Reusing concrete panels from the industrial mass housing of the 1960s

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Abstract. A strong political strategy of demolishment is currently seen in the social housing sector from the 1960s and the early 1970s in Denmark. Architecture and building technology of that period are based on industrial mass production of concrete panels. The ideas behind the current demolition strategies are to overcome social problems by erasing housing blocks and replace them with new housing types and new functions. In this processs, even architectural heritage is demolished and the neighborhoods transformed into so-called mixed areas. Valuable building materials and a great number of excellent flats are downcycled into banal gravel. In contrast this paper will provide considerations concerning the question of reusing concrete panels in future architectural construction in Denmark. The paper clarifies potentials and barriers for reusing concrete panels in Denmark. It is the ambition to develop a more environmentally friendly thinking concerning the transformations of the neighborhoods towards more responsible housing areas. It is argued that if more environmental regards were taken, concrete panels can be reused as building materials in their second life and thereby as building components create both an architectural narrative of what was here, and at the same time apply for a more ecological use of already existing building materials. The paper forms a knowledge foundation to which further research regarding reuse of concrete panels can be developed in new architecture in Denmark.

1. Background

The Gellerup neighborhood in Denmark is a pattern example regarding transformation of the main layout of the area and a change of the blocks range of housing types, which are forming the current Danish housing policy of the social housing areas from the 60s in general [1]. Gellerup's 50 years history has been turbulent, as this neighborhood has been exposed for social segregation resulting in problems. Changing governments have decided to eliminant the problems by radical transformations, including demolition of housing blocks and adding new possibilities for workplaces [2,3]. Architecture and building technology from the 1960s and the early 1970s are based on industrial mass production and montage of concrete panels. As in many other countries the repetitive montage and concrete panel systems are dominant.

1.1 Transformation of architectural heritage

Transformations are currently ongoing in a row of similar housing estates, argued by law. These neighborhoods are named ´ghettoes´ or lately ´parallel societies´ by the Danish government [4]. The overall goal for these transformation areas is to solve the social problems by changing the demography inside the neighborhoods by demolishing larger parts of the area and by rebuilding new city functions, both housing and social meeting points and places for liberal businesses [1,5]. The architectural quality of the welfare society in Denmark is not officially considered as cultural heritage and is therefore not listed. This means, that in some cases housing areas with great architectural value are demolished, when the actual neighborhood is transformed into so-called ´mixed areas´ [3]. The architecture of the Gellerup case is of high architectural and technological standard.

1.2 Environmental issues

The Danish government prioritize balanced and mixed areas, and they are also offering huge investments in transforming the social housing areas like Gellerup neighborhood [1]. A great number of excellent flats in blocks and built by concrete panels are downcycled into banal gravel. This create serious environmental issues. The research will provide considerations concerning the question of reusing concrete panels in architectural construction illustrated by facts from Gellerup. In this transformation case, it was noticed, that gravel from the demolition of the school in 2008 was used under new roads, and later in 2015 at the first phase of the transformation, five blocks were demolished and utilized under the new main road through the Gellerup area.

1.3 Definition

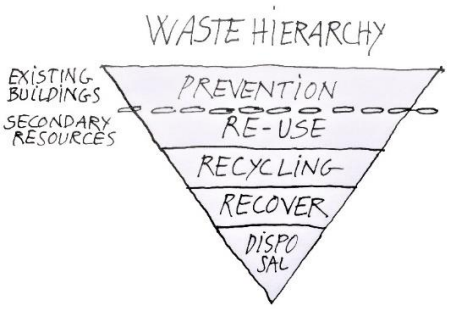

Fig. 1 The Waste Hierarchy, slightly translated into waste as building resources

Meanwhile the EU and also Danish waste policy demands to use the priority tool ´waste hierarchy´ to be explained here (Fig.1). Waste prevention are to be prioritized at the highest degree, which means that buildings should be utilized in its full consequence. If this is not possible the next level in the hierarchy is reuse. Below that is recycling, and a step lower recovery and finally disposal, but at a minimum. The hierarchy diagram illustrates grafically, that waste should as much as possible be avoided [7]. This means at best, that politicians and building owners over the coming years must address the demolition questions regarding climate change by considering the waste hierarchy, and thereby change their attitude to demolition: waste should be seen as a resource and ought to be reused inside the neighborhood at the next transformation stage in Gellerup.

1.4 Amount of concrete waste

In Denmark the waste law predicts, that all waste should be delivered to incineration plants. Concrete waste represents the largest fraction of total building waste in Denmark with a percentage of 25% of the total amount of building waste according to 1,3 mill tons in year 2019. The real amount of concrete waste is estimated to minimum the double, as a large amount of concrete is often handled next to the waste treatment plants according to Copenhagen Resource Institute (CRI) [8]. Further, it is the fact that of the official 1,3 mill tons concrete waste 95% are recycled into gravel [9].

1.5 The research purpose
This paper tries to identify the potentials and the barriers for reusing concrete panels from the actual demolition of the welfare states housing blocks addressed towards the next stage of the Gellerup transformation.

2. Methodologies
The research was applied through mixed research methods. Reuse as a phenomenon was investigated through a theoretical literature review regarding legislation and statistics concerning building waste. Recently published research papers clarified the possibilities for reuse instead of processing to sink. Case studies had been executed through examining drawings of the Aarhus municipalities' drawing archive. Practical aspects were performed through interviews and visiting homepages of architects, engineers and demolition compagnies. The investigations showed both the barriers and the potentials for reusing concrete panels. Together the examinations predict how physical barriers regarding future reused concrete panels meet demands from society and the building sector. Finally, the findings from the three methodologies are brought together in a discussion, which try to summarize the psychological, environmental and political potentials.

3. Findings
Since the modern movement of the 1920s the architecture and the building methods have changed in many countries in the world. As in other countries the Danish architects had been aware of this change since the beginning of the 1930s, where the architecture was named as modernism. New materials such as concrete, glass and steel took over the traditional building techniques regarding materials and methods. The industrial development of the building techniques was growing at high speed after WWII.

3.1 Literature review
In his three books ´Praktisk modulprojektering´, ´Modul og montagebyggeriet´ and ´Montagebyggeri ´ Nissen takes departure in both the Danish vernacular building habits and the old Greek temple building, when developing the rules for modules and constructing the modules regarding the montage buildings for all functions. From this departure a system was developed and exemplified as an ´open` system which defined a basic working method for both architects, engineers and production businesses [11,12,13]. The method is seen as a `grammar´ for all industrial development of buildings from the 1960s and are also applicable today. As the system build on knowledge from vernacular and ancient building technique, the industrial panels have an imbedded physic to be disassembled and reused in new constructions, although Nissen does not mention this quality.

Huuhka & Vestergaard presents an understanding between building conservation and circular economy based on the values for both of these phenomenon's in the article ´Building conservation and the Circular Economy: a theoretical consideration´. Referring to the Waste Hierarchy [7] Huuhka & Vestergaard suggest the following understanding based on these parameters: looking at buildings as a resource for application preventing them from demolition in their highest degree. If deconstruction is needed, then it is extremely relevant from a circular consideration to deconstruct the building for reuse of the components [14]. From both stages, building conservation and component preservation might contain materials, which as a third level can be preserved. The lowest level of the demolished materials can be either used for energy production or disposed [7].

The document from Copenhagen Resource Institute (CRI) investigates potentials for reuse and recycling of concrete waste. The total fraction of concrete waste in Denmark represents 25% of the yearly produced building waste [8]. The practice today is that the recycled concrete is utilized as gravel under infrastructural roads, paths etc., which means that the concrete is downcycled to a very low value. RCI investigates how a better utilization of concrete could be developed. CRI divides the embedded value of the material in four levels: highest value is reuse of panels, high value is recycled in green concrete, low value is sink under motorways, streets, paths and the lowest value is surcharge

in new products e.g. tiles. Currently it is very rare to find examples of the highest valued panel reuse in Denmark. The two low valued secondary resources are normaly used for a minimal and innovative production of green concrete.

Knowledge Center of Circular Economy in the Building Sector has published a guide `How much CO2 is saved by applying circular building materials´ [10]. The guide investigates, if reused and recycled buildings materials are worthwhile to use instead for virgin materials. It is recommended to calculate the actual LCA for the single building project, but as the second-best advice the guide offers key numbers which can be used as a decision foundation for the choice of building materials [8]. Calculations regarding concrete show two comparable conditions for concrete; green concrete containing 20% recycled concrete offers a climate gain of 0,91 kgCO2-ækv/m2 concrete corresponding to recycle 0,3% and reused concrete panels/columns/beams offers 295 kgCO2-ækv/m2 concrete corresponding to recycle 96%. This underline, that green concrete offers very little advantage, whereas reusing panels and elements offer an important value to the building process as for the building material as such.

The report ´Ressourceblokken´ reviews the potential of waste in 15 Danish hard ghettoes, if they are demolished. Each case is calculated and available materials are predicted [15]. When looking at the estimation at the case Gellerup, it is found, that material as roof, windows and columns are mentioned and calculated in quantity related to a housing area of 203.274 m2. These fractions are primarily saved from the climate screen and can easily be taken down, but the fraction of concrete panels is not estimated. It is noticed, that the potentials for reusing some double-T elements are mentioned; the example verifies, that in this case there was no interest for reusing these construction elements.

The title ´Bygninger som resource bank` refers to reuse of existing buildings and seeing them as a bank for materials [16]. The thematic sheet is a summary of several more or less scientific articles and creates an overview on how buildings can serve a resource bank nowadays.

Recently information on the project (P)RECAST, `Reuse of precast concrete elements´ running from January 2022 until June 2024 is published at the (DTI) Danish Technological Institutes homepage. DTI is project leader and a row of innovators, professionals from the building industry, the housing association Brabrand Boligforening and some public authorities e.g. have in unity developed a project seeking new paradigms of how to tear down buildings, secure technical qualities of the panels, finding methods to reuse concrete panels as static structures, showing cases where reuse is applied and documenting data and elaborating new business models towards new building cases. The project argues that environmental profit can be obtained for both the building industry and the environment [17]. The aim is to prove CO2 savings within the building sector, which have been absent for a long period. The visions are ambitious, and in combination with the architectural challenge of reusing concrete panels the project looks promising. Until now no results are informed in public.

3.2 Case studies

Three Danish cases from the montage period are chosen in order to bring practical knowledge and experience regarding reuse into the research (Fig. 2). The investigation is based on studies of drawings, on interviews and on available literature. The cases form a perspective on reuse of Danish concrete panels, and argue that reuse in rare examples has been done in practice. In parallel the cases help to identify the barriers and the potentials for reuse.

3.2.1 Nordgårdsskolen, architects Knud Blach Petersen & Mogens Harboe, Friis & Molkte

The school was built in 1971 and situated in Gellerup. That times architecture was influenced by new ideas, which more or less characterized the welfare states buildings. The school was designed as a modern, open and flexible structure, which gave room for future transformations regarding both pedagogical demands and new demands for spaces regarding e.g. the number of scholars [18]. Therefore, architectural and technical demands to the concrete structure both as industrial production and a reuse strategy was embedded in the original building planning. Shortly, the structural system consisted of reinforced loadbearing walls, beams and facades (Fig. 2). Bolts were used as connections

Fig. 2 Three cases: the school, the industrial building and the housing Gellerup

of the concrete components, which allowed the panels as prepared for deconstruction [18,19,20]. Unfortunately, the later political situation demanded tearing down the school in 2007. Unknown for what reason the structures embedded value for reuse was either ignored or forgotten, and the main part of the building was torn down [19,20].

3.2.2 Circle Electric, Viby J., original built in 1977 and remodeled in 1991

The industrial building was constructed in a rather pragmatic manner as a static structure of reinforced concrete columns and beams covered with a façade of concrete sandwich panels (Fig.2). In 1991 the original building was remodeled to a combined office and industrial building: some of the original façade panels was moved from their original position in connection with a remodeling of the whole building complex [21]. The Circle Electric case showed the possibility to reuse panels by moving them from one place to another within a short distance. There was no information whether the façade was predestinated for reused, but the remodeling did not force any problems [21].

3.2.3 Gellerup Housing, built 1968-72, architects Knud Blach Petersen and Mogens Harboe

Gellerup is one of the largest social housing estates planned and built in the 60s in Denmark. The housing association initiated the first stage of a huge transformation in 2015-2020. The architecture is remarkable and represent the strong and contrasted architectural heritage from the welfare state (Fig.2) [22,23]. As a result of large social problems starting few years after the neighborhood was completed, the area came in 2010 on the Ghettolist [4]. Political negotiations let to large radical transformation plans in order to change the demography by changing the infrastructural systems and by tearing down several blocks and rebuilding new functionalities, and in the near future also by adding a new low housing neighborhood [6]. The government and municipality characterize the plan as a pattern plan for Danish transformation concepts of other large housing schemes. The structural system of the housing blocks was shaped in a very condensed but effective design, where the stabilizing system was concrete panels as loadbearing wall panels perpendicular to the façade. The wall structure was closed horizontally by slaps as expanded hollow panels. This structure formed an open façade grid where light carpenter panels of windows and doors were mounted. All living rooms have access to either a wider or slimmer balcony, which as façade forms a highly contrasted design characterized of light and shadow [22]. Solid concrete panels as facades are only used at the gables [24]. This design creates a very strong and articulated façade, where all flats have unbroken view to the landscape in front of all indoor spaces. The transformation process of Gellerup area is comprehensive and divided in several phases. As earlier mentioned the school was already demolished in 2007, followed by demolishing of five blocks in 2015 [25]. The current demolition plans are prepared for 360 flats in total six blocks. The difficulties of calculating the climate effects are mentioned at the district plan meant for legalizing of the demolition [26]. Currently there is a situation, where this plan is in public hearing in order to approve the demolition. The demolition operation is calculated to include a total building area of 37.304 m2, which corresponds to a concrete mass of 16.251 m3. This mass is calculated to 38.781 tons concrete in weight. The calculated volume of crushed concrete is predicted to be stored at site for future use in new city development. If the material cannot find future application at site, the predicted

possibility is to involve transportation to an incineration plant, which also include huge CO2 impact and transportation. The demolition process contains lots of problems, both CO2 emissions, transportation, storing, dust and noise in the middle of the housing area. The district plan predicts the demolition time to last app. 15 month [26].

4. Discussion

The discussion mirrors the climate question when reusing concrete panels in Denmark.

As mentioned earlier the modular building system carry learnings from the old Greek and Danish vernacular building techniques [11,12], and the building system is basically still applicated. Walls and slaps of concrete are easily joined, and because of the materials heavy load very few extra efforts are needed, when the whole building is brought together. Two case studies show, that reusing of concrete panels have few problems, and the Gellerup case show that there are huge amounts of resources to be activated reuse. When we apply the Waste Hierarchy in the building sector, it is possible both to protect our architectural heritage, but also to save resources for new buildings, still there will be smaller components and material left for gravel [7,14].

As we can see from the CRI, Danish building industry does not utilize concrete panels at a high-quality [8]. If the building industry were forced to reuse concrete panels, a great deal of CO2 could be saved. Resourceblokken [15] describes only the low hanging fruits in form of add on´s from the building demolition, although the largest resource lays in either preventing the building from demolition or reusing the panels with all its formal qualities. This research suggest that we look at the buildings as material banks [16].

The case study of the school was prepared for decomposition and reuse. The joints were made with bolds, and the number of different sizes and functions of the components were carefully minimized [18]. As mentioned, nobody took care of these details at the time of demolition. This calls upon an information system in order to realize the qualities, which are embedded in our buildings.

Although the case study of the industrial building did not belong to the mass housing system, the remodeling of the panels location shows us, that in the detailing both the industrial and the housing panel system have embedded qualities, which can provide easy possibilities for remodeling within the rules of the systems [21].

A video of the demolition of Gellerup indicate, that an extreme violent demolition technique is used, with the goal to crush and tear out the steel from the panels [27]. In order to harvest concrete panels quite another demolition technique must be used, namely circular demolition where all elements are taken carefully apart [28]. In a circular demolition technique, the main part of the structural panels could easily be harvested for new use.

When approaching other research projects dealing with circular economy, demolition and remodeling, it is relevant to refer to the concrete panel project `ReCreate: Reusing precast concrete for a circular economy` [29]. The premise for the project is to look at ´concrete structures that humanity has already produced` and which ´make up significant deposits for salvageable concrete components`. The Recreate project ´wants to close the loop for concrete at the highest level of utilization…of precast concrete components`. The project is financed by Horizon 2020, and four countries in our close region namely Finland, Sweden, The Netherlands and Germany are now investigating respectively pilot projects in order to realize the potentials and barriers of reusing concrete panels [29].

The project (P)RECAST shows an interesting vision in a Danish context on how to secure qualities when reusing concrete panels [17]. Actually, no information is given regarding an overall circular thinking or whether the project is related or referring to research projects already under investigation in the Northern European region.

When reusing concrete panels several uncertainties have to be examined regarding the building industries environmental responsibility. Focus must be directed at those chemical substances, which were used during the early montage period, and these must be identified and handled to nowadays restrictions [30]. PBC is one of these [31]. Currently stripping is the most reasonable way to minimize the substance to a limited value, but maybe other opportunities can be developed in the future. Also

qualifying the strengths and developing ways to physically cleaning and protecting the valuable panels must be taken. Such a project cannot succeed if you go bias to the subject, research is needed.

The author has through interviews of architects, engineers, producers, entrepreneurs and clients understood, that the building sector believe heavily in usual habits, saying that it is appreciated to use new materials, because it is also much cheaper and easier. But the Danish Government has announced a changed law, applicable from 2023, that all buildings of more than 1000m2 should fulfill calculations for CO2 load at a certain maximum [32]. Hopefully this rule along the way will be increased and thereby stress the building sector to reuse more materials and components in new buildings than today.

Summarizing the discussion new demolishing techniques must be developed, questions as local storing places and a modern advanced information system, where the access to knowledge of what is where, which sizes and which quality, when can the material be delivered and for which economy must be developed. In their project and research Vestergaard & Guillermo have explored the field of urban mining from two teaching projects [33]. The work proves, that methods of registration, mapping, storing and visibility in e.g. the form of a harvest map is of great importance [34].

Finally, society should care for the environmental awareness of demolition of e.g. Gellerup housing in such a way, that concrete panels from the industrial mass housing can to be reused. But to succeed with such an idea it is also obvious, that there is a need to push the political decision makers of the ghetto transformations to think in more responsible directions. The political system must elaborate an awareness of climate questions, and through responsible and positive attitudes forward rethinking of building resources by replacing virgin materials with secondary material in the ghetto areas.

5. Conclusion

The purpose of the research was to investigate whether reuse of structural concrete panels from the Danish mass housing from the 1960s had potentials, and which barriers such a construction could have. Through literature, case studies and interviews it is realized that reusing concrete panels have realistic potentials, but there are also barriers, which are created from human resistance and from the marked. Barriers of how to store, visualize and communicate the existence of secondary resources are still remaining to be solved.

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References

[1] Regeringen 2018 *Et Danmark uden parallelsamfund – Ingen ghettoer i 2030* (Regeringen Slotsholmen København K)

[2] Mortensen, MB 2008 *Nedrivning – hel eller delvis nedrivning af ghettobebyggelser* (Arkitektur der forandrer – fra ghetto til velfungerende byområde) ed. Bjørn N (Gads Forlag)

[3] Bech-Danielsen C & Stender M 2017 *Fra Ghetto til blandet by: danske og internationale erfaringer med omdannelse af udsatte boligområder* (Gads Forlag)

[4] Ghettolisten 2021 https://bl.dk/politik-og-analyser/temaer/her-er-listen-over-parallelsamfund/

[5] Helhedsplan for Gellerup og Toveshøj 2007 (Århus Kommune + Brabrand Boligforening) https://helhedsplangellerup.dk/media/28419/helhedsplanen-gellerup-og-toveshoej-2007

[6] Helhedsplan 2021 (Århus Kommune Granville Vandkunsten) https://helhedsplangellerup.dk/media/67004/karen-blixen-kvarteret-kvartersplan.pdf

[7] *Waste Hierachy* EU definition https://ec.europa.eu/environment/green-growth/waste-prevention-and-management/index_en.htm accessed 03.2022

[8] CRI 2017 *Note* (Copenhagen Ressource Institute)
[9] MST 2019 *Affaldsstatistik* (Miljøstyrelsen København)
[10] VCOB 2021 *Hvor meget CO2 spares ved at bygge med cirkulære byggevarer, Guide*, ´How much CO2 is saved by applying circular building materials? Guide´ translation by author (Videnscenter for Cirkulær Økonomi i Byggeriet, Taastrup, Denmark)
[11] Nissen H 1966 *Praktisk Modulprojektering* (Teknisk Forlag, København)
[12] Nissen H 1970 *Modul og Montagebyggeri* (Polyteknisk Forlag, København)
[13] Nissen H 1984 *Montagebyggeri* (Polyteknisk Forlag, København)
[14] Huuhka S & Vestergaard I 2019 *Building conservation and the Circular Economy: a theoretical consideration* (Journal of Cultural Heritage Management and Sustainable Development)
[15] Heunicke NM Gimmel KS Poulsgård KS Udbye K Dalvang K Smith KH Haukhol J and Eberhardt L 2021 *Ressourceblokken – Upcycling af 60érne og 70érnes almene byggeri* (Realdania, Copenhagen)
[16] TI 2021 *Bygninger som ressourcebank, Temaark #2,* (Teknologisk Institut, Videnscenter for Cirkulær Økonomi i Byggeriet, Realdania)
[17] DTI (P)RECAST https://www.dti.dk/projects/p-recast/43887 , accessed April 2022
[18] Sigurdsson T 2018 Authors interview 27th Sep. 2018
[19] Skriver PE 1974a *Nordgårdsskolen, Brabrand* (Arkitekten DK 8/1974, Arkitektens Forlag, København K) p. 289-295
[20] Moseng K Vestergaard I & Jensen BG 2019 *The role and value of local welfare institutions in multicultural areas* (IOP Conference Series: Earth and Environmental Science 297:012015)
[21] Sigurdsson T 2021 Author interview 9th Dec. 2021, recorded by author
[22] Gudmand-Høyer SM Bach RC Jensen BG Moseng K. Nielsen T Olesen K & Vestergaard I 2021 *Gellerup* (Aarhus School of Architecture, Aarhus & Arkitektens Forlag, Copenhagen)
[23] Skriver PE 1974b *Gellerupplanen, Brabrand* (Arkitekten DK 8/1974, Arkitektens Forlag, København K) p. 289-301
[24] Min Ejendom, Aarhus Kommune accessed 01.2019
[25] Vestergaard, I., Moseng, K. & Jensen, B.G. (2019) *Resource Strategies-discussions on remodeling modernistic housing and related social impacts* (IOP Conference Series: Earth and Environmental Science 297, IOP Publishing)
[26] District Plan 1173 2022 *Forslag til Lokalplan 1173, nedrivning af seks boligblokke i Gellerup*, authors translation: Proposal to Local Plan no 1173, demolotion of six housing blocks (Gellerup, Teknik og Miljø, Aarhus Kommune) p. 47
[27] Olesen P 2015 *P. Olesen Nedbrydning/Genbrug Nord 2015* video https://www.youtube.com/watch?v=q_PZPfDHDj4
[28] Værdibyg 2020 *Cirkulær nedbrydning* author translation: Circular demolition (Værdibyg & Grundejernes Invsteringsfond, København)
[29] Huuhka S 2021 *Introducing H2020 project ReCreate - Reusing precast concrete for a circular economy* (The 10th International Conference on Life Cycle Management Sept. 2021)
[30] VCOB *Pas på farlige stoffer i gamle byggematerialer, Guide* (Videnscenter for Cirkulær Økonomi i Byggeriet Taastrup Denmark)
[31] PCB 2022 https://mst.dk/kemi/kemikalier/saerligt-for-borgere-om-kemikalier/kend-kemikalierne/pcb/ (Miljøstyrelsen, Copenhagen) accessed March 2022
[32] Regeringen 2021 *Ny aftale sikrer bæredygtigt byggeri* https://im.dk/nyheder/nyhedsarkiv/2021/mar/ny-aftale-sikrer-baeredygtigt-byggeri
[33] Vestergaard I & Jiménez GM 2020 *Exploring secondary resources in an architectural project* in *Built Environment and architecture as a resource* (The Nordic Association of Architectural Research) p. 111
[34] Harvest Map https://www.oogstkaart.nl/ (Superuse Studios NL)