

YOUNG PROFESSIONALS' CDW RECYCLING OBSERVATIONS

Anne-Marie Tuomala

LAB University of Applied sciences, Finland

ABSTRACT

Finland was the first country in the world to prepare a national road map to the circular economy (CE) in 2016. Since that many industrial fields have been planning and implementing various business applications and the authorities have been developing new regulation.

Demolition industry in Finland is unified under Finnish Demolition Association (FDA). It mainly consists of small and medium sized companies (SMEs), which have managed to grow and create new jobs. At the same time there is a growing need for qualified employees and engineers. The FDA noticed that it is a remarkable player as an implementer of the CE goals, as the construction and demolition waste (CDW) is the second biggest waste producer after the mining industry. The demolition industry has done and is able to do new business by innovating, but it needs more qualified forces.

The applied university level virtual course Demolition Waste Recycling has been running twice in 2021-2022. The interviewees were 19 recently graduated from universities of applied sciences, who worked in demolition sites during the past years and the interview gathered their observations and innovative ideas.

The result has important implications for national policymaking when designing new incentives to speed up the transformation to the CE. Moreover, demolition SMEs lack the resources to promote reuse of side streams, especially where essential actors are missing from the value chain.

KEYWORDS

Circulation Economy, Recycling, Construction and Demolition Waste, CDW, Sustainable Engineering

1. INTRODUCTION

1.1 Rationale and Background

The circular economy (CE) is a megatrend, where circulation of materials has a significant role. Finland was the first country in the world to prepare a national road map to the circular economy in 2016, under the leadership of Finnish Innovation Fund Sitra. The 2nd version published in March 2019 to update Finland's plans to reform its economic model to ensure successful sustainability by the circular economy.

Construction and demolition waste (CDW) accounts for more than a third of all waste generated in the European Union (European Commission 2023). According to the EU Waste Framework Directive (2008/98/EC), Finland was committed to reuse 70% of the construction and demolition waste (CDW) by 2020. However, the present utilization rate is still less than 60% (Ministry of Environment 2022). In Finland, about 84 % of the CDW is generated from repair projects and demolition of buildings and about 16 % from new buildings. The specialty in Finland is the wood-based waste, which is 41 % of the total CDW, whereas in the Central and South-Europe it is ca. 5 % (Peuranen & Hakaste 2014, 11). The new target year for 70 % of CDW recycling is 2027 (Finnish Environment Institute 2022, 23). To note, the current CSW utilization percentage is mainly generated in downcycling processes like energy production. The upcycling, such as recycling in new construction materials, keeps at much lower percentage level.

CDW circulation can be divided in two groups: backfilling and recycling. Backfilling is in practice downcycling because the material application is of low value. The upcycling is that the CDW is transformed into new materials and products that increase its value compared the material just after the demolition. It is always more beneficial to apply upcycling not only for the market itself but also to increase the number of products produced with this waste and therefore increasing the demand of it as source mate (Ferriz-Papi &

Thomas 2020, 2). This requires that there are enough remanufacturers for the CDW utilization.

According to the EU's Waste Framework Directive (WFD), preventing waste is always the preferred option and sending waste to landfill should be the last resort. Each industrial field, like the construction, renovation and demolition industry among others, should understand the CE applications and take into use so, that materials and wastes can be recycled and upcycled. The figure below, Waste hierarchy to construction and demolition activities (Dodd et al. 2020, 19) introduces separately applications of EU's waste hierarchy and in demolition and in construction activities.

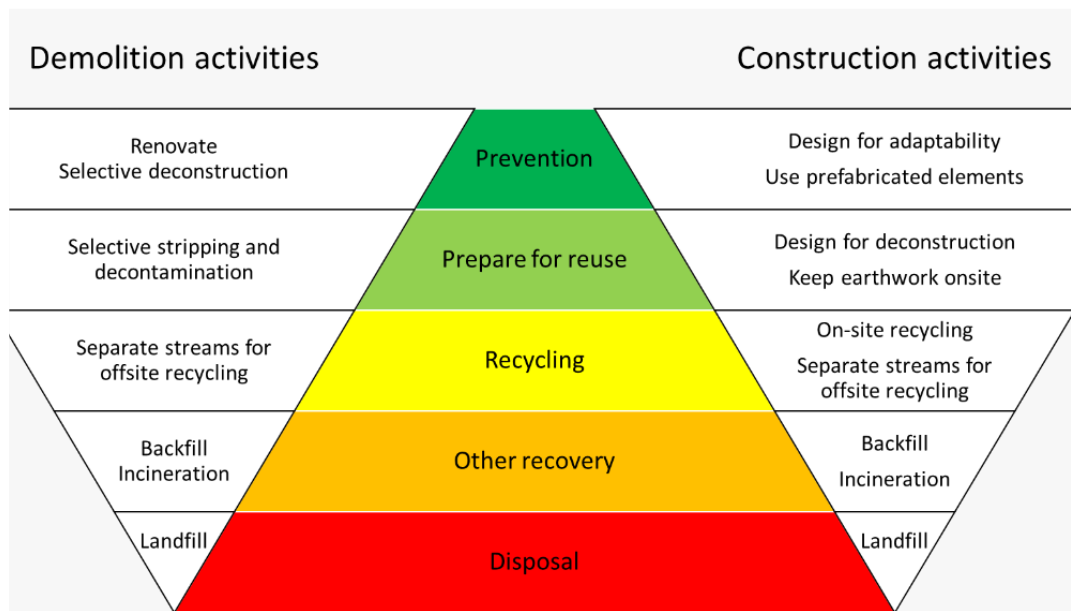


Figure 1. Waste hierarchy to construction and demolition activities based on Waste Framework Directive (Dodd et al. 2020, 19)

In Finland, the Government Decree on Waste from 2012 was the starting point. That time the country was far away from the recycling targets for CDW and below the average European level of 47%, being only 26% (Kojo & Lilja, 2011, 73). Another study (Høiby & Sand 2018, 45) states that in 2012, ca. 16 million tons of construction and demolition waste were generated in Finland; ca. 14 million tons of soil waste and 1.5–2.0 million tons from buildings. It was estimated that utilization of construction and demolition waste is now ca. 60%. However, due to the state of construction and demolition statistics, this figure is surrounded by a high degree of uncertainty.

The decree defined that by the end of year 2020 the recycling rate of CDW in Finland must be 70%. Dahlbo et al. (2015, 338-340) estimated that achieving the 70% recycling rate of CDW by 2020 would have required the overall recovery rate to be at least 80% in practice, since some waste will inevitably be utilized as energy. This research group was of the opinion, that overall system produced environmental benefits and was economically profitable, but it was far behind the target of a 70%. Major changes will be needed for sorting, separation, and recovery within the system. Wood was the critical component for increasing recycling, because it is a large fraction currently recovered as energy.

The amount of plastic waste keeps growing in all over the world. Häkkinen et al. (2019, 5) state that the building and construction sector is the second largest consumption sector of plastics, accounting for 19% of all non-fiber plastics in the EU. PVC, PE, PP, EPS, and PU are typical plastics used in buildings. Different kinds of recycling techniques have been investigated and proposed. However, in Finland the current recycling rate for mechanical recycling is low (<20%), and most of the plastics in construction and demolition waste goes for energy recovery and disposal.

The Figure 2 illustrates the waste amount and treatment situation development from 2010 until 2019, when there was one year left until the target year 2020, when 70% recycling rate should have been achieved. In 2019 total waste amount was declining as well as material recovery.

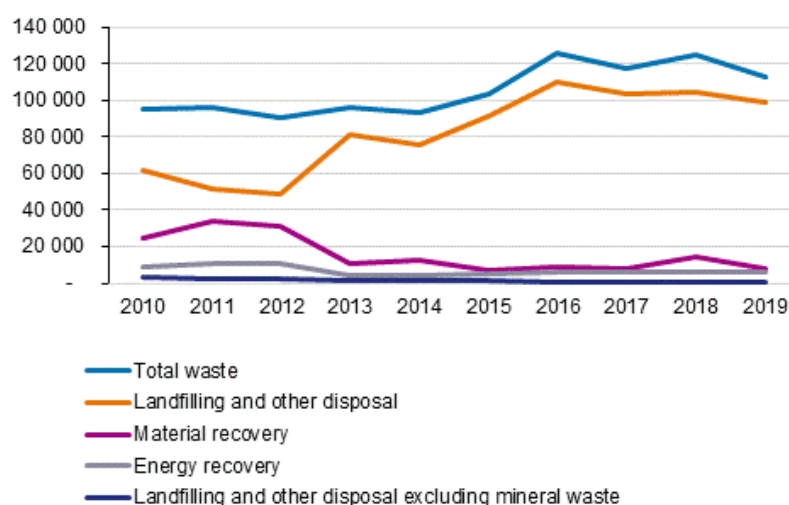


Figure 2. Waste amounts and treatments in Finland 2010-2019, 1,000 tons per year (OSF 2021)

The decrease in 2019 was mainly explained by the changed amount of waste from mining and quarrying, but the decrease was also affected by the fallen amount of waste from construction and demolition in general. The amounts of waste treatment were the result of the lower amount of waste. Most of the waste was mineral waste landfilled in mining areas and landfilled soil masses of construction. Due to the lower amount of waste, their material recovery was lower than in previous years, which decreased the share of material recovery, being 7.2 per cent of all treated waste (OSF 2021.). The Finnish Environment Institute (2022, 5, 23) reports for the year 2019 as total amount of waste 116 million tons of which share of construction was 13,7 million tons (ca. 12 %). CDW re-use as materials was 720 000 tons, which equals with the 48% of the total CDW amount. Researchers estimate that Finland presents a steep decline after 2010, which is likely to be the result of intense demolition activities prior to 2010, rather than prevention strategies (Zhang et al. 2022, 7).

The statistics of the year 2020 in Table1 below show growth in total waste amount. The mineral waste, the biggest among in tons, consists of concrete, brick, gypsum, asphalt, asbestos, and soil.

Table 1. Waste generation by industry by NACE, Information, Waste class and Year (OSF 2021).

	Year 2020
NACE F Construction (41-43)	1 000 tons
Amount of waste 1000 tons, TOTAL	13 689
Chemical waste	0
Metallic waste	217
Paper and cardboard waste	0
Wood waste	273
Animal and vegetal waste	1
Household and mixed waste	9
Sludges	721
Mineral waste	12 453
Other waste	16
Of which hazardous waste	314

Finally, the recycling rate of 48% was achieved by 2020, which was maybe embarrassing for the Ministry of Environment, as in the previous year the recycling rate was a bit higher exceeding 50 % clearly. Some media channels give for the year 2020 over 50% recycling rate. The official percentage in the Ministry of Environment (2022) site states that the present utilization rate is less than 60%, but the more exact percentage is not available.

CDW is one of the focus areas of the National Waste Plan in Finland. The national strategy also aims at increasing the safe utilization of CDW as well as improve the availability of accurate data on CDW (Karppinen 2021, 2.). The Figure 3 serves as an example of the new and more updated data dissemination.

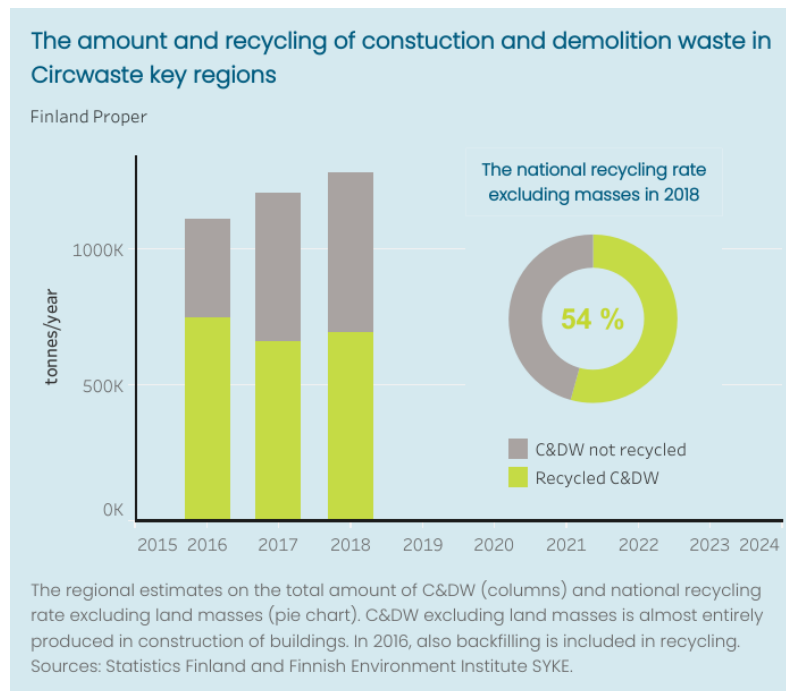


Figure 3. The national recycling amounts of CDW (Finnish Environment Institute SYKE 2021)

In Finland the CDW markets have been developed quite slowly, but new businesses are established like Ecoup and Conenor among others and supply chains are developing. There are also several tools and measures launched by the Ministry of Environment to speed up the progress. It has been published three guidebooks for the acting bodies to understand sustainability in building demolition. Furthermore, Materials Marketplace is a free of charge internet service and contact point for the producers and users, sellers, and buyers, of waste and side streams. In parallel, also private companies have established sharing platforms. To add, the reform of the Land Use and Building Act is ongoing and to be finished, hopefully, during this year. Important measures in operational level are e.g. the agreement on the collection of plastic films and use of recycled material and the GreenDeal on Sustainable Building between Ministry of the Environment and Finnish Property Owners RAKLI.

1.2 Research Question

The development tendency of CDW recycling has not been in Finland as expected in the national level, coordinated by the Ministry of Environment. It is good to shed light what kind of issues – positive or negative - we can find from the root level, that contribute to the overall situation.

This study explores the practices of CDW management in Finnish demolition field work. The primary research question is what kind of information a self-initiated employee can bring from the CDW field work into the common CDW management development activities.

1.3 Study Aims and Objectives

This study aims to explore employees' experiences and development ideas of CDW management on demolition sites. To add, through a review of above introduced literature, which is mainly based on statistical information of the country, focuses on the factors, barriers, motivations that influence the generation and management of CDW in the actual field work.

The following objectives facilitate the achievement of this aim (1) examine the current recycling activities in the demolition sites that contribute to keep materials in loops, (2) explore the behavioral implications of the employees in the context of environmental sustainability, and (3) propose the development ideas for the recycling or upcycling activities.

2. METHODS

Very little research has been made on construction employees with respect to the CDW recycling development. Employees, workers on the demolition sites, are the actual implementors of the society level of regulations, business contracts, rules etc. and, at the same time, they should proceed well with the goals. Therefore, their roles as agents of the CE transformers in practice is valuable as well as feedback on development ideas and because of that their contribution should not be overlooked.

This study employs two qualitative methods for data collection and analysis, which include two parts, thematic interviews, and employee-to-employee observations. The methods were chosen to collect data to formulate a systemic exploration of major recycling activities on demolition sites and to find needs for the further development. It is supposed that empirical data could be used to add value and deepen the theoretical background.

Interviewing relies on an interactive method in which mutual learning occurs between those involved in the interview process. Interviews are flexible, allowing in-depth analysis from a relatively small sample size and place the focus of research on the views of participants. (Young et al. 2018, 11). In relation to the chosen topic, the semi-structured thematic interview was chosen that interviewees could be encouraged to speak freely about their opinions and experiences and not be guided too much.

Field observations are usually extremely difficult as observers need to overcome several barriers, including employers' resistance to perceived additional liabilities, employees' fear that their level of activity will be reported to managers and many other practical and technical difficulties.

The research of Yun & Shen (2011, 1) conclude that that survey and case study are major methods for data collection in CDW management research, and the data are mostly processed through descriptive analysis. In Finland case studies have been used in calculations of CDW amounts. In this research we ended up using something else than a case study and decided to use two complementary methods. And, as the multimethod approach enables data triangulation and can limit the bias associated with any one single method (Young et al. 2018, 17), the combination of two methods was assessed to be more reliable for the results and bring more new information.

2.1 Thematic Interviews

Data gathering begins with the identification of interviewees (Young et al. 2018, 11). The used sampling strategy was a key informant sampling. This follows from the fact that the interviews were targeted to key people that are knowledgeable about the issue as the course participant of the topic and as employees in the demolition fields. More precisely, the interviewees were 19 persons recently graduated from the universities of applied sciences and they worked during the interview time or maximum in past two years on demolition sites during the last. Their study backgrounds were from construction engineering (10), environmental engineering (7), and business administration (2). They all had participated during their studies Bachelor level course Demolition Waste Recycling (5 ECTS) before their graduation.

The timing of the interviews was April – May 2021 and June 2022. The interviews were recorded by the Teams virtual meeting program by the permission of each interviewee. The cameras were open during the session, which enabled good communication. The interviewees were from 6 different Finnish regions from the south and west part of the country. The length of interviews varied mainly between 30 to 45 minutes, 2 exceeded this time as the start was delayed because of the technical problems in use of Teams software or internet connection.

When defining and identifying the interview themes, the following ones were picked up in the interview strategy analysis and taken in the use:

1. General practical experience in demolitions industry and participated projects.
2. Description how the material collection and waste recycling is organized. Highlights and development needs.
3. Reasons behind the current situation, personal assessment.
4. Future perspectives of the CDW management development.

It was taken into the consideration that the purpose of the study was explorative, and the thematic questions should be issues that are familiar to the interviewees and essential for to the study subject.

In the following we give quotations as samples for each theme. The interviewees are numbered randomly as persons 1, 2, 3 etc.

General practical experience in demolitions industry and participated projects

P10: "If we could get rid of incineration of the wood waste, that would be good and for the nature and for the circular economy".

P11: "In demolition it is easy to see, that we should now remove all harmful construction materials in new buildings – less problems in the future".

Description how the material collection and waste recycling is organized. Highlights and development needs.

P5: "It is about the willingness to do thing in a different way. There is so much wood material among the mixed waste. I think we could easily reuse the wood e.g., in manufacturing smaller furniture like shelves in parts, wood boxes etc. And, of course, to reuse as repair materials."

Reasons behind the current situation, personal assessments

P 1: "The waste collection points, bins and containers have been placed here and there on many sites...that confuses and the right one is not necessarily found in a hurry. If the bins and containers are too full, that causes disorder as well. Sometimes they are not discharged and left for waiting too long time."

Future perspectives of the CDW profession

P4: "If the pre-demolition audit becomes compulsory, I think that the persons must be accredited specialists of asbestos and hazardous components...such a requirement."

P 7: "5G is coming, which speed up the data management. When users can manage the data by the web-based applications, the data is always available. This development, for sure, brings buzz for the field".

Remarkable amount of interview data included suggestions to tightening up regulation and rules and in general to have consequences of the possible irresponsibility. One interviewee did a calculation, which indicates the remarkable savings when demolitions materials are carefully sorted, and the amount of mixed waste is minimized. Another consideration is that the majority of the interviewees talked about the possibilities of digitalization, but that is not so much in focus in top administration of the employer companies – or not disseminated to the citizens and companies very efficiently from the administration.

As demolition project itself is run by the companies, the general development is much about the cost-effectiveness and new business opportunities. The private companies do not like any more to take the materials and waste to the regional municipal waste management companies, which they see as competitors. They rather want to develop new products for own business, which is a good sign for the circular economy development. Crushed concrete, one of the mineral waste sorts, is a good example, as each of the leading companies have a product name for their demolished and crushed concrete. Companies have also started to demonstrate their recyclability skills in their own office and warehouse buildings. In February 2022 it was opened a new waste treatment plant in Vantaa. The value of investment is 35 M€ and the capacity fulfills 1/3 of the waste handling need of the capital region. The handling capacity of the CDW will be 70% in the capital area, which is remarkable for the progress in the whole country. As interviewees were totally aware of the importance of the practices on-site, 7 of them saw some help in sorting by robots and AI-utilization.

Like mentioned, the demolition companies are actively developing new recyclable products. Still, the interviewees told, that it is not always about the money (it is done what is written in the contract), at least in some extent willingness to do in a new way and behind this unwillingness is lack of knowledge. This concerns many activities, like organizing waste collection points and their logistics. Orientation and familiarizing for new workers are not always systematic. As there is not yet enough knowledge, on every site there is not a recycling/sustainability specialist, who could guide the other properly and organize activities.

2.2 On-Site Observations

The observers of this study were 11 from the group of 19 interviewees. Their selection was done first by their own willingness, but also based on their possibility to do the observation itself. They wrote observation diaries

in May-July 2021 and 2022, depending on the work occupation schedule. The diaries were returned into the electronic platform's drop box, where they were accessible only for the researcher and the observer personally. Before the observation actions, the diary form was ready made and sent for the observers. It is recommended to use in observation research a diary, which can be submitted as form (Kananen 2014, 66-69), like shown in Table 2 below.

Table 2. Observation diary model (Kananen 2014, 69).

Time	Place	Situation	Persons and their roles	Activity	Description

In most of the cases, and the superiors and the employee colleagues were aware of the observation project on-sites, but in all cases the superior(s) were aware of that and authorized the activity. The notes were written as fresh as possible, but many times the observed issue required re-checking or asking from other the reasons behind or is the noticed issue new, continuing, once-off etc.

In data analysis it was possible to distinguished five idea types, which are listed in the Table 3 and their characteristics are described by examples. For each idea type categories were found 2-5 ideas.

Table 3. Characteristics of interviewees ideas based on-site observations

Idea type	Example	Amount by idea type
Need for legislation improvement	End of Waste (EoW) definition	3
Staff training	How to organize training especially for often changing employees and subcontractors	5
Connections with stakeholders	Active attitude, practices vary in different regions	2
New circular product	Horizontal utilization of materials between industries incl. composites	4
Best practice	How to organize work more efficiently in the process or in the demolition site	5

Sometimes the End-of-Waste (EoW) procedures and its definitions and interpretations might even cause the situation to be on the verge of **bankruptcy**. The cases are known among demolition professionals and that is why very rarely a company wants to be a forerunner. Demolition companies rather follow, which company takes the first step and then apply the similar idea by themselves, when the "product case is closed and working".

The need for staff training is also well known, but the characteristics of the industry has not yet enabled systematic approach in on-site project level. There are much sub-contracts, temporary employee agencies are in active use and every operator takes care of own training activities. There is also lack of workers in general and emerging lack of qualified workers.

Connections with stakeholders are developing and becoming diversified. This concerns especially public-private partnerships in cases when the municipalities and cities are main contractors. This have led to e.g. organizing seminars and training together. The demolition companies' contacts with the educational institutions have also become more intensive.

Like stated earlier, the new circular products are in the focus of the demolition industry. For the recycling and upcycling it is also to search horizontal utilization of materials between industries. Wood waste material needs urgent recycling solutions. Fortunately, some innovations have appearing like wood stone and products of wood fiber plastic composites.

There were notified many best practices, which might bring efficiency in the CDW on-site management. One observation was that if the temporary employees on sites would be trained to recognize waste fractions, the recycling rate 70 % would easily be achieved. Storing materials properly, new, or demolished ones, would prevent from entering in the waste stream and keeping at least the possibility for recycling.

3. RESULTS AND DISCUSSION

This section presents the key results of the study, how young professionals proceeded with the information and innovative ideas and how that could contribute to the development of CDW recycling. First, when it was examined the current recycling activities in the demolition sites that contribute to keep materials in loops, the gathered information indicates that managers seek more actively company partnerships, which work in reuse or recycling business. We also found that field workers had an impression, that recycling is in general steadily developing, but Finland looks like to be behind e.g., Sweden. This is based on the observations of two employees, who have worked and in Sweden and in Finland. In Sweden they did not see any bins or containers for mixed waste, but in Finland that is still a standard waste stream.

Second, the results are discussed in the context of the demolition company in the supply chain as it gives the framework for the sustainability implementation in the demolition project. The starting point of the demolition project is the procurement and the main contractor, who is in the top of the supply chain. The main contractor is either a private company or a public body, like city administration. The demolition project itself follows the accuracy in sorting how it is determined in the contract with the main contractor. Demolition companies, the next in order in the supply chain, have sub-contractors as well, which are consultants, laboratories, temporary employee agencies etc. Demolition companies must work according to the contract and budget. If there is a need to require more of their implementation, the main contractor must be ready for a bigger budget. However, there are simple things, what demolition company could do for the progress of CDW management. The most emerging on-site activity is the orientation training that every employee knows the CDW basics, starting from the recognition of waste fractions and person-in-charge of the site plans the material and waste logistics as carefully as possible with the notable markings on the bins and containers, also safeguarding enough often emptying of containers. And demolition companies can transfer these requirements for the own sub-contractors including **compliance with** the principle of sincere **cooperation**. Lastly, small and medium sized companies (SMEs) lack the resources to promote reuse of side streams, especially where essential actors are missing from the value chain. These are the most remarkable behavioral implications of the employees in the context of environmental sustainability, found in this research.

Third, even if employees on-site are not decision makers, and thus cannot implement own innovative ideas just like that, they also haven't seen – nearly at all – new initiatives or instructions coming from the top management. The most remarkable change has been the new Waste Act Regulation 2021, which added asphalt and mineral wool as well as bitumen and roofing felts among separately collectible waste fractions, which means that those streams have now own waste collection containers and spot, but not enable new ideas to flourish very much. The interviews or observations did not support the approach that employees would be proposed to suggest ideas for the recycling or upcycling activities.

The primary research question, what kind of information a self-initiated employee can bring from the CDW field work into the common CDW management development activities is found to be suitable from the research methods point of view. The observations and thematic interviews in the field are methods, brought the reality to the researcher's table and created new perspectives and generated more detailed information. To summarize, employees can bring information, which might look like minor or modest, like a suggestion that waste sorting instructions should also be visual and locate in coffee break premises, but if specialists in the field see this worth to try, would it be better to react from the management side as well? The costs would be minor, and it would be easy to put in practice. It looks like that objective, the need to increase CDW utilization rate consists of many projects specific practical barriers and lack of information.

4. CONCLUSIONS

The interviews and observations supported a high degree of common **situation awareness in the field work** and assessment that managers behave like let business as usual continue. A proposed development activities form a framework to evaluate and govern the overall sustainability potential of recycling activities.

In recent years, environmental problems caused by the CDW have become increasingly prominent. The share of the CDW in the total emissions is ca. 30%. That is why the Ministry of Environment has begun to pay attention to this industrial field and has launched tools and guidance and started to prepare new regulation. The new goal is to achieve 70 % utilization rate of the CDW by 2027.

The thematic interviews and demolition on-site observations provided an overview of various activities performed and what kind of obstacles and practices are currently in use. The interview analysis and observation reports delivered together insights into this fast-developing professional area of CDW recycling. To do more field work investigations, would also help in creation of new practices and policies.

ACKNOWLEDGEMENTS

I gratefully acknowledge the European Unit project Sustainable Horizons (GA 101071300), which has enabled the report writing. I also thank each interviewees-observers for their valuable time and contribution to the development of the circulation of demolished materials.

REFERENCES

- Conenor. 2022. Company website. Available at <http://www.conenor.com/>. Last accessed 2022/10/27.
- Dahlbo, H. & Bacher, J. & Lähtinen, K. & Jouttijärvi, T. & Suoheimo, P. & Mattila, T. & Sironen, S. & Myllymaa, T. & Saramäki, K. 2015. Construction and demolition waste management - A holistic evaluation of environmental performance. *Journal of Cleaner Production*. March 2015. DOI:10.1016/j.jclepro.2015.02.073
- Dodd, N., Donatello, S., & Cordella, M. 2020. Level(s) indicator 2.2: Construction and Demolition waste and materials User manual: overview, guidance and instructions (Publication version 1.) Available at https://environment.ec.europa.eu/topics/waste-and-recycling/construction-and-demolition-waste_en
- Ecoup.2022. Company website. Available at <https://ecoup.fi/en/>. Last accessed 2022/10/18.
- European Commission.2023. Construction and Demolition Waste. Available at https://environment.ec.europa.eu/topics/waste-and-recycling/construction-and-demolition-waste_en Last accessed 2023/04/07.
- European Commission. 2022. Waste Framework Directive. https://ec.europa.eu/environment/topics/waste-and-recycling/waste-framework-directive_en. Last accessed 2022/10/18.
- Ferriz-Papi, J. & Thomas, S. 2020. Aggregates from Construction and Demolition Waste in Production of Concrete Blocks. *Journal of Construction Materials*. October 2020.
- Finnish Environment Institute SYKE. 2021. Construction and Demolition Waste. Available at https://www.materiaalitikiertoon.fi/en-US/Monitoring/Construction_and_demolition_waste Last accessed 2022/10/18.
- Finnish Environment Institute SYKE. 2022. Finland's Waste Management in Figures. Available at (in Finnish) <https://issuu.com/suomenymparistokeskus/docs/valtsu-4.3-d>, Last accessed 2022/10/27.
- Häkkinen, T.& Kuittinen, M. & Vares, S. 2019. Plastics in buildings – A study of Finnish apartment buildings and day-care centre. Ministry of the Environment.
- Højbye, L. & Sand, H. 2018. Circular economy in the Nordic construction sector Identification and assessment of potential policy instruments that can accelerate a transition toward a circular economy. Nordic Council of Ministers. <http://dx.doi.org/10.6027/TN2018-517>.
- Kananen, J. 2014. Laadullinen tutkimus opinnäytetyönä. Miten kirjoitan kvalitatiiviseopinnäytetyön vaihe vaiheelta. Jyväskylän ammattikorkeakoulun julkaisuja. Suomen Yliopistopaino. Oy – Juvenes Print, 2014.
- Karppinen, T. 2021. Finnish Environment Institute SYKE. Description on the Calculation Method. Construction and Demolition Waste (C&DW) – Regional Amounts and National Recycling Rate Excluding Land Masses.
- Kojo, R., Lilja, R., 2011. Talonrakentamisen materiaalitehokkuuden edistäminen (Removing the barriers to material efficiency in housing construction). Reports of the Ministry of the Environment 21/2011. Available at <https://helda.helsinki.fi/handle/10138/41495>. Last accessed 2022/10/27.
- Ministry of Environment of Finland. 2022. Circular economy in the construction sector. <https://ym.fi/en/circular-economy-in-the-construction-sector>. Last accessed 2022/10/27.
- Official Statistics of Finland (OSF). 2019. Waste statistics. Helsinki. Statistics Finland. Available at http://www.stat.fi/til/jate/2019/jate_2019_2021-06-16_tie_001_en.html. Last accessed 2022/10/27.
- Official Statistics of Finland. (OSF). 2021. Waste Statistics. Statistics Finland. Available https://pxweb2.stat.fi/PxWeb/pxweb/en/StatFin/StatFin__jate/statfin_jate_pxt_12qw.px/table/tableViewLayout1/ Last accessed 2022/10/16

- Peuranen, E. & Hakaste, H. 2014. Rakentamisen materiaalitehokkuuden edistämishjelma. Ramate-työryhmän loppuraportti. Reports of Ministry of Environment. 17/2014. Available at https://julkaisut.valtioneuvosto.fi/bitstream/handle/10138/135172/YMra_17_%202014.pdf?sequence=1&isAllowed=y Last accessed 2022/10/28.
- Sitoumus2050. Green Deal on Sustainable Building in Finland. https://sitoumus2050.fi/fi_FI/kestavapurkaminen/ Last accessed 2022/10/27.
- Sitra. Finnish road map to a circular economy 2016-2025. <https://www.sitra.fi/en/projects/leading-the-cycle-finnish-road-map-to-a-circular-economy-2016-2025> Last accessed 2022/10/16.
- Tam, V. W.-Y. & Lu, W. 2016. Construction Waste Management Profiles, Practices, and Performance: A Cross-Jurisdictional Analysis in Four Countries. *Sustainability*; Volume 8, Issue 2. <https://www.mdpi.com/2071-1050/8/2/190>
- Young, J.C., Rose, D.C., Mumby, H.S. et al. 2018. A methodological guide to using and reporting on interviews in conservation science research. *Methods Ecol Evol.* 2018; 9: 10–19. <https://doi.org/10.1111/2041-210X.12828>
- Yuan H. & Shen L. Trend of the research on construction and demolition waste management. *Waste Management.* 2011 April ;31(4):670-9. DOI: 10.1016/j.wasman.2010.10.030
- Zhang C., Hu M., Di Maio F., Sprecher B., Yang X., Tukker A. 2022. An overview of the waste hierarchy framework for analyzing the circularity in construction and demolition waste management in Europe, *Science of The Total Environment*, Volume 803, 2022. DOI: <https://doi.org/10.1016/j.scitotenv.2021.149892>