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Reusing concrete panels from buildings for building: Potential in Finnish 1970s mass housing

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ABSTRACT

A remarkable share of European mass housing was built with large-panel systems during the 1960s and 1970s. In many countries, this stock is already being demolished or demolition is discussed due to vacancies or social problems. This trend may result in the creation of an unforeseeable amount of concrete waste. Simultaneously, EU has issued the Waste Framework Directive aiming at reuse instead of recycling. Unlike *in situ* cast concrete, reclaimed prefabricated concrete panels from mass housing carry the potential for reuse. The purpose of this study is to review the reuse potential embedded in Finland's mass housing stock from the perspective of the dimensions of the panels and spaces, *i.e.*, their suitability for architectural (plan) design. The research material consists of architectural drawings of 276 blocks of flats that contain over 26 000 prefabricated wall panels and nearly 14 000 hollow-core slabs, the dimensions of which are compared to current norms and guidelines for dimensioning living spaces. The technical prerequisites for reuse are reviewed with the help of literature. The study results in identifying an inventory of panels typical to Finnish precast concrete construction, which, in principle, should not exist because the building plans were not standardized but were supposed to be unique. The panels are found to be still usable in architectural (plan) design of detached houses, which form one third of annual residential production in Finland.

1. Introduction

The majority of the Finnish building stock is residential and 1970s was the peak decade in residential construction. At that time, most of the apartments were realized in high-rise mass housing with prefabricated concrete panel construction. This is in common for most European countries with notable mass housing stocks (Turkington et al., 2004). During the last ten years, a public discussion on the demolition or preservation of these housing estates has accelerated in Finland. Large-scale demolitions have taken place elsewhere in Europe, especially in the UK, Germany, France and the Netherlands because of vacancies following urban shrinkage and as an attempt to mitigate social segregation (*ibid.*, p. 276; for Germany, Deilmann et al., 2009). Both these circumstances appear in Finland, too, in different parts of the country. Examples of demolitions of public housing with respective motives can be recognized here and there even though the demolitions have so far remained local and small in scale. However, should the demolitions of the contemporary mass housing stock accelerate, an unforeseen amount of concrete waste could be created. This applies not only to Finland but even more so to the countries that are already demolishing mass housing. Therefore, it has been suggested that old buildings should been seen as reserves for resources such as building materials (Agudelo-Vera et al., 2012; Thomsen and van der Flier, 2011).

At the same time, the European Union is tightening the demands for recycling construction and demolition (C&D) waste. The Waste Framework Directive defines a waste hierarchy according to which preparation for reuse is to be prioritized over destructive recycling as material (European Union, 2008, p. 10). With its 70%-by-weight utilization target for C&D waste (*ibid*, p. 13), the directive puts a strong emphasis on recycling of heavy mineral materials. Concrete is a material that is easily recyclable in roadbeds; yet this kind of utilization is downcycling and ranks low in the waste hierarchy (Hiete et al., 2011). Researchers have warned that downcycling or even disposing of concrete will increase in Germany in near future if new sinks, such as new construction, are not promoted (*ibid.*). Indeed, manufacturing recycled aggregate concrete from crushed concrete is a more refined and higher-ranking option for the recy-

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cling of concrete. Unfortunately, it has a carbon footprint worse than virgin aggregate concrete (Asam, 2007); so what is gained on resource depletion is lost for global warming. Unlike *in-situ* cast concrete, prefabricated concrete panels may carry the potential for reuse. Some systems, such as the Dutch CD-20, have been designed for deconstruction and reuse (Kibert and Chini, 2000; p. 103–109; fib, 2008, p. 69–70), but the majority of systems do not have this asset. Nevertheless, several experiments on reusing panels from prefabricated housing have proven successful even though the panels were not originally designed for deconstruction. In addition to having a very low carbon footprint, reuse usually reduced the cost of new construction by 20–30%. (Huuhka, 2010a).

The research on reclaiming and reusing panels is most progressed in Germany (see *e.g.*, Mettke, 2003, 2007; Asam et al., 2005, 2007; Mettke et al., 2008; Asam, 2006). For example, panel inventories have been compiled from most widespread German systems to aid the design of new buildings (Mettke, 2003, 2007). Some studies have also been conducted in the Netherlands (Coenen et al., 1990; Van Nunen, 1999; Naber, 2012; Glias, 2013) and Finland (Huuhka, 2010a; Saastamoinen, 2013; Lahdensivu et al., 2015) and some experiments have been carried out in Sweden (Addis, 2006; p. 25–26; Huuhka, 2010a; p. 110). While these experiences are generally encouraging, the results acquired from one building system may not be directly applicable to other systems because structural details, degrees of standardization and geographical distributions of systems may vary significantly. For example in East Germany (GDR), there were only a handful of different panel systems; they were used in the whole country; and the systems were highly standardized, including the panels and building plans (Blomqvist, 1996; p. 53–58). In Finland, then again, there were multiple factory-specific panel systems that were used locally; the national standard given in 1969 only aimed at standardizing the connections and the modular grid; and buildings were designed individually at all times (Hytönen and Seppänen, 2009; p. 116).

Although most of the aforementioned research has been published in local languages, the international scientific interest in salvage and reuse has been growing. The latest articles include *e.g.*, Gorgolewski (2008), Gorgolewski et al. (2008), Gravina da Rocha and Aloysio Sattler (2009) and Pongiglione and Calderini (2014). Unlike this paper, none of the aforementioned contributions concentrates on concrete structures. The purpose of the current study is to evaluate the reuse potential embedded in the mass housing of Finnish cities with regard to the dimensions of the concrete panels, *i.e.*, their suitability for new architectural design. Although the study situates in Finland, it may have relevance for other countries as well because Finnish panel systems were based on international examples. The research questions are as follows: What parts (*e.g.*, exterior walls, interior walls, slabs) of mass housing were prefabricated and up to what extent? Do the panels come in recurrent sizes and if, which dimensions? Are these dimensions suitable for new construction and for which purposes?

2. Background

As explained above, knowledge on deconstructing and reusing panels from one system may have a very limited applicability to other systems. Therefore, this section focuses on exploring existing knowledge on Finnish precast concrete construction that acts as the starting point for the current study. The first chapter presents an overview of the large-panel systems used in Finland. The second and third chapters concentrate on the technical opportunities and limitations for reuse. The fourth and last chapter looks into the influence of norms and design guidance.

Table 1
Dimensions of structures used in factory-specific panel systems.

Building part or structure	Dimension(s), mm
Floor height	2800
Room height	2600–2640
One-room panel, typical width	3000–3900
Two-room panel, typical width	6000–7200
Solid concrete slab, maximum size	3600 by 5400
Solid concrete slab, thickness	160–200
Load-bearing part of exterior sandwich panels, thickness	150–160
Load-bearing interior walls, thickness	150–160

Sources: Mäkiö et al. (1994); Saastamoinen (2013).

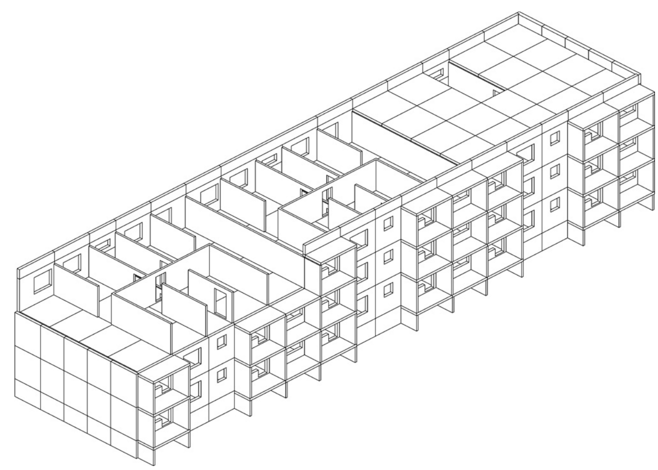

Fig. 1. Finnish large-panel system used from 1960s to 1975. Both panels and slabs were room-size. Interior walls between rooms are load-bearing. (Remodeled from Mäkiö et al., 1994, p. 67).

2.1. Finnish concrete panel systems

Prefabrication came into use in Finland during the 1950s, first in non-residential construction (Hytönen and Seppänen, 2009; p. 38–57). The first fully prefabricated block of flats was constructed in 1959, and several significant construction companies shifted to panel construction in the beginning of 1960s (Hytönen and Seppänen, p. 53). In these early days, each panel factory had its own panel system, many of which were loosely based on French or Swedish systems (Hankonen, 1993; p. 141–145, 158–159; Hytönen and Seppänen, 2009; p. 51, 91). The differences localized in dimensions, connections and other structural details. (Hytönen and Seppänen, 2009; p. 53–54). Architecturally, the differences between the systems were minor. The structural skeleton of lamellae blocks was a crosswall frame, in which crosswalls are load-bearing and longitudinal walls are non-load-bearing (Mäkiö et al., 1994; p. 62). Exterior walls were sandwich panels and floors were solid concrete slabs. Table 1 gives more details on the structures and dimensions. These factory-specific systems (Fig. 1) were in use up to 1975 (Mäkiö et al., 1994; p. 72). Nonetheless, partial prefabrication remained the most common practice throughout the 1960s and early 1970s (*ibid*, p. 66). Most contractors used prefabricated walls and casted floors *in situ* while at least one major contractors did the opposite (*ibid* p. 66; Hankonen, 1993; p. 159). By 1966, 25% of public housing was fully prefabricated and 35% was partially prefabricated (Hytönen and Seppänen, 2009; p. 75).

In the end of the 1960s, the concrete industry launched a research project that aimed at the creation of one open standardized panel technology (Fig. 2) called the BES (abbreviation of '*betonielementtistandardi*', Finnish for 'concrete panel standard'). The main aim was to allow purchasing different elements, such as exterior walls, interior walls, slabs, balconies and stairs from