CONSTRUCTION INDUSTRIES WASTE CIRCULATION PROBLEMS IN LATVIA

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Abstract. Construction is crucial for the development of a country, it affects both individuals and the whole society's life, as well as the environment. As construction is so crucial, it must be done as environmentally friendly as possible. During construction processes, a large amount of waste is produced. Incorrect management of this waste degrades our environment. Disposal of construction waste is a very popular way, but it is not a very environmentally friendly way of managing this waste. Interviews and surveys have been conducted in the study to investigate the opinion of construction participants about construction waste in Latvia. The research uses the theoretical research method, survey, interviewing, and data processing methods. Construction waste can be recycled. In construction in Latvia, legal requirements are observed, and construction waste is mostly handed over to processing companies, where a part is sorted. The processing and reuse of construction waste are relatively small. The construction waste sector in Latvia is regulated, but not sufficiently monitored, allowing a grey area to form. Sorting of construction waste at construction sites in Latvia practically does not take place, part of the waste is sorted in landfills. There is not enough research on the possibilities of recycling construction waste. Construction participants are not interested in starting construction waste sorting and recycling with their own initiative. In the procurement of municipalities and state institutions, construction waste sorting should be included as a mandatory requirement.

Keywords: CDW, construction materials, sustainability.

Introduction

Increasing attention is paid to the problems of waste management since 1975 in the European Union when the problems of global warming became increasingly relevant, this is evidenced by the legislative acts adopted by EU [1-12].

According to the principles of the circular economy [13-14], construction waste can be sorted, buried, and recycled, extending its life cycle. It is the circular economy that emphasizes the importance of the principles of reuse and recycling, rather than the extraction of natural resources. This means that previously used materials must be recovered and reused in different ways, thus protecting natural resources from overuse. In turn, this requires the development of innovative technologies that allow the recovery of valuable materials.

More than ever, the new sustainability transition has exacerbated the need for companies and their supply chains to rethink their investment in three important values – environmental, social, and economic - the so-called triple bottom line.

All modern building material production plants are practically based on zero-residue technology. In the past, every plant that produced concrete or aerated concrete had piles of materials that were redundant or illiquid and were either simply piled up or sold, and these were even more in demand than new materials because they were cheaper. Today, practically all modern technologies are such that everything that remains is reused, either in the production of the same or a different material.

When it comes to the recycling of construction debris that is generated, for example, from the demolition of buildings, the biggest problem is that any waste generated would need to be separated into components. By sorting construction waste separately into glass, metal, wood, plastic, concrete chips, and similar fractions, each of them can be reused in the production of building materials.

The greatest difficulty in the processing of construction debris comes from the chemicals used in construction, which are difficult, if not impossible, to separate and which can have the greatest impact on nature and people. The most difficult cases are when to deal with unsorted piles of construction debris.

Materials and methods

This study presents an analysis of the development of the waste hierarchy, how EU is using it to support CDW management in Europe and Latvia. Excavated soil is not included in this study. The

methods used in this study include literature reviews, surveys, and respondent interviews. The analytical structure and material sources of this study are described below.

European waste hierarchy system

The largest consumer of resources and generators of waste in Europe is the construction industry. Following the initiative of the European Union (EU), the construction industry must move from the traditional linear resource and waste management system to a high level of circulation. In accordance with the circular economy theory, a new paradigm - the waste hierarchy - was introduced in the EU Waste Framework Directive.

The authors [20-24] have researched the waste hierarchy system and analyzed European construction and demolition waste (CDW) management practices. The development of the waste hierarchy in Europe and its comparison with the circular economy was also discussed.

Based on the petition, the performance of CDW management in EU member states was analyzed. Innovative treatment methods for CDW are investigated, focusing on concrete waste. It provides insight into the optimization and improvement of CDW management considering advanced technologies and guides the EU's transition to a circular society.

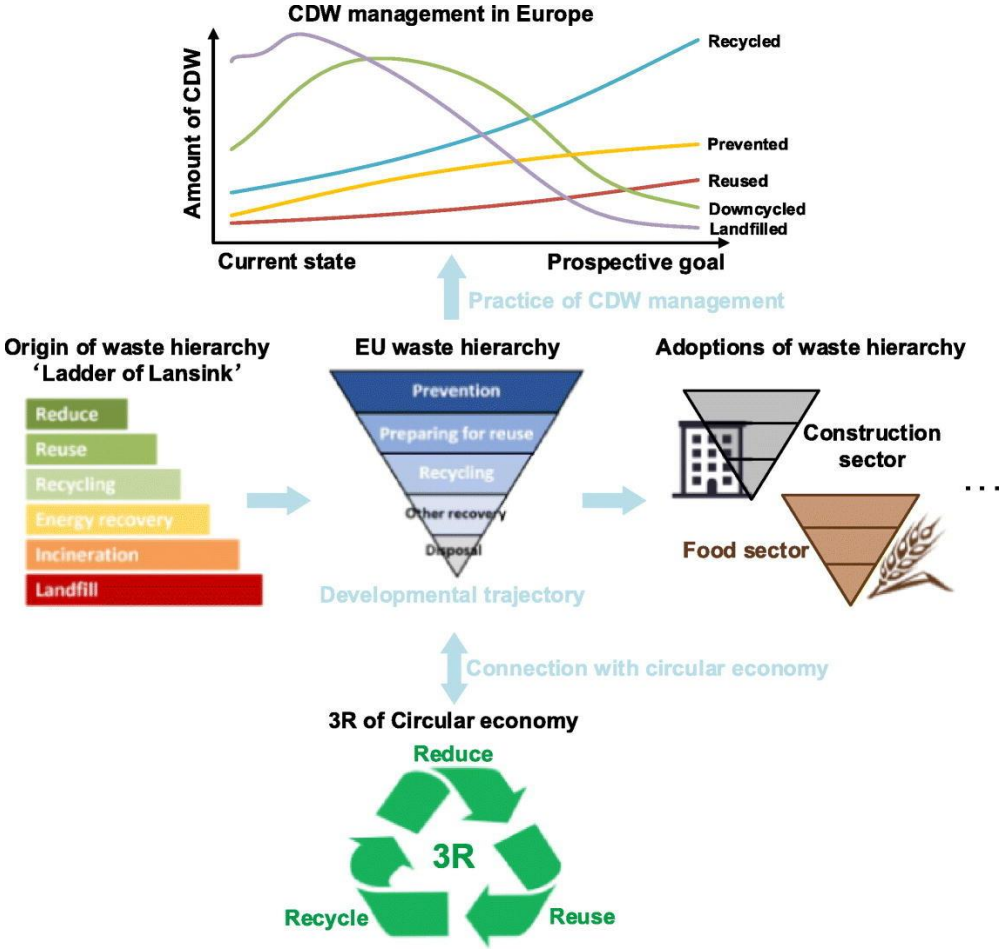

Fig. 1. **Waste hierarchy system and European construction and demolition waste (CDW) management practice [23]**

Raw material consumption (RMC) in Europe [15-20]

Raw material consumption (RMC) or material footprint represents the global demand for the extraction of materials (e.g. minerals, metal ores, biomass, fossil energy materials) caused by the consumption of goods and services in a given area, thus RMC shows the amount of extraction needed to produce goods demanded by end users.

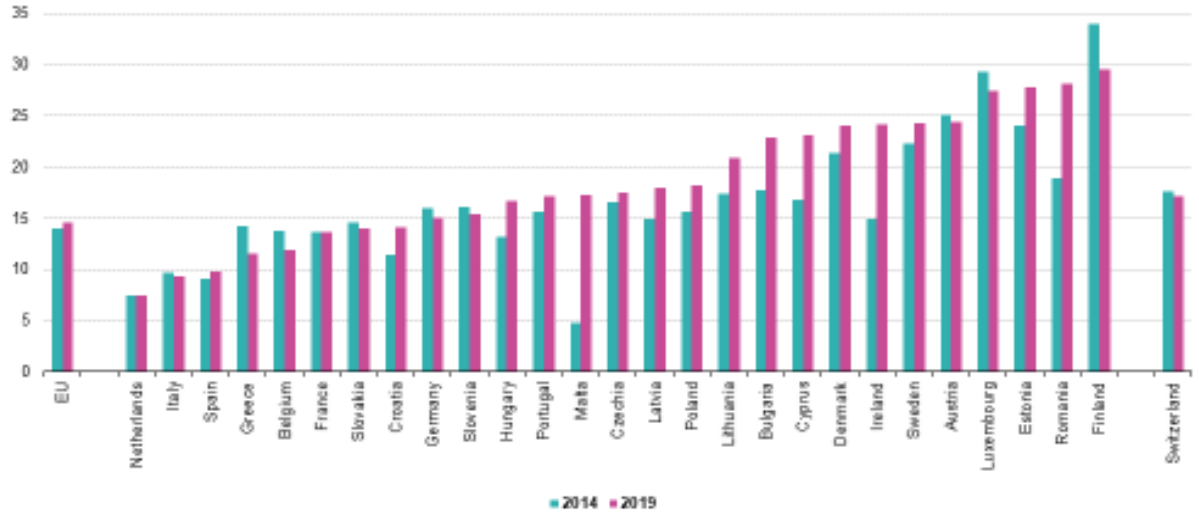

Fig. 2. **Raw material consumption (RMC), by country, 2014 and 2019 (tonnes per inhabitant, source: Eurostat)**

From Fig. 2 we see that the consumption of raw materials by country in 2019 compared to 2014 has increased throughout the European Union and in Latvia.

The circular material utilization rate (CMU) means the share of material recovered and returned to the economy in total material use. CMU is the ratio of circular material use to total material use. Total material use is measured by summing total household material consumption (DMC) and circular use of materials (1).

$$DCM + CMU = TMU, \quad (1)$$

where TMU – total material use, tonnes per inhabitant;
DCM – total household material consumption (DMC), tonnes per inhabitant;
CMU – circular use of materials, tonnes per inhabitant.

DMC is defined in economy-wide material flow accounts. The circular use of materials is roughly calculated by considering the amount of waste processed in local recovery plants, minus the imported waste for recovery plus the exported waste for recovery abroad. A higher CMU rate value means that primary raw materials are replaced by more secondary materials, thus reducing the environmental impact of primary material extraction.

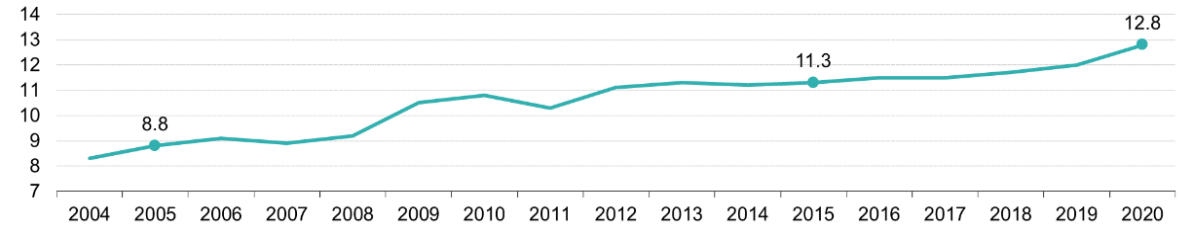

Fig. 3. **Circular material use rate, EU, 2004-2020 (% of material input for domestic use, source: Eurostat)**

According to the information shown in Figure 3, we can see that the level of use of circular materials (CMU) in the European Union has significantly increased from 8.8% in 2004 to 12.8% in 2020.

The rate of circular material used by the country, in 2015 and 2020 (% of the material used for domestic use) can be seen in Figure 3. The Netherlands, Belgium, France, Italy, and Estonia have advanced to the leading positions.

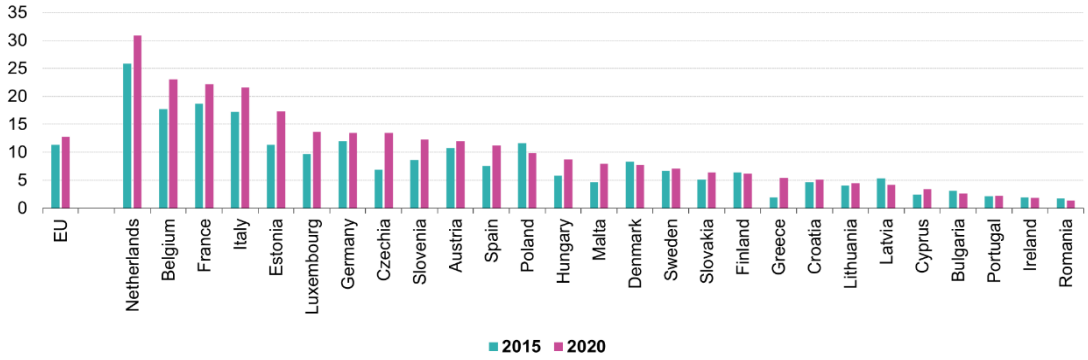

Fig. 3. **Circular material use rate, by country, 2015 and 2020 (% of material input for domestic use, source: Eurostat)**

Results and discussion

The construction industry plays an important role in the national economy of Latvia - its share in terms of added value reaches 5.9%; it occupies 6.4% of the total number of jobs; its contribution to the Latvian budget is 2.3% of all tax revenues. The regulatory base of the construction industry consists of several laws and regulations of the Cabinet of Ministers, according to the construction process, starting with general regulatory enactments, planning – design preparation – design – construction work – special construction regulations – operation, and other binding regulatory enactments and applicable standards. At each of these stages, waste is generated, which, if sorted wisely and economically, could be passed on to further circulation. Until now, the construction process of households and the private sector and the waste flow generated in it have not been sufficiently studied in Latvia.

In a circular economy, waste is not waste, but valuable resources that can be recycled into new products. In the construction process, the recycling of construction waste instead of disposal is considered a positive mark in obtaining the BREEAM certificate. In Table 1 we can see a summary of recycled materials and manufacturers (good examples) [26-31].

Table 1

Summary of recycled materials and manufacturers (good examples)

Enterprise	Construction waste type	Recycled material
Rockwool	Rock wool scraps	New rock wool production
Lafarge Holcim	Construction debris	Aggregate for concrete
Saint-Gobain	Glass wool scraps and plasterboard scraps	New glass wool production and new plasterboard sheets
Greenmax	Styrofoam sheet scraps	New styrofoam thermal insulation sheets
Knauf UK	Plasterboard scraps	New plasterboard sheet

From interviews with industry specialists in Latvia, several manufacturers can be mentioned as good examples, such as the “Schwenk Latvija” factory, which uses ash in the production of cement, and the “Sakret” practice of using recycled window glass in building finishing materials. There are several factories where all scraps are collected and used in the production of new products, such as “Tenax”, “Bauroc”, “Evopipes” and other factories. However, since the Soviet times, outdated production plants have also continued to operate in Latvia, which try to save money at the expense of construction debris utilization and try to dispose of their production residues somewhere, thus undermining the overall competition in the industry [38].

As part of the research of the Department of Architecture and Building of the Latvian University of Life Sciences and Technologies [25], a survey was conducted in the months of February and March 2023, with the aim of finding out the opinion of persons involved in construction on the possibilities of sorting and recycling construction waste in Latvia. A total of 98 persons related to the construction industry participated. Out of the total number of respondents, 40,81% persons are engaged in

construction, 22.45% persons represent the design industry, 11.22% persons are customers of construction objects or representatives of customers, and the remaining 25.51% are private individuals who have had contact with construction.

Regarding the open question about the use of concrete with crushed construction debris fillers, most respondents answered positively that they would be ready to use it, but with conditions.

Table 2

Respondent answers to the question "Would you use concrete with crushed recycled mineral materials in construction?"

No.	Answers to the question
Positive answers	
1	Yes, already in use.
2	Yes, if you provide all the requirements and the carrying capacity.
3	Yes, if it was proven that it does not deteriorate the quality of the concrete; also, if the quality were lower, I would gladly use it. The main thing is to have defined/declared/measurable characteristics.
4	In accordance with the quality requirements of the recovered material.
5	If construction products of this type have been properly tested and certified, then yes – recovered materials.
6	Should be used where appropriate. For example, in load–bearing structures, which are then filled in or finished.
7	I think so – because concrete fillers can be different (crushed bricks, pre–built, and crushed concrete) – in my opinion, such fillers would not reduce the strength of concrete.
8	For roads, squares.
9	Yes, if it reduces costs and does not change the quality of construction products.
10	Yes, if it is possible to prove that the strength of the concrete meets the requirements of the construction project.
11	Yes, with proper documentation and if it would reduce construction costs.
12	Yes, if these materials reduce costs but produce an equivalent material.
13	Yes, if it would reduce the amount of waste and improve the quality of the environment.
14	Yes, if the price and quality meet the requirements.
15	Depends on the content of the materials.
16	Yes, if the manufacturer of this concrete will give a quality guarantee and be responsible for it.
17	Yes, it would be used, but it depends on what constructions – it could be used in foundations and walls. Covers must have dolomite chips.
18	Dismantled concrete elements, asphalt, and road surface construction layers (sand, crushed stone mixtures) are not construction waste! These are the recycled (recovered) mineral materials, which are used more and more widely (after appropriate processing – crushing, and screening) in accordance with the requirements of the Road Specifications 2017, 2019, and 2023… In a few years (in the next Road Specifications) there will be a requirement for priority reuse of recyclable materials.
19	Regarding concrete with recycled fillers – everything depends on the regulatory framework (if it will be as in the road specifications – then ok, if not, then no).
Negative answers	
1	No, because project requirements and standards do not allow it.
2	The use depends on the solutions of the construction project and the position of the construction supervisor.
3	No, not applicable to our production technology.
4	No, because we are worried about whether the final product will be of high quality.
5	No, we do not see the need.

Table 2 (continued)

6	No, the material might not have the same strength and durability. It should be tested and then you could think about using it.
7	Not until it is determined by LVS or other regulatory acts.
8	Depends on the content of the materials.
9	We do not use it, usually, such materials are not allowed to be used in objects.

Regarding the open question about polystyrene granules, which are produced by processing different types of polystyrene foam waste, most respondents answer positively that they would like to use them.

The European Parliament has decided that all new buildings must be climate neutral from 2028 and has determined measures to reduce energy bills and fight climate change.

In the European Union, 36% of greenhouse gas emissions come from buildings.

The European Parliament adopted measures that will increase the pace of building renovation and help reduce energy consumption and greenhouse gas emissions.

The aim of the proposed amendments to the Energy Performance of Buildings Directive is to significantly reduce greenhouse gas (GHG) emissions and energy consumption in the EU construction sector by 2030 and to make this sector climate neutral by 2050. These regulations are intended to increase the pace of building renovation and improve the exchange of information on energy efficiency.

This means that the production of insulation materials will increase, which is closely related to the need to reuse materials.

Table 3

Respondent answers to the question "Would you use stone wool in construction, which is produced by processing different types of stone wool surpluses?"

No.	Answers to the question
Positive answers	
1	Yes, already in use.
2	Yes, if it was proven not to degrade quality, even if the quality were lower. The main thing is to have defined/declared/measurable characteristics.
3	Would be used if required by the project and standard.
4	If construction products of this type have been properly tested and certified, then yes - recovered materials.
5	Yes. This would lower the disposal of construction debris and the price of the material.
6	Yes, because there is no risk of collapse.
7	It would be used; it could be used as bulk wool in a cold-type attic. It should be seen whether thermal conductivity can be ensured.
8	Yes, if it retains its thermal properties.
9	As far as I know, cotton wool blown from cotton scraps is already being used. Yes, I would use it.
10	If it was cheaper.
11	Yes, cotton wool is cotton wool, and it will probably not lose its properties.
12	Yes, if it would help reduce waste and reuse resources.
13	Yes, if it reduces costs and does not change the quality of construction products.
14	Yes, in principle it is loose cotton, which is already used in some cases.
15	Yes, if the building regulations allow it.
16	Yes, with appropriate documentation and if it would reduce the cost of construction.
17	Yes, if these materials reduce costs but produce an equivalent material.
18	Yes, if all properties are preserved.
19	Yes, used as bulk thermal insulation material.

Table 3 (continued)

Negative answers	
1	No application in the construction process.
2	I am not competent to answer this question...
3	The use depends on the solutions of the construction project and the position of the construction supervisor.
4	No, not applicable to our production technology.
5	I have not been interested.
6	Unlikely.
7	Yes, it would improve nature and reduce waste.
8	We do not use such materials that are not available on the Latvian market. This is a problem because cotton wool waste is not ground up to be used for roofing insulation but is mostly sent as waste to landfills.
9	No, I would not use it.

There are many scientific studies in the field of construction waste recycling and the application of new construction materials/products. Some of them are:

1. Recycling of unseparated construction and demolition waste (UCDW) through geopolymer technology [32].
2. Review of construction and demolition waste management in China and the USA [33].
3. Upcycling of construction waste powder for sustainable ultra-high performance engineered cementitious composites: Effects of waste powder source and content [34].
4. Washed recycled sand derived from construction and demolition wastes as engineering fill materials [35].
5. Construction waste used in new construction products [36].

As mentioned by the executive director of the Association of Building Material Manufacturers, Leonids Jakobsons [38], two aspects of why construction debris processing is not developing as fast as it would be desired: First, there is a lack of raw materials suitable for processing in Latvia, which could ensure enough workload for the factories, and, secondly, any production process that uses secondary raw materials is more expensive than if they are already taken as ready raw materials.

Latvia should cooperate with manufacturers of neighboring countries because there is strong competition in the building material market. Often, the amount that each plant can produce is greater than the demand for them, so no plant is operating at full capacity. The issue of the possibility of potential construction waste sorting factories importing raw materials from neighboring countries is debatable because imports would make recycling more expensive. To promote the recycling of construction debris, state support is necessary, which would allow providing relief to bona fide builders.

Significant work should be done in raising public awareness of the circular economy, green living, and the use of secondary materials in places where it is possible.

Conclusions

1. Based on the survey, the Latvian construction industry is ready to consider using recycled materials in future construction projects if there is enough research made to prove that recycled materials can meet the requirements and specifications of standard materials.
2. Adjusted laws and standards would help use materials from construction waste more widely. For example, the specifications of the Latvian National Roads also mention the LVS standards by which compliance with each recycled material is measured [37].
3. Construction industry is not ready to use recycled materials for bearing constructions such as beams, columns, and others as they are essential for the overall strength and longevity of buildings.
4. 33,33% of the surveyed respondents believe that the price of materials and the inclusion of recycled materials in construction projects could promote the use of construction materials produced from recycled construction waste in construction projects, and 21,4% of respondents state that legislation would be a contributing factor, 15.3% of respondents state that the availability of such materials would also promote their use, 1% of the respondent pointed out that such materials should not

hinder the progress of construction works, but rather make the project cheaper and reduce the impact on the surrounding environment.

5. The respondent survey data and expert opinions [38], clearly indicate the weak points in the circulation of recycled and reusable materials - gaps in the legislation, lack of standards, lack of funding for the research of new materials, and lack of knowledge about circular economy and sustainability.

Acknowledgments

There are already some companies that are using recycled materials for construction such as recycled mineral wools for ceiling insulation and recycled mineral materials for concrete.

Author contributions

Conceptualization, S.G.; methodology, S.G., M.P., and K.G..; software, K.G.I.; validation, M.P., and S.G.; formal analysis, S.G., K.G.; investigation, S.G., K.G., M.P.; data collection, S.G., K.G., M.P; writing – preparation of the original draft, S.G.; writing - K.G., M.P., revision and editing, S.G., M.P.; visualization, K.G.; p All authors have read and agreed to the published version of the manuscript.

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