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De-construction as part of life cycle management

La déconstruction dans le cadre de la gestion du cycle de vie

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ABSTRACT: Finland has committed to utilizing 70% of construction and demolition waste (CDW) by 2020. However, the current re-utilization rate is still below 60%. Altogether 85% of the total CDW is generated by repair projects and demolished buildings, while the remaining 15% is coming from new construction. Hence, the main emphasis should be on the recycling of demolished or repaired buildings and constructs. Construction in urban areas start often with the demolition of old buildings and structures. At the same time, there is a need to construct new or upgrade old infrastructure such as streets, footpaths and bicycle lanes, parking areas, and noise barriers. The demolition materials should be utilized *in situ*, near the demolition site. This would result in apparent economic savings in terms of heavy transportation and thereby and lower emissions. Also, the strain on existing road structures and congestion on the city's street network would be relieved. Finally, the need for virgin raw materials would be less. This paper presents a novel operating model that combines demolition operations and construction operations by optimizing material quantities, quality, work scheduling, and site operations. Various demolishing aggregates, side flows and other fraction flows will be tested in experimental structures with the aim of finding out whether they meet the regulatory requirements and standards for infrastructure construction.

RÉSUMÉ: La Finlande s'est engagée à utiliser 70 % des déchets de construction et de démolition (CDW) d'ici 2020. Cependant, le taux de réutilisation actuel est toujours inférieur à 60 %. Au total, 85 % des déchets CDW sont produits par des projets de réparation et des bâtiments démolis, et les 15 % restants proviennent de nouvelles constructions. L'accent devrait donc être mis principalement sur le recyclage des bâtiments et constructions démolis ou réparés. Dans les zones urbaines, la construction commence souvent par la démolition de vieux bâtiments. Dans le même temps, il est nécessaire de construire de nouvelles infrastructures ou de moderniser les anciennes infrastructures telles que les rues, les sentiers piétonniers et les pistes cyclables, les aires de stationnement et les écrans antibruit. Les matériaux de démolition peuvent être utilisés à proximité du site de démolition. Cela se traduirait par des économies économiques apparentes en termes de transport lourd et donc par une réduction des émissions. De plus, la pression sur les structures routières existantes et la congestion du réseau routier de la ville seraient réduites. Enfin, le besoin de matières premières vierges serait moindre. Cet article présente un nouveau modèle d'exploitation qui combine les opérations de démolition et les opérations de construction en optimisant les quantités de matériaux, la qualité, la planification des travaux et les opérations sur le site. Différents agrégats de démolition, écoulements latéraux et autres flux de fractions seront testés dans des structures expérimentales dans le but de déterminer s'ils répondent aux exigences réglementaires et aux normes relatives à la construction d'infrastructures.

Keywords: Construction; demolition; waste; infrastructure; recycling.

1 INTRODUCTION

Construction and demolition waste (CDW) accounts more than a third of all waste generated in the European Union (EU). CDW contains a wide variety of materials such as concrete, bricks, wood, glass, metals, plasterboard, and plastic. EU set an ambitious target for 2020: recovery, re-use, and recycling of non-hazardous CDW materials should be increased to at least 70% by weight (Directive, 2008). Many countries are behind the target, including Finland in which the recycling rate is still less than 60% (Figure 1) (Statistics Finland, 2023).

The Finnish National Waste Plan for 2027 has objectives for CDW waste management as follows: a) the total amout of CDW waste should be decreased, b) CDW utilization rates should reach the level of 70%, and c) the high-quality recovery of CDW waste is increased by managing the risks (Ministry of Environment, 2022). The forthcoming risk management objective will be an important part in the circulation of CDW waste. The same principle has been followed in the rehabilitation of contaminated soils for a decade.

Figure 1. In Finland the recycling of construction waste is behind the recycling target set by the EU (green line) (Statistics Finland, 2023.

Ginga et al. (2020) considered the importance of future research in exploring new construction applications for CDW waste. Menegaki and Damigos (2018) collected data on the factors enhancing and hindering CDW waste recovery. More specifically, Kourmpanis et al. (2008) collected data on the challenges and benefits of on-site crushing and sorting. Disadvantages included, for example, noise and dust emitted in urban areas. However, today's technologies and machines are more advanced, as was the case almost 20 years ago. Also, the readiness to change many working practices and processes has increased.

This paper introduces the preliminary framework to be tested and evaluated in PURKU project. The project, Demolition as part of urban construction - eco-efficient utilization of demolition material in infrastructure and building construction, start in the beginning of 2024. The project is funded by the EU's Just Transition Fund (JTF). In addition, the paper introduces effective measures that will be executed in the project to enhance CDW waste recovery and recycling.

2 DATA AND METHODS

The PURKU project is divided into seven work packages including value network and life cycle analysis, development of project practices and operation methods, laboratory studies, demolition pilots, support for the industry change, and project management and communication. The main objective is to create new operating model that will be studied and tested at the test sites (demolition pilots). Particular attention is paid to new working methods for crushing rock to be suitable for reuse at or in the vicinity of the site, without the materials being transported to be processed away from the demolition sites and back after treatment. On the other hand, attention is paid to project management and that in the future demolition would be better managed in the life cycle of construction. Laboratory studies aim to investigate the properties of structures and the conversion of harmful substances to a less harmful form. The workshops will bring together different stakeholders to learn about sustainable demolition. Together with various actors the operation model is developed and implemented.

2.1 Value chain and project management practices

The project develops a new kind of value chain and project management practices for construction that assume that demolition is at the beginning of the value chain and life cycle models. Traditionally, demolition has been the end point of construction (e.g., Yeheyis et al., 2013). The construction industry involves various stakeholders at different stages of a building's life cycle. These include, for example, legislators, authorities, city planners, customers, designers, contractors, material suppliers, subcontractors, demolition companies, material, and waste handlers. The construction industry's operating models and practices are well-established and regulated in many ways, but the transition to a circular economy (CE) poses new challenges and needs for change. The transition to a more efficient material life cycle and the utilization of side streams and demolition material requires value chain and project practice development to comply with CE principles.

To achieve the goals above, our project will analyse the construction value chain and its development opportunities from building aggregates' perspective by using life cycle, stakeholder, and business model analysis as tools. The analysis will be conducted on previous demolition-construction cases in Oulu area as well as the demolition pilots implemented in the project. Furthermore, the analysis will cover project management practices (including processes, actors, decision-making, tools) with the aim of identifying development opportunities in different phases of the project's extended life cycle (conceptualization, planning, implementation, operational phase). The use of CE thinking and strategies in case projects will be utilized to develop a project management model and a business model that integrates demolition with construction. The aim is to develop stakeholder management, procurement management, and risk management, as well as replicable project management procedures that take CE principles into account. Finally, demolition-construction related operating models, practices and material management will be developed. Figure 2 shows the current and target life cycles and practices in the construction value chain.

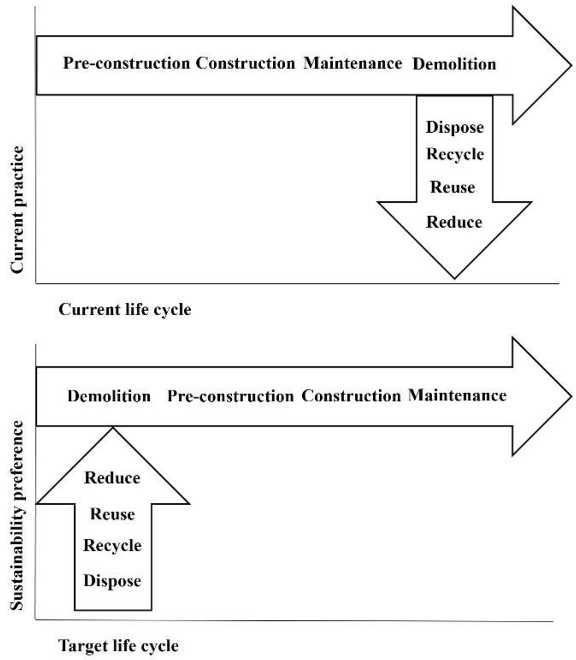

Figure 2. Current and targeted construction value chain.

2.2 Demolition pilots

The research pilots are in Oulu region, Finland. Oulu is home to Finland's largest demolition site, the old University Hospital, which is one of the selected research and pilot sites. In addition, there are other pilot sites coming from the area, but they are smaller.

The purpose of the pilots is to change the crushing activities of the materials so that the mineral based structures are crushed on-site in the urban area. During the crushing, the following parameters are monitored 1) dust, 2) vibration and 3) noise generated by on-site demolition pilots, and 4) other emissions that are harmful to the environment and the populations.

In Finland, a large part of the year is worked in winter conditions and it brings its own challenges e.g., to dust-binding. Water has typically been used for dust-binding, but water freezes, so other additives must be used economically end enviromentally wise for winter dust-binding. To achieve the best possible results, it is possible to test new additional equipment and alternative bio-based dust-binding methods at the sites.

Crashing and demolition is generally known to be loudly processes. Efforts are made to identify noise-sensitive activities at the site and find ways to prevent noise and vibration. Pilots require from contractors' equipment to be used to reach the permitted noise and vibration levels.

The non-hazardous CDW waste from the pilots are planned to be use in the sites or nearby infrastructure construction sites, like the foundation of bridges. Still, contaminated CDW waste is generated. The purpose is to build test fields in which those hardly utilized materials are used for bottom structures. The fields will be monitored for several years to provide information on environmental impacts. Similar smaller laboratory scale test structures will be built in parallel, in which climate conditions can be modified and accelerated to obtain information on the environmental impact of materials.

2.3 Laboratory studies

The laboratory-scale studies of the project support the demolition pilots but also make some completely new research openings (e.g., related to asbestos waste). The topics are (1) dissolution studies of asbestos fibres to render them non-hazardous; (2) studies of Polycyclic Aromatic Hydrocarbons (PAH) and heavy metal containing demolition waste fractions; (3) dust suppression during demolition; and (4) seepage water studies. For asbestos, the aim is to utilize additives enhancing the dissolution of the fibres with potential to utilize the dissolved asbestos (rich in silica (Si), calcium (Ca), magnesium (Mg), and iron (Fe)) as a raw material to the development of new recycled construction materials. PAH and heavy metal quantities and distribution in demolition materials are studied with their solubility under different conditions, which supports the material choices for the pilots. In terms of dust suppression, the goal is to conduct preliminary studies with enhanced dust-binding chemicals. The aim of seepage water experiments is to build laboratory-scale model systems simulating the behaviour of the materials when exposed to outdoor conditions.

2.4 Workshops

During the project training events and workshops will be arranged together with stakeholders to achieve new value chain-based operation model. In addition to public training events and seminars, the joint collaborative workshops will be organized with the key stakeholders that are involved in de-construction and construction value chain. The objective is to verify and elaborate the change requirements that are caused by the transition to more sustainable de-construction and life cycle management practices based on circular economy methods. The analyses of earlier de-construction projects and experiences gained during the de-construction pilots will be used as inputs in the work conducted in the workshops. The intended outcome of the workshops is to create a joint regional development plan to advance the use of de-construction materials and circular economy in the construction industry overall.

3 RESULTS AND CONCLUSIONS

The project will officially start at the beginning of 2024. The first demolition sites will be started during the spring or summer. Preparations have already been commenced and will continue throughout winter 2024. The project will demonstrate how on-site demolition can make sense, by utilising life cycle calculation methods and narrating practical examples.

Direct positive effects are expected to be observed for example regarding reduced heavy truck traffic. This would improve road safety and reduce the load stress of the local roads and streets, as well as minimize emissions from heavy traffic.

Alternative project management concepts can be applied to enhance wider use of demolition materials. For instance, the project attempts to find new synergies between local construction projects to create local mass/material balance. This will improve local material circularity. The main ambition is to demonstrate that materials from demolition are valuable and usable building material, and it makes both economic and environmental sense to make maximum use of them.

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REFERENCES

Directive. (2008) Directive 2008/98/EC of the European Parliament and of the Council, Fundamental Texts on https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02008L0098-20180705&from=SV.

Ginga, C.P., Ongpeng, J.M.C., Daly, M.K.M. (2020) Circular economy on construction and demolition waste: A literature review on material recovery and production, *Materials*, 13(13), pp. 1–18. https://doi.org/10.3390/ma13132970.

Kourmpanis B., Papadopoulos A., Moustakas K., Stylianou M., Haralambous K.J., Loizidou M. (2008) Preliminary study for the management of construction and demolition waste, *Waste Management and Research*, 26(3), pp. 267–275. https://doi.org/10.1177/0734242X07083344.

Menegaki, M., Damigos, D. (2018) A review on current situation and challenges of construction and demolition waste management, *Current Opinion in Green and Sustainable Chemistry*, 13, pp. 8–15. https://doi.org/10.1016/j.cogsc.2018.02.010.

Ministry of the Environment. (2022) From Recycling to Circular Economy, *National Waste Plan to 2027*.

Statistics Finland. (2023) *Waste statistics*. Available at: https://stat.fi/index_en.html.

Yeheyis M., Hewage K., Alam M.S., Eskicioglu C., Sadiq R. (2013) An overview of construction and demolition waste management in Canada: A lifecycle analysis approach to sustainability, *Clean Technologies and Environmental Policy*, 15(1), pp. 81–91. https://doi.org/10.1007/s10098-012-0481-6.