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Review Article

Design of concrete buildings for disassembly: An explorative review

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Abstract

Due to various kinds of obsolescence, a large number of concrete buildings around the world are removed to give space for new buildings, however, the elements of these buildings in most cases have the ability to serve longer time, but the dominant demolition end-of-life scenario prevents from the reuse of these elements. It has been demonstrated that reuse of elements and materials is an environmentally responsible option that turns the current linear model of building materials and elements into a cyclic one, which pushes toward reconsidering the construction design of concrete buildings to support future disassembly, that facilitate reuse and adaptation. This study tends to explore and review the current issues related to concrete technologies and their role in building assembly and disassembly, as well as DfD "design for disassembly" aspects and theories that clarify and pave the way for future innovations, which move the construction design of concrete buildings to a higher degree of environmental responsibility. The study found out that despite the continuous developments in the field of concrete technologies, the link of these developments to the end-of-life phase is still missing. The study concluded that it is possible through the application of DfD criteria on precast concrete systems and elements to change the liner life-cycle model to a cyclic one.

Keywords: Construction design concrete buildings; Precast concrete; DfD; Reuse concrete; Building lifecycle

Contents

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1. Introduction

The construction of buildings has always been criticized as a conservative sector that lacks innovation and change, and this is true if we compare it to the technological field for example, or review some related serious concerning matters such as its impact on the environment. The linear life cycle model "cradle-to-grave" which distinguishes the concrete buildings prevents from reuse and adaptation, where very little attempts to reuse concrete building elements have been made. One possible reason is the way in which the concrete buildings are constructed which make it as rigid interties that lack adaptability and potential for change (Durmisevic, 2010). At the same time, the concrete technologies are very open to continuous development and improvements that make them more environmentally friendly, more efficient and smarter. Nowadays development of self-cleaning concrete, self-healing concrete and ultra-strength concrete opens the door for new applications and practices. These facts push toward a number of inquiries concerning the current construction of concrete buildings and its ability to fulfill the complications of the continuous development and change in life.

Buildings are constructed using the available building technologies which give them their final appearance and stability; the act of building represents an exercise of control over form (Habraken, 1998). In the case of concrete buildings it can be distinguished between two main building and construction practices and a combination of both: cast-in-situ and precast, however, the second type mostly found in combination with the first one.

Two facts that need to be kept in mind regarding concrete: first, it is the most used construction material that shapes an enormous amount of the physical environment (Crow, 2008), secondly is the relatively high embodied energy due to the use of clinker in its component (Cabeza et al., 2013), however the recent use of fly ash and other Industrial by-product materials such as Ggbs which is a by-product of iron and steel manufacture and silica fume which is a by-product of manufacturing of silicon and metal alloys in concrete leads to decrease the needed amount of cement and makes concrete more environmentally friendly (Stacey, 2011). The current way of dealing with concrete in buildings restricts its life cycle to a linear model which leads these buildings to end up in a landfill, so imagining the amount of concrete that needs to be demolished and dumped in the near future should alert and motivate for other intelligent solutions. Due to the fact that a considerable amount of concrete buildings and structures around the world end their service life and demolished, while their elements still able to serve a longer time, some voices around the world have been raised to consider demolition as a design error (Durmisevic, 2010). While a study by Morrison Hershfield Engineering showed that significant environmental benefits from reuse of concrete could be obtained including saving of 1.23 GJ of energy (Huuhka et al., 2015), the dominant strategy of dealing with demolished concrete in most cases is recycling which shows negative environmental impacts (Catalli, 2009).

One of the possible keys to the avoidance of demolition of concrete buildings is the design of buildings for future disassembly that supports reuse and adaptation. But the currently used building construction technologies still produce a kind of buildings that has a mono direction which considers fast assembly without taking the future disassembly into consideration. DfD is a relatively new concept in building industry; the first try was in 1851 through the historical well-known structure Crystal Palace in London (Durmisevic, 2010). Despite that this attempt has been followed by other attempts such as Shanghai Bank, or Pompidou center, the majority of these attempts were restricted to steel structures. Concrete structures have been ignored in this context and very little attempts have been made. One unique example could be the CD20 system which has been developed in the Netherlands. It can be said that DfD remained experimental till it has been studied theoretically and scientifically by Crowther in 1999 who