10m, (b) CoSFB with Cofradal 260mm flooring system section (Braun et al., 2011)

Table 1. Embodied Carbon and Embodied Energy of flooring systems

CONCLUSIONS

Stage	Embodied Energy (GJ)	Embodied Carbon (tonne CO_2 e)	Embodied Energy (GJ)	Embodied Carbon (tonne CO_2 e)
	New ultra-light shallow flooring system		CoSFB with Cofradal 260mm flooring system	
Production	90.19	8.67	106.25	8.69
Transport	3.01	0.19	5.24	0.32
End of Life	36.54	2.12	46.63	3.10

It was found that the embodied energy and embodied carbon for the production stage of the new ultra-light and ultra-shallow flooring system are 90.19 GJ and 8.67 tonne CO_2 e. These are well comparable if not less than the figures for the production stage of the CoSFB with Cofradal system which are 106.25 GJ and 8.69 tonne CO_2 e, respectively. The values for the transport stage for the new ultra-light and ultra-shallow flooring system are 3.01 GJ and 0.19 tonne CO_2 e, also compares well if not less than the values of the CoSFB with Cofradal system with 5.24 GJ and 0.32 tonne CO_2 e, respectively. In addition, lower values have been observed from the end of life assessment of new ultra-light and ultra-shallow flooring system with 36.54 GJ and 2.12 tonne CO_2 e comparing with 46.63 GJ and 3.10 tonne CO_2 e for the CoSFB with Cofradal system, respectively. This indicates that the new ultra-light shallow flooring system is a valid solution and can provide an effective, a sustainable, and a valuable alternative solution to the construction industry in terms of both environmental performance and speed of construction while reducing site work and site risks.

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