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# EARLY CASES OF PRECAST CONCRETE REUSE IN SWEDISH CONSTRUCTION (1984-2002): REPURPOSING THE MILLION HOMES PROGRAMME

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**ABSTRACT**

**Background and aim:** Precast concrete elements are structural components with significant potential to support circular construction practices, and several initiatives are currently underway to address the technical, regulatory, and economic challenges associated with scaling up element reuse from a niche practice to mainstream application. Although the reuse of concrete elements is gaining renewed interest within the broader framework of circularity, the earliest initiatives to reuse precast concrete elements in Sweden can be traced back to the 1980s. During this period, widespread vacancies in newly constructed mass housing developments under the Million Homes Programme prompted several municipal housing companies to explore deconstruction as a strategic alternative to conventional demolition. This paper examines the lessons learned from these early pioneering projects and investigates how insights from past reuse efforts can inform and advance current and future circular practices in the building sector.

**Methods and data:** The paper presents a comparative study of early cases involving the reuse of prefabricated concrete elements in Sweden over a twenty-year period. The analysis draws on a combination of literary sources, architectural drawings, and interviews with key individuals involved in the original projects. Through this multi-source approach, the study conducts a structured examination of the deconstruction and reuse processes associated with each identified case. Particular emphasis is placed on the architectural transformations between the donor buildings and their corresponding recipient buildings, providing deeper insights into the potential of precast concrete systems to be repurposed in new construction projects.

**Findings:** Between 1984 and 2002, seven building projects in Sweden were completed incorporating salvaged precast concrete elements from deconstructed Million Programme developments. Although the original structures were widely criticized for their systematization and repetition, these very characteristics made the precast concrete systems particularly well-suited for deconstruction and reuse. The recipient projects demonstrate that, through relatively simple design interventions, precast systems can be effectively adapted to meet diverse site contexts, building types, and spatial requirements.

**Theoretical/practical/societal implications:** Gaining a deeper understanding of the early cases of concrete element reuse in Sweden and the reasons why this seemingly successful approach failed to lead to broader implementation can support current reuse initiatives in fostering a more systematic and lasting transformation of the construction sector, extending beyond the scope of isolated pilot projects

**KEYWORDS:** Reuse, precast concrete elements, architecture, reuse potential, the Million Homes Programme.

## 1 INTRODUCTION

To mitigate the environmental impact of construction, circular solutions are increasingly promoted as alternatives to the traditional linear economic model in building production. The Circular Economy (CE) approach seeks to extend the service life of products and materials by preserving their highest possible value across multiple life cycles. When the reuse of entire buildings is not feasible, repurposing building components in new construction offers the most effective strategy for prolonging the lifespan of materials. When successfully implemented, this approach contributes to reducing demolition waste, decreases reliance on virgin natural resources, and offers considerable potential for lowering the carbon emissions associated with new construction. Given that the structural frame accounts for approximately 60% of a building's embodied carbon



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during the construction phase (Malmqvist et al., 2023), the reuse of structural components represents one of the most effective strategies for reducing carbon emissions in building production. Precast concrete elements (PCEs) are structural components with significant potential for circularity (Huuhka et al., 2023). Unlike cast-in-place concrete structures, precast concrete buildings are designed as modular systems, with concrete elements typically prefabricated off-site and subsequently assembled on location. The types and configurations of elements in a precast system are determined by the spatial requirements of the building's intended function, ranging from room-sized slabs and walls in residential wall-frame systems to long-spanning beams and columns in portal frame systems (Hernández Vargas & Stenberg, 2024). The building technology was widely adopted in the post-war period, and as a result, a significant portion of Europe's building stock consists of precast concrete elements (Alonso & Palmarola, 2019). Although these buildings were not originally intended to be disassembled, several projects have successfully demonstrated the deconstruction and reuse of prefabricated concrete elements in new construction. A study by Küpfer et al. (2023) identifies approximately 50 completed projects incorporating reclaimed precast concrete elements between 1967 and 2022. The majority of these projects were carried out in Germany, with a smaller number of initiatives implemented in the Netherlands, Sweden, Belgium, France, the United States, and Finland.

One of the earliest documented cases of large-scale reuse of precast concrete elements was carried out in the Swedish city of Gothenburg during the mid-1980s. Faced with a severe surplus of vacant apartments, the municipal housing company Göteborgsbostäder made a groundbreaking decision: instead of resorting to conventional demolition, they opted for partial deconstruction, salvaging precast concrete elements for reuse in four new housing developments in the Gothenburg region. Approximately two decades later, another reuse project was initiated in the Swedish city of Linköping, involving precast concrete elements salvaged from a mass housing area in the neighbouring city of Norrköping. In addition to these internationally recognized Swedish cases commonly cited in the discourse on concrete element reuse, at least two further initiatives involving the repurposing of precast concrete elements were undertaken during the same period. In total, the early history of precast concrete reuse in Sweden, which forms the focus of this study, comprises at least four donor buildings and seven receiver buildings, spanning a period of approximately twenty years, from 1984 to 2002. All four donor buildings were located in large-scale housing areas developed as part of so-called Million Homes Programme—a national initiative implemented between 1965 and 1974 that led to the construction of over one million housing units, representing approximately twenty percent of Sweden's current housing stock (SCB, 2025). Approximately one-third of these units were high-rise multifamily buildings with four or more storeys, and around fifteen percent were constructed using precast concrete systems (Vidén & Lundahl, 1992). Although they constitute a relatively modest share of the total housing stock, these large-scale developments incorporating precast concrete have become the most emblematic representations of the Million Programme and are often associated with its perceived shortcomings (Johansson, 2012).

Although the early pilot projects examined in this study demonstrated the technical feasibility of precast concrete reuse, they did not lead to its widespread adoption within the construction sector. Today, reuse rates for concrete remain negligible, highlighting a significant gap between the theoretical potential of precast concrete reuse and its practical implementation in contemporary construction practices. Currently, several research initiatives are actively working to scale up the reuse of precast concrete for broader implementation. Notable examples include the EU project ReCreate (Huuhka et al., 2023) and the Swedish research initiative Återhus (Återhus, 2023). As part of these efforts, two pilot projects were completed in Sweden in 2022: a temporary exhibition pavilion in Helsingborg for the City Fair H22 with repurposed concrete elements from three different donor buildings (Westerlind et al., 2025), and a temporary building known as Hållbarhetshuset in Stockholm, which incorporated repurposed hollow-core slabs sourced from a nearby office (Återhus, 2023). Alongside these research-driven efforts, initiatives to promote the reuse of concrete have also been undertaken by the building sector itself. In 2023, approximately 300 square meters of hollow-core slabs were salvaged from an office building in Lund and reused in a new office development in Karlskrona (Ikanobostad, 2023). The following year, 3,000 square meters of hollow-core slabs were salvaged from a decommissioned IKEA department store to be reused in a new housing development in Gothenburg (Framtiden Byggutveckling, 2024). This growing momentum reflects an emerging shift in both research and industry practices toward the integration of circular strategies in concrete construction. However, current efforts in concrete reuse appear to be developing in relative isolation, with limited recognition or reference to the early reuse initiatives implemented several decades earlier. This historical disconnect is further underscored by the limited availability of sources documenting these initial projects. Although several of the deconstruction and reuse projects received substantial media coverage at the time, first-hand accounts remain scarce. Within the discourse on the Swedish Million Programme housing stock, the reuse of precast concrete has received only limited attention, with a few notable exceptions (Botta & Vidén, 2006; Huuhka et al., 2019). It is primarily within the expanding international research field on precast concrete reuse that the memory of these early projects is preserved, with several of the early Swedish cases regularly cited (Mettke, 1995; Asam, 2005; Addis, 2006; Huuhka, 2010; Fischer et al., 2011; Küpfer et al., 2023). Yet, to date, no comprehensive study has been undertaken to systematically examine this initial period of concrete element reuse in Sweden. As a result, while the reuse of concrete elements is currently gaining renewed attention in the Swedish building sector within the framework of the Circular Economy, many of the experiences and lessons learned from these early projects risk being overlooked and lost.

This paper seeks to address this knowledge gap by presenting a comparative study of early cases of precast concrete reuse in Sweden, with a particular focus on the architectural transformations that occurred between donor and recipient buildings. The objective is to compare the context, reuse process, and outcomes of these pioneering projects, in order to better understand the factors that contributed to their reuse potential. Drawing on written sources, architectural drawings, and interviews with individuals involved in the original projects, the study aims to compile valuable experiences and insights from these early reuse efforts, making them accessible to a new generation of practitioners and researchers. Gaining a deeper understanding of these projects—and the factors that inhibited their wider implementation—can support current reuse initiatives in achieving a more systematic and enduring transformation of the construction sector, beyond the scope of isolated pilot projects.

## 2 METHODOLOGY

The study employs a three-step methodological approach. First, a literature search was conducted to identify early cases of precast concrete reuse in Sweden. Given the limited documentation available in academic sources, the search scope was expanded to include news articles, trade magazines, and other forms of grey literature. In the case of Norra Bergsjön, the study benefited from a collection of news clippings generously provided by retired KTH researcher Sonja Vidén. This expanded approach led to the identification of two additional early reuse projects not included in the international case compilation by Küper et al.

In the second step, the collected material was reviewed to extract relevant data on the deconstruction and reuse processes of each identified case, with particular emphasis on the architectural transformations that occurred between the donor buildings and the resulting recipient buildings.

Given the often fragmented and limited nature of the available literature, architectural drawings for both donor and receiver buildings have been obtained from local planning offices to support the analysis. Efforts were also made to conduct interviews with individuals directly involved in these projects. In several cases, these first-hand accounts serve as the only remaining sources of meaningful insight into the reuse efforts. The data collection for each case was guided by the following research questions: What were the primary incentives and driving factors behind the reuse projects? What were the specific characteristics of the original precast systems? How did the deconstruction and reuse processes unfold? What were the main design features of the receiving buildings, and what adaptations were necessary to integrate the reclaimed elements for their new intended purpose? The results are summarized in Section 3, beginning with a description of the donor buildings, followed by an account of the reuse outcomes in terms of the corresponding receiver projects for each case.

In the final step, the similarities and differences among the projects are analysed and discussed in Section 4, with an emphasis on their relevance for future reuse efforts. This methodological approach enables a structured examination of the early reuse projects, facilitating a deeper understanding of their successes, limitations, and potential applicability within contemporary circular construction practices.

## 3 REUSE CASES

### 3.1 Norra Bergsjön

The municipal housing company Göteborgsbostäder AB was one of four municipal housing companies active in Gothenburg during the Million Programme Era. Under the leadership of its director, Inge Hjertén, a strong proponent of industrialized construction methods, the company began using prefabricated concrete elements as early as the late 1950s (Hjertén, 1969). Over the subsequent 20-year period, the company was involved in the development of several new mass housing areas on the outskirts of Gothenburg (Hjertén, 1969). However, by the 1980s, the demand for apartments in Gothenburg had declined drastically, leaving approximately 3000 of the company's 40,000 apartments vacant (Axelsson, 1983).

The Norra Bergsjön area, located northeast of Gothenburg, was one of the Million Programme neighbourhoods particularly affected by high vacancy rates. Originally completed 1969, the development comprised ten four-storey housing blocks, containing approximately 650 apartments. By the early 1980s, 90% of these units were unoccupied, contributing to substantial social challenges in the area and placing considerable financial strain on the housing company (Huuhka et. al., 2019). The discontinuation of a government subsidy for vacant apartments in 1982 ultimately prompted the company to take action (Huuhka et al., 2019). Rather than opting for demolition, an idea emerged to partially dismantle the buildings and reuse the concrete elements in areas with higher housing demand. The concept was initially proposed to Göteborgsbostäder by architect Lars Broberg and Lars Jonsson, head of development at the contractor ABV, and was met with great interest by the company (Kubu, 1983; Huuhka et al., 2019). Before fully committing to the concept, the company decided to test the approach through a pilot project, initiating the deconstruction of the first housing block in 1984.

A collaboration was established between Göteborgsbostäder, the contractor ABV, and the architectural group CFL Arkitekter, which included

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architect Bengt Forser, who had also been responsible for designing the original buildings eighteen years earlier (Forser & Sundbom, 1986). In addition, engineer Helmut Junker, who had contributed to the development of the precast concrete system, also became involved in the project, bringing valuable continuity and technical insight (Huuhka et al., 2019).

In the project's first phase, 107 apartments were dismantled by removing the top three floors of a four-storey, U-shaped residential block. Many of the salvaged elements were reused in the construction of a new residential building in central Gothenburg. The remaining ground floor was converted into 32 row houses, incorporating design modifications such as bay windows, a new wooden facade, and a pitched roof (Fig. 1). Following the successful completion of this initial pilot project, the transformation of Norra Bergsjön continued with the deconstruction of additional buildings in subsequent phases. Salvaged elements from these deconstructions were reused in three new housing developments in and around Gothenburg.

*Figure 1: View of the Norra Bergsjön residential area showing the partial deconstruction and conversion into row houses during Phase 2. (Photo: Lars Mongs, 1985. Used with permission).*

### 3.1.1 The Elementhus 65 System

The original housing blocks in Norra Bergsjön were constructed using the *Elementhus 65* system, one of seven precast concrete systems employed by Göteborgsbostäder between 1956 and 1974 (Hjertén, 1969) The system consisted of room-length floor slabs supported by load-bearing internal walls positioned transversely relative to the building block, forming what is referred to as a cross-wall system or 'bookshelf' structure. The primary element types of the system included hollow-core slabs in two lengths (3.0, and 4.8 meters) and 2-meter-wide load-bearing inner wall elements (Hjertén, 1969). The facade elements of the building were non-load bearing, except for the gable walls. In the case of Norra Bergsjön, the facade elements were produced in white concrete with marble aggregate and featured a distinct geometric relief pattern (Hjertén, 1969). Like Göteborgsbostäder's previous systems, this system was based on standardized apartment layouts comprising one to four bedrooms, which could be varied and configured around a central stairwell (Hjertén, 1969).

### 3.1.2 Deconstruction of Donor Building

The partial deconstruction of the housing blocks in Norra Bergsjön involved the removal of the upper floors of each building. The process began with cutting the roof into sections and lifting it off, together with its insulation. A specialized forklift was then employed to carefully remove the top floor slabs. To maintain structural stability during disassembly, both exterior and interior walls were braced prior to the detachment of the wall elements. These elements were subsequently lifted down using the original iron lifting loops that had been utilized during the initial assembly eighteen years earlier (Tibblin, 1986). The system's connectors proved particularly suitable for reuse, as the elements were neither welded nor screwed together and could simply be 'unhooked' from their positions (Huuhka et al., 2019). Once disassembled, the elements were transported to Göteborgsbostäder's vacant element factory in Ingebäck, where they underwent a thorough cleaning process (Tibblin, 1986). High-pressure washing was used to remove wallpaper, dirt, and loose mortar, restoring the components to near-original condition. After cleaning, the elements were temporarily stored at the factory, awaiting reuse in future construction projects It was estimated that only 5% of the elements were damaged during the disassembly process (Forser & Sundbom, 1986).

### 3.1.3 Receiver Project 1: Olivedal (1986)

Approximately two-thirds of the disassembled elements from the first pilot project at Norra Bergsjön were reused in the construction of a new residential building in central Gothenburg (Nyström, 1984) (Fig. 2). The urban context of the city block site differed significantly from that of the original location, necessitating adaptations to both the building's overall form and its internal spatial configuration. CFL Arkitekter served as the project's architects, while ABV acted as the main contractor.

In contrast to the original four-storey structure, the new building comprises both six- and seven-storey sections, accommodating a total of 108 apartments arranged around an internal courtyard on a horseshoe-shaped building plot. Integration of the salvaged elements into this irregular urban site was made possible through the addition of newly fabricated elements, which were used to form the chamfered corners of the building (Fig. 6) (Nyström, 1984). Salvaged facade elements were used for the courtyard-facing elevations, while the external facades were clad in brick to harmonize with the surrounding architectural context (Nyström, 1984).

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*Figure 2: The new residential building in Olivedal. (Photo: Lars Mongs, 2025. Used with permission).*

Similar to the original building, the new structure comprises a mix of one-, two-, three-, and four-room apartments. However, the salvaged elements were reassembled in new configurations, resulting in apartment layouts that, in some cases, differed significantly from the original (Fig. 3). The new floor plan also accommodated the integration of an elevator into each service shaft, necessitated by the increased number of storeys. To reconfigure the elements according to the new layout, slight modifications to their original dimensions were sometimes necessary to ensure a proper fit, as evidenced by the original construction drawings for the project (Fig. 4).

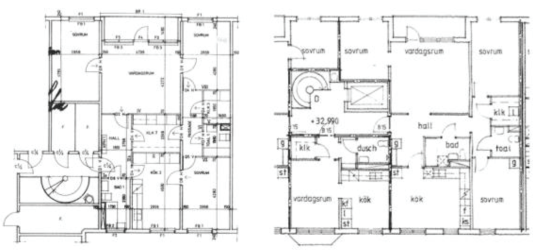


*Figure 3: Floor plans showing the layout of a three-bedroom apartment in Norra Bergsjön (left) and Olivedal (right).*

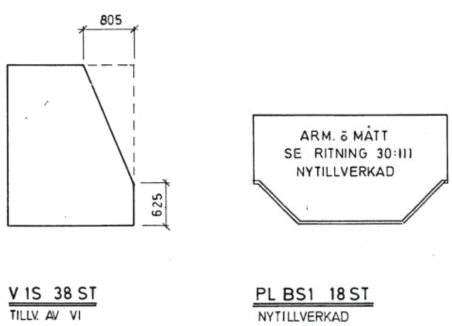


*Figure 4: Details from the construction drawings of the new building in Olivedal, showing modifications to reclaimed element V 1S (left) and specifications for a new element (right).*

### 3.1.4 Receiver project 2: Lerum (1986)

A smaller selection of salvaged elements from Norra Bergsjön was repurposed in a new housing development in the neighbouring municipality of Lerum, where ABV was also involved as the contractor (Fig. 5). The project comprised four two-storey buildings, providing a total of 29 new apartments, and was situated approximately 12 kilometres from the original donor building. The housing development represented a significantly smaller scale compared to the housing blocks in Norra Bergsjön and the salvaged elements were reconfigured to accommodate substantially altered floor plans (Fig. 6).

*Figure 5: The new two-storey residential buildings in Lerum. (Photo: Lars Mongs, 2025. Used with permission).*

The new buildings are narrower in depth compared to the original mass housing blocks and feature hipped roofs. In certain sections of the exterior envelope, wood stud infill walls were incorporated to complete the facade. The development comprises a mix of one- to three-bedroom apartments, which are accessed through private entrances at the front of each building. The apartments on the upper floor are reached via wooden access balconies.

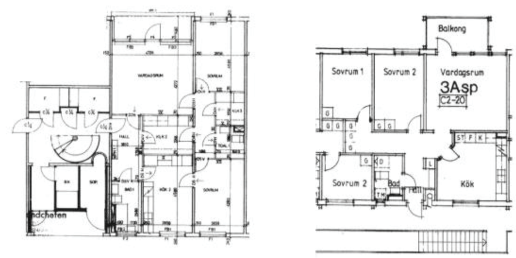


*Figure 6: Floor plans showing the layout of a two-bedroom apartment in Norra Bergsjön (left) and Lerum (right).*

### 3.1.5 Receiver project 3: Ytterby (1985)

Concrete elements from Norra Bergsjön were also repurposed in a residential development in Ytterby, located in Kungälv Municipality, approximately 15 kilometres from the original site in Norra Bergsjön. In this project, ABV again served as the main contractor. The development comprises a mix of row houses and low-rise multifamily buildings, each containing up to four apartments. Although the buildings were originally


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*Figure 7: Installation of concrete slabs from Norra Bergsjön at the construction site in Ytterby. (Photo: Lars Mongs, 1985. Used with permission).*

designed with wooden structural frames, precast concrete slabs from Norra Bergsjön were used to construct the foundation slabs, as shown in Fig. 7.

#### 3.1.6 Receiver project 4: Backatorp (1989)

Salvaged elements from Norra Bergsjön were also utilized in the construction of a new low-rise residential area in Backatorp, located approximately 6 kilometres from the original donor building. The development comprised 41 two-storey buildings accommodating in total 150 new apartments (Isemo, 1989).

*Figure 8: One of the new receiver buildings in Backatorp. (Photo: Lars Mongs, 2025. Used with permission).*

The three-bedroom apartments in the new buildings retain a general resemblance to the original floor plan of the donor building, though several key modifications were introduced (Fig. 9).

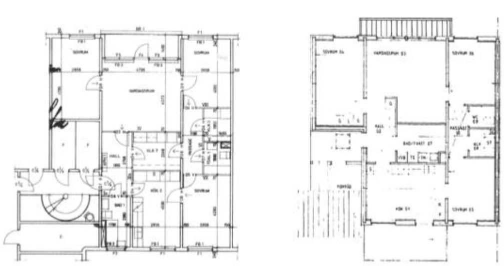

*Figure 9: Floor plans showing the layout of a three-bedroom apartment in Norra Bergsjön (left) and Backatorp (right).*

The new buildings are slightly narrower, incorporating only 12 floor slabs across their depth, compared to 13 in the original structure. The recessed balconies featured in the initial design were replaced with a larger living room area, marking a notable departure from the original layout. Another significant alteration was the integration of the kitchen with the former bathroom area, creating a more spacious cooking and dining zone that benefits from two windows. The main bathroom was relocated to the center of the building, replacing the space that previously served as a walk-in closet. The apartment entrances remain in their original positions and are thus accessed from the two gable facades of the new buildings, with apartments on the second floor accessed via an external staircase. In total, approximately 6,400 elements from Norra Bergsjön were reported to have been reused in the construction of the new residential area at Backatorp (Isemo, 1989).

### 3.2 LÖVGÄRDET

Approximately a decade after the partial deconstruction of Norra Bergsjön, the same municipal housing company, by then renamed Bostads AB Poseidon, once again turned to deconstruction as a strategy to address the problem of vacant apartments, this time in the Lövgärdet residential area. Located approximately 13 kilometres northeast of central Gothenburg, Lövgärdet was built between 1972 and 1974 during the final phase of the Million Programme. The area was never fully completed according to its original plans and had faced persistent vacancy challenges since its inception. In 1997, a project was initiated to remove six of the twelve existing nine-storey tower blocks in the area, with the aim of creating a more open and appealing living environment (Kraenzmer, 1999; Vidén & Botta, 2006). There were advanced plans to donate the dismantled elements to Poland as part of a Swedish aid package initiated by Prime Minister Göran Persson following a severe flooding (Ekenstam, 1997). When these plans fell through, Bostads AB Poseidon shifted its primary focus from the reuse of elements to concrete recycling (Ekenstam, 1997). Approximately 25,000 tons of dismantled concrete elements were crushed on-site and repurposed for various applications, including use as infill material for the construction of a new football pitch in the area (Kraenzmer, 1999; Vidén & Botta, 2006). However, a smaller number of concrete elements were salvaged and reused in a nearby municipal building project at Lärjeåns Trädgårdar (Vidén & Botta, 2006).

#### 3.2.1 The Byggtema System

The tower blocks in Lövgärdet were originally constructed using the *Byggtema* building system, the last of seven precast concrete systems developed by Göteborgsbostäder (Hjertén, 1969). At the time of construction, the elements were produced at the company's newly established factory in Ingebäck, which had a production capacity of 2,000 apartment units per year (Wallinder, 1969). Similar to the Elementhus 65 system, the Byggtema system employed a cross-wall structural approach, utilizing a limited set of precast elements that could be configured into various standardized apartment layouts. The system also featured a hook fastening solution for connecting the elements, which significantly facilitated the disassembly process (Kraenzmer, 1999). The main differences compared to the earlier system were the design of the slabs, which were now produced as solid elements up to 3 meters wide, and the increased length of the load-bearing wall elements, which reached up to 4.8 meters (Wallinder, 1969). These modifications resulted in fewer joints and enabled a more rapid assembly process.

#### 3.2.2 Deconstruction of Donor Building

As with the Bergsjön project, deconstruction at Lövgärdet began with stripping the buildings down to their structural frames. The roofs were cut into sections and removed using a crane. To expose the hook joints of each element, a small robot was employed, and approximately 1,300 holes had to be drilled per floor of each tower block (Kraenzmer, 1999). The five upper storeys of each tower were then disassembled with the aid of a crane. Aside from the limited number of elements salvaged for reuse, the disassembled elements were subsequently broken down into square-meter sections using an excavator equipped with a demolition shear, and then transported to a concrete crushing facility (Kraenzmer, 1999).

#### 3.2.3 Receiver Project 5: Lärjeån (1998)

Approximately 3 kilometres from Lövgärdet, a municipal initiative to develop a commercial garden and cultivation centre on the outskirts of Angered Centre had been underway since the early 1990s (Engelbrektson, 1997). As part of the development, a new building was planned to accommodate a café and meeting rooms, serving as the central hub for the garden. Reflecting the project's strong ecological orientation, a significant portion of the construction materials was sourced from demolition sites within the Gothenburg region. In this context, a small number of salvaged concrete elements from Lövgärdet were repurposed for the construction of the warehouse's basement (Kvist, 1998; D. Björklund Jonsson, personal communication, February 14, 2025) (Fig. 10). The superstructure was subsequently built using reclaimed timber components from a dismantled wooden warehouse formerly located in Gothenburg's harbour (Heyman, 2000)

*Figure 10: Construction of basement at Lärejåns Trädgårdar. (Photo by courtesy of D. Björklund Jonsson).*

### 3.3 HAMMARKULLEN

In 1996, Göteborgs Stads Bostads AB, another municipal housing company in Gothenburg, initiated the most ambitious deconstruction effort to date in Hammarkullen, a Million Programme neighbourhood located approximately 12 kilometres north of the city centre (Fig. 11). Originally constructed between 1968 and 1972, the area had been planned to accommodate 2,700 new apartments. However, as part of a broader neighbourhood redevelopment strategy implemented during the 1990s, a 225-metre-long housing block comprising 176 apartments and located near the central square was designated for demolition (Lövkvist, 1996). This intervention, along with other planned measures, sought to enhance the area's attractiveness by reducing housing density and fostering a more open and varied living environment. Sixteen semi-detached houses were later constructed on the same site, incorporating salvaged elements from the original building (Sahlberg, 1997).

*Figure 11: Facade element disassembled at Hammarkullen. (Bengtson, 1997).*

#### 3.3.1 The Göteborgs Stads Bostäder System

The original nine-storey housing block in Hammarkullen was constructed using Göteborgs Stads Bostäders' own precast concrete system. This system was developed based on a Danish system by Larsen & Nielsen (Wallinder, 1969). Similar to the two previously mentioned systems, it employed a cross-wall structural design with load-bearing gable and internal walls. However, this system was distinguished by significantly larger room-sized wall elements, measuring up to 7 meters in length. The floor slabs were produced as solid precast elements, ranging from 3.5 to 5.1 meters in length (Bengtson, 1997; Wallinder, 1969). A distinctive feature of this system was the use of volumetric kitchen and bathroom modules, which were prefabricated with cabinets and installations already in place at the factory. The floor plans were based on standardised two-, three- and four-room apartments, which could be configured in various arrangements around a central stairwell (Wallinder, 1969). The non-load-bearing sandwich facade elements were typically room-sized and featured an exposed aggregate surface finish (Wallinder, 1969).


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#### 3.3.2 Deconstruction of Donor Building

The proposal to deconstruct the housing block, rather than proceed with conventional demolition, was initiated by Stabilator, the demolition contractor commissioned to carry out the removal (Blomquist, 1997). Before implementing the plan at full scale, Stabilator conducted a test dismantling and prepared a demonstration apartment, in which materials and structural components were carefully separated to gain a clearer understanding of their composition and assembly. The tests revealed that the concrete was of high quality, exhibiting a compressive strength that significantly exceeded the original specification (Bengtson, 1997). It took approximately one month to determine the optimal method and necessary tools for the deconstruction and to facilitate the reuse process. Part of this work involved devising a method to separate the walls from the slabs, which had originally been cast together. The selected technique employed high-powered demolition hammers to achieve the necessary separation (Lövkvist, 1996). This method also allowed the original metal loops, used during the initial assembly 25 years earlier, to be exposed and reused during disassembly (Lövkvist, 1996).

The initial phase of the deconstruction process consisted of stripping the building to its structural frame and systematically labelling all elements prior to dismantling (Bengtson, 1997). Disassembly then commenced at the gable ends and proceeded in a stepwise manner to maintain the stability of the remaining structure. Notably, the facade elements were dismantled with the windows and balcony doors still attached. The kitchen and bathroom interiors were also preserved, as they were deemed to be in good condition (Bengtson, 1997). Once removed, the prefabricated elements were transported to an intermediate storage site in Surte, where they occupied an area equivalent to three football fields (Bengtson, 1997; Kraenzmer 1999). In total, approximately 3,800 concrete elements were dismantled at Hammarkullen, corresponding to 16,000 square meters of living space and 18,000 tons of concrete (Bengtson, 1997).

#### 3.3.3 Receiver project 6: Hammarkullen (1998)

Despite ambitious plans to export the salvaged elements for use abroad, the construction of 16 semi-detached houses on the same site in Hammarkullen remains the only documented recipient project resulting from the large-scale deconstruction effort. The project was completed with financial support from the government's newly established *'Kretsloppsfond',* which aimed to support refurbishment and reconstruction initiatives with a clear environmental focus (Sahlberg, 1997).

The new two-storey buildings, featuring pitched roofs and private gardens, bear little visual resemblance to the original housing block. Although facade elements from the original structure were reused, their exposed aggregate finish was concealed beneath a new layer of plaster to modernize the appearance (Blomquist, 1997). The architect responsible for the new design was Gunnar Werner of White Arkitekter, who had also contributed to the design of the original housing block three decades earlier (Lövkvist, 1996).

The shift in building typology—from a multi-family residential block to semi-detached houses—also necessitated substantial changes to the original floor plan (Fig. 12). Most notably, the depth of the building was reduced from approximately 13 meters to 9 meters. Reclaimed wall elements were installed on new slab foundations, alongside the salvaged kitchen and bathroom modules, and subsequently covered with a layer of floor slabs. As the new dwellings were constructed as two-storey structures, internal staircases were incorporated into each unit to accommodate the vertical layout. The main entrance to each house is positioned at the gable facades, consistent with the original design in which entrances were arranged around a central stairwell.

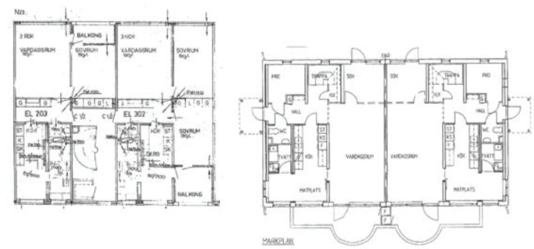

*Figure 12: Floor plans showing a building section from the original donor building (left) and the new ground-floor plan of the semi-detached houses completed on the same site (right).*

### 3.4 NAVESTAD

In 1999, the municipal housing company Hyresbostäder initiated an extensive refurbishment project in Navestad, a Million Programme residential area located on the outskirts of Norrköping (Fig. 13). The objective was to reduce the number of apartments from 1,600 to 950 by removing the upper floors of several buildings and converting around 200 of the remaining units into offices and educational facilities (Vidén & Botta, 2006). At the same time as Norrköping, a former industrial town, faced a surplus of housing, the neighbouring university city of Linköping was experiencing a severe shortage of student accommodation (Eklund et al., 2003). A few years earlier,

*Figure 13: Assembly of precast concrete elements during the construction of the Navestad estate.*

the municipal housing company AB Stångåstaden had successfully completed a student housing project in Linköping, utilizing reclaimed concrete elements from a cast-in-place residential building in Finspång (Rapport Profilen–Ryd, 1999). Gunnar Sundbaum, the initiator and project manager of the earlier reuse project, saw an opportunity to improve the reuse process in a new initiative by utilizing salvaged precast concrete elements from the ongoing work at Navestad (G. Sundbaum, personal communication, February 21, 2024). For Hyresbostäder, the idea to reuse the disassembled elements aligned with the high environmental ambitions of the Navestad refurbishment project, for which the company had received a substantial government grant (Vidén, & Botta, 2006; Eklund et al., 2003). Consequently, an agreement was reached between the two municipal housing companies to facilitate the transfer and reuse of concrete elements for a new project.

### 3.4.1 The Norrköpings Byggelement System

The Navestad estate was originally designed by architect Eric Ahlin and conceived as multiple buildings arranged in concentric rings around two circular courtyards. The buildings were designed with varying heights, reaching up to eight storeys, and featured a high concentration of two-bedroom apartments, complemented by a smaller number of one-bedroom and studio units. Completed in 1972, the estate was constructed using the *Norrköpings Byggelement* system, a precast concrete system employed by the company in new housing developments between 1965 and 1972 (Nilsson & Eliaeson, 1998). This highly rationalized system was developed by Eric Ahlin in collaboration with structural engineer Arne Johnson, specifically for Hyresbostäder. Like the previous three donor buildings, the system followed a cross-wall structural logic, with load-bearing walls positioned transversely relative to the building block. The wall elements were room-sized to minimize assembly time and restrict joints to the corners of rooms (Johnson, 1965). The floor slabs were solid concrete slabs, produced in widths of up to 3 meters and spanning approximately 3.5 meters (Wallinder, 1969).

### 3.4.2 Deconstruction of Donor Building

The deconstruction of elements at Navestad was completed prior to the commencement of construction at the Linköping site. Following disassembly, the elements were transported to a nearby intermediate storage site. Each component was specially marked with a designation and identity number to facilitate tracking and reuse components (AB Stångåstaden, 2002). Loading and unloading operations were carried out using a mobile crane (AB Stångåstaden, 2002). To verify that the reclaimed concrete elements met the structural requirements of the new buildings, pressure tests were conducted on selected components (Eklund et al., 2003).

### 3.4.3 Receiver project 7: Ryd (2001)

Salvaged wall elements, floor slabs, and staircases from Navestad were repurposed in the construction of new

*Figure 14: Receiver buildings accommodating student housing in Ryd. (Photo: Mikael Damkier. Courtesy of AG Arkitekter).*

student housing in the Ryd area of Linköping, located approximately 57 kilometres from the original site. The architectural design was led by P.O. Kelpe of AG Architects, the same design office responsible for the refurbishment project at Navestad (P.O. Kelpe, personal communication, January 21, 2025). The development consisted of one four-storey and one two-storey building, together providing 54 new student apartments. In total, the buildings were completed using reclaimed elements amounting to approximately 1,400 tonnes of salvaged concrete (Eklund et al., 2003). In addition to the reuse of the concrete structural frame, the project incorporated other salvaged components, including windows, windowsills, and stair railings also sourced from the Navestad refurbishment (Eklund et al., 2003).

The concrete elements were reassembled in the same curved layout as the original structure, but the buildings were updated with a new metal mono-pitched roof, new entrances, and canopy roofs. The facade elements received new insulation to meet current standards and were plastered in white and red, lending the buildings a modern aesthetic (Eklund et al., 2003). Internally, the apartments range in size from 29 to 32 square meters and feature either an open-plan layout with a small kitchen or a separate bedroom with a kitchenette (Fig. 15). This adaptation of the original two-bedroom apartment configuration into single-room flats required the incorporation of new wrought-iron details to reinforce the connections between walls and slabs (AB Stångåstaden,

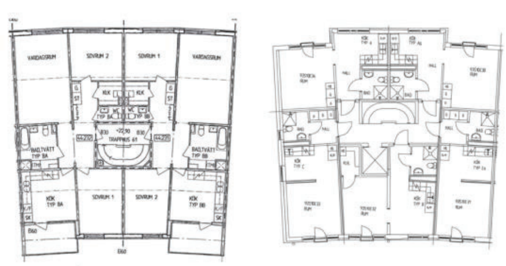

*Figure 15: Floor plans showing a building section from the original donor building with two tow-storey apartments (left), and the new student housing block with five apartments (right).*



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2002). Since the time of the original construction, building regulations concerning acoustic performance had evolved, and the existing elements no longer complied with current standards. Consequently, partition walls between apartments were upgraded with improved sound insulation and the addition of new gypsum boards (Eklund et al., 2003).

# 4 DISCUSSION

## 4.1 THE PUBLIC HOUSING SECTOR: PIONEER IN PRECAST CONCRETE REUSE

### 4.1.1 Reuse as a Strategy for Addressing Uneven Housing Availability and Demand

All reuse cases examined in this study originate from the deconstruction of mass housing blocks constructed during the so-called Million Homes Programme (1965–1974). During this period, demand for new housing began to decline even before the programme was fully completed, contributing to widespread vacancies and a perception of socioeconomic decline in many of the newly developed areas (Hall, 1999). In both Gothenburg and Norrköping, this housing surplus was largely driven by the decline of local industries, which significantly reduced the anticipated need for housing. The reuse initiatives that characterize the initial phase of precast concrete reuse in Sweden were thus closely tied to the public housing sector and can be understood as pragmatic responses to an uneven distribution of available housing in relation to housing demand. A similar context shaped the adoption of precast concrete reuse in Germany, where most known reuse initiatives have taken place. Following the reunification of the country, many mass housing areas in former East Germany, commonly referred to as Plattenbau, faced high vacancy rates. This situation prompted efforts to dismantle and repurpose precast concrete elements in smaller-scale residential projects, such as single-family homes, for which there was a larger demand (Asam, 2005; 2007).

### 4.1.2 Economic and Ecological Incentives for Reuse

While the deconstruction of the donor buildings examined in this study share clear common economic and social incentives for reducing vacancy rates in Million Programme areas, a shift in the motivation to pursue reuse rather than conventional demolition can be observed over time. While resource efficiency is commonly promoted as a key benefit of the reuse process, the earlier projects primarily framed efficiency in economic terms, whereas later initiatives reflect a more pronounced ecological orientation. By the late 1990s, the concept of circularity, referred to in Swedish as *'kretsloppsprincipen',* had begun to gain traction in Swedish society (Johansson, 1995). This shift is clearly exemplified in the Navestad reuse case. The government grant that supported the refurbishment of the Navestad donor building was closely linked to environmental objectives. Furthermore, collaborations with researchers at Linköping University enabled the first attempt to assess the environmental benefits of reuse compared to conventional construction methods. These studies indicated that the reuse approach reduced greenhouse gas emissions by two-thirds and decreased construction waste by 82% relative to a standard concrete building (AB Stångåstaden, 2002). Upon completion, the Swedish National Board of Housing, Building, and Planning recommended the project for the highest available subsidy level for ecological construction. As a result, the project received a green building grant of 2,000 SEK per square meter, bringing the total cost in line with that of a conventional project (Eklund et al., 2003)

## 4.2 REUSE POTENTIAL OF PRECAST CONCRETE SYSTEMS

The reuse potential of precast concrete elements largely depends on two key factors: the feasibility of disassembling the elements in a safe and economically viable manner, and the adaptability of the elements to meet the design requirements of a new building. A key aspect of the deconstruction and reuse process therefore involves understanding the structural and spatial logic of a specific system and exploiting its potential for new applications. By 1968, at least sixteen different precast concrete systems for multi-family residential buildings were in use across Sweden (Andersson, 1968b). Each system had distinct characteristics and followed different structural logics, depending on the spanning direction of the slabs and the placement of the load-bearing walls. The four precast concrete systems used to construct the donor buildings in this study were all cross-wall structural systems, featuring room-length slabs supported on interior load-bearing walls. However, the spans of the floor slabs varied between systems, and the sizes of the wall elements differed—ranging from smaller components to full room-sized panels—resulting in varying conditions for the reuse process.

### 4.2.1 Deconstructability

The deconstruction of the four donor buildings that enabled the seven receiver projects examined in this study demonstrates both partial deconstruction approaches, as seen in Norra Bergsjön and Navestad, and the complete dismantling of entire buildings, as undertaken in Hammarkullen and Lövgärdet.

In both Norra Bergsjön and Hammarkullen, the disassembly process proved more straightforward than initially anticipated. A key advantage of the Elementhus 65 system in Norra Bergsjön was that the elements were simply stacked without welding, secured using a hook-and-loop connection system. Although the system was not originally designed for disassembly, the original connectors effectively facilitated the lifting and separation of components during deconstruction (Tibblin, 1986). Similar to the experience in Norra Bergsjön, the actors involved in the deconstruction of the housing block in Hammarkullen expressed surprise at how well the precast concrete system could be disassembled (Bengtson, 1997). Because the system was based on the repetition of the same configuration of elements on every floor, the disassembly procedure could be consistently repeated once the appropriate technique had been established (Lövkvist, 1996).

However, in Navestad, the deconstruction process turned out to be more complex and costly than anticipated. Many elements were damaged during dismantling and rendered unusable, necessitating more careful handling than initially expected. As a result, the costs associated with reusing entire concrete elements significantly exceeded those of crushing and recycling, ultimately leading Hyresbostäder to pursue the latter approach (Eklund et al.). Consequently, following the completion of the Nya Udden project, the ambitious plan to salvage concrete elements for the construction of an additional 500 student apartments in Linköping was abandoned. Although the design for these buildings had been developed to accommodate reused elements from Navestad, construction ultimately proceeded with newly produced concrete elements (P.O. Kelpe, personal communication, January 21, 2025). A published report on the Nya Udden project provides valuable insights into opportunities for improving the deconstruction and reuse processes, as identified by the actors involved (Eklund et al., 2003).

Organizational challenges were largely attributed to a compressed timeline, which hindered proper coordination between deconstruction and reconstruction. The lack of preparatory planning led to disassembly progressing ahead of new construction, requiring improvised and inefficient temporary storage. Additionally, assigning different subcontractors to each phase resulted in poor material handling due to limited understanding of the elements' intended reuse, causing damage and waste. The involved actors therefore recommended synchronizing deconstruction and reconstruction to reduce storage needs and involving the same personnel throughout to ensure careful handling and promote collaboration

At Norra Bergsjön, the partial deconstruction and conversion of the remaining housing blocks at Norra Bergsjön into rowhouses continued in subsequent stages, even in the absence of further government financial support. However, efforts to reuse the remaining disassembled elements gradually diminished, as matching them with new building projects proved more difficult than initially expected. Attempts to export the salvaged components abroad turned out to be a complex and prolonged process that ultimately failed to materialize (Ekelund, 1985). Even within the Gothenburg region, reuse efforts were problematic due to a tendency to 'cherry-pick' only the best elements, leaving many components unused (Beck-Friis, 1984). Reflecting on this issue, engineer Helmut Junker suggested that the ideal scenario would be to sell an entire building rather than individual elements (Beck-Friis, 1984). In their evaluation of the project, architect Bengt Forser and Jan Sundbom, the technical manager at the housing company, concluded that the refurbishment process carried out at the factory had been too costly. As a potential improvement, it was proposed that, in future projects, elements should be transported directly from the deconstruction site to the new construction site, with refurbishment undertaken only when necessary to minimize costs (Forser & Sundbom, 1986).

Similarly, at Lövgärdet and Hammarkullen, none of the ambitious plans to export the salvaged elements to countries experiencing housing shortages ultimately materialized. At Hammarkullen, only a small percentage of the salvaged elements were ultimately reused in the construction of semi-detached houses on the same site, while the remaining materials were eventually crushed (D. Chroneberg, personal communication, June 25, 2024).

#### 4.2.2 Architectural Flexibility

In the process of deconstruction and reconstruction, it is unlikely that the spatial and functional requirements of the new building will align precisely with those of the original structure (Huuhka et al., 2015). This is evident in the seven recipient projects analysed in this study, all of which differ from their respective donor buildings in terms of building type, size, and floor plan. Consequently, a critical factor influencing the reuse potential of a precast concrete system is its inherent flexibility and the extent to which its constituent elements can be reassembled into new configurations.

The versatility and flexibility of precast concrete systems were already central concerns during the construction of the Million Programme. Every precast system faced the inherent challenge of balancing maximum production efficiency—achieved through the mass production of a limited number of element types—with the need to preserve a high level of spatial quality and flexibility in its application. Several studies were undertaken to evaluate the advantages and limitations of existing systems, with particular emphasis on assessing their architectural potential for generating flexible apartment layouts and accommodating a variety of building types (Anderson, 1967; 1968a; 1968b; 1968c; Wallinder, 1969).The most defining feature of precast concrete systems is the length of the floor slabs, which determines the positioning of the vertical load-bearing components within a system (Andersson, 1968a). Two main types can be distinguished: slabs that span the width of a single room and slabs that span longer distances, exceeding the length of one room. A vertical load-bearing element in a precast concrete system for residential buildings is typically a wall element, although some systems also incorporate columns. Depending on the length and orientation of the slabs, a wall-frame system can follow three different structural typologies (Hernández Vargas & Stenberg, 2024). In an integral wall system, room-sized slabs are supported by load-bearing walls positioned both longitudinally and transversely in relation to the building block. In a cross-wall system, floor slabs are supported by load-bearing walls positioned transversely relative to the building block. In a spine wall structure, the facade elements function as load-bearing components, allowing the floor slabs to span the full depth of the building.


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A general advantage of the cross-wall typology, employed in all four donor buildings, is the potential flexibility it offers in floor plan design, as non-load-bearing partition walls can be freely positioned between the structural cross-walls. Another recognized benefit is the design freedom it affords for façades, since the exterior walls are non-load bearing, except for the gable walls (Wallinder, 1969). However, the range of possible floor plan configurations within a cross-wall system is largely determined by the maximum span length of the floor slabs used. In the *Elementhus 65* system, the maximum slab span of 4.8 meters significantly constrained the possible arrangement of room types within the floor plan (Wallinder, 1969). At the building scale, the system was designed for the construction of rectilinear buildings with a fixed depth of approximately 12 meters. Furthermore, building height was restricted to four storeys, as the system did not incorporate elevator shafts (Wallinder, 1969). In the development of the system into the later *Byggtema* version, the ability to accommodate other building types, such as tower blocks, was incorporated (Hjerten, 1969).

The *Göteborgs Stad Bostäder* system was the only system that incorporated volumetric elements. While these elements represented a high degree of prefabrication, they offered limited flexibility in the spatial layout of apartments. Moreover, all volumetric units were dimensioned for three-bedroom flats, resulting in oversized units when used for smaller apartments (Wallinder, 1969). Similar to the *Elementhus 65* system, the *Göteborgs Stad Bostäder* system was intended to be assembled into rectilinear housing blocks and featured little variation in possible building types (Wallinder, 1969). The Norrköping system used in Navestad is the only one of the four systems that was applied to various types of buildings, including tower blocks and curved structures (Wallinder, 1969). However, the flexibility of the system's spatial layout was considered limited due to the restricted span of the floor slabs and the fixed positions of the kitchen and bathroom, which were connected to special floor slabs containing installations (Wallinder, 1969).

Nevertheless, the recipient projects examined in this study demonstrate that the versatility of precast concrete systems can extend far beyond their original intended applications. At the building level, all receiver buildings differ significantly from their respective donor structures. In most cases, elements from large-scale mass housing blocks were repurposed into smaller-scale residential developments, including, low-rise multifamily buildings (Lerum and Backatorp), row houses (Ytterby), and detached houses (Hammarkullen). The most ambitious project—also unique in an international context—is the receiver building in Olivedal. In this case, the new structure features more storeys than the original donor building and is constructed on an irregular city block site, positioned between two existing buildings. This was made possible through the adaptation of existing elements combined with the addition of complementary new elements. In addition, the increased number of floors in the new building was facilitated by the incorporation of lift shafts positioned adjacent to the original staircase within the floor plan. Only in the case of the student housing in Ryd does the new building resemble the donor structure, as the salvaged elements were reassembled to follow the same circular layout as in Navestad, although the new building comprises only two sections. The smaller number of salvaged elements reused in the slab foundations of the row houses in Ytterby and in the basement of the warehouse in Lärjeån represents an alternative reuse scenario for salvaged concrete elements. These cases demonstrate that, rather than forming the complete structural frame, salvaged elements can also be successfully reused in combination with other structural materials, such as wood.

At the room level, the spatial layouts of all seven receiver buildings differ significantly from those of the original donor structures. At Lerum and Backatorp, all housing units were designed with private entrances, marking a distinct departure from the original floor plan at Norra Bergsjön, where apartments were arranged around a central stairwell in each section of the building blocks. In Olivedal, the arrangement of apartments around a central stairwell was retained, but the reused elements were reassembled in sometimes new combinations, allowing for new apartment layouts. These three different receiver projects involving reclaimed elements from Bergsjön highlight the system's versatility and flexibility, demonstrating that the components could be effectively repurposed across various new building types of differing sizes and spatial configurations. Architect Bengt Forser attributed this adaptability to the relatively small size of the elements, which allowed for numerous combinations in diverse applications (Forser & Sundbom, 1986).

In the case of the student housing building in Linköping, the original layout of two two-bedroom flats arranged around a stairwell in Navestad was adapted into five apartments in the new floor plan, varying in size from studios to one-bedroom apartments. At Hammarkullen, the reassembly of elements into row houses resulted in distinct layouts for each floor to accommodate the separation of functions across two storeys. This represents a significant departure from the conventional logic of the precast concrete system, which typically depends on identical configurations of elements on each floor of a building.

## 5 CONCLUSIONS

All seven early reuse projects that characterize the initial phase of precast concrete reuse in Sweden originated from the deconstruction of mass housing developments built under the so-called Million Homes Programme, a national housing initiative aimed at constructing one million new dwellings between 1965 and 1974. Closely tied to the public housing sector, these initiatives emerged as pragmatic responses to uneven patterns of housing demand. The rapid expansion of housing during the

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Million Programme resulted in a surplus of apartments in large-scale, often less desirable residential areas, leading to widespread vacancies. Simultaneously, there remained a demand for smaller-scale residential developments in other parts of the country. Although interest in the reuse of precast concrete elements has grown in recent years, and several new projects have been initiated, contemporary efforts have yet to match the ambitious scope of the projects realized during this initial period.

Interestingly, the very characteristics that led to widespread criticism of many of the mass housing areas built under the Million Homes Programme—namely their systematization, standardization, and repetition—are the same attributes that made these precast concrete systems particularly well-suited for reuse. Especially during the deconstruction phase, the reuse process benefits from economies of scale, as upfront costs are reduced and standardized working methods can be systematically repeated throughout the disassembly process.

All four donor buildings involved in the reuse efforts analysed in this study were based on cross-wall structural systems, with load-bearing walls positioned transversely relative to the building block. However, the spans of the floor slabs varied between systems, and the sizes of the wall elements ranged from smaller components to full room-sized panels, resulting in differing levels of flexibility in design at both the building and room scales.

The most important finding of this study is that the recipient projects demonstrate that the architectural potential of precast concrete systems extends well beyond their original applications. Through relatively simple design interventions—such as reassembling elements into new configurations, adapting existing components, and integrating complementary new elements—these systems can be successfully repurposed to meet diverse site contexts, building types, and floor plan requirements.

Yet, despite the demonstrated reuse potential of precast concrete systems, both in terms of their deconstructability and their adaptability across a wide range of recipient buildings, these early initiatives did not lead to the widespread adoption of precast concrete reuse within the Swedish construction sector. With the exception of the Navestad project, it can be concluded that the primary reason most reuse initiatives during this initial phase failed to result in a greater incorporation of salvaged elements into new constructions was not a reflection of the reuse potential of these elements, but rather the difficulty in generating sufficient demand for salvaged components in new projects.

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