


<https://doi.org/10.21272/mmi.2020.3-17>

JEL Classification: L74, Q53, Q55, M11, O32

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INNOVATIONS IN CONSTRUCTION WASTE MANAGEMENT: CASE OF LATVIA

Abstract. *The environmental concern has become the top trend nowadays and the ideas of environmental protection, green orientation and green innovation, highly concern from the last few decades in all research areas. The construction industry is one of those that has a very strong impact on the environment. Air, water, noise and vibration, as well as soil pollution caused during construction processes, negatively impact on the environment and its natural ecosystems, as well as on humans at a global level. Construction waste generated during the construction, renovation and demolition process occupies huge landfills due to significant volumes. It may also contain substances that are hazardous to the environment and human health. This paper summarizes the research results on the possibilities for more efficient construction waste management as well as the experience of companies operating in the construction sector with a purpose to reduce the causes of pollution. The data obtained within the framework of the survey on people's understanding in the field of construction pollution and waste in Latvia have been analyzed. The main goal of the study is to present the main findings of the authors' survey and to discuss the current construction waste management challenges and potential innovations in Latvia. The authors used the following research methods: literature review, analysis of statistical data; questionnaire creation and conduction a survey; interviews with waste management companies. The research was conducted during the period from October 2019 to July 2020. The obtained results showed that there was a huge potential for innovation because the current situation was far from ideal. The results of an empirical analysis demonstrated that the collection of sorted construction waste on construction sites currently was practically impossible, as the industry points to the human factor in the waste sorting process. Although the data obtained within the framework of the survey clearly indicated the interest of employees in sorting construction waste already on the construction site, waste industry companies currently consider such a practice impossible also due to the influence of other side factors related to economic considerations. It is necessary to develop a normative framework for the implementation of the construction waste certification system to promote the reuse of construction waste in construction as efficiently as possible.*

Keywords: construction waste, management of technological innovation, environmental management, Latvia, sustainable development.

Introduction. Human development in recent centuries has been characterized by the exponential growth in population, production and consumption, and the globalization of several processes, which also increases the need for new infrastructure and housing.

Improperly managed waste is harmful to humans from the point of view of labour protection and causes

significant environmental pollution. The goal of a sustainable society is to manage waste in a way that minimizes the potential for pollution. Adherence to proper occupational safety and health requirements protects workers from harm and raises awareness of pollution and how to reduce it. The more people understand, the better the environment and working conditions. Construction will always exist as a sector of the economy. Therefore the circulation of polluting emissions - waste - is a topical issue at the level of employees involved in construction, society and the state. The process of waste management in construction is especially relevant, as the construction sector generates the largest percentage of waste in Europe, i.e. 34.8% (Eurostat, 2016).

The purpose of the research is to present the main findings of the authors' survey and to discuss the current construction waste management challenges and potential innovations in Latvia.

The article includes four parts: 1) literature review, 2) methodology and research methods, 3) results and 4) conclusions. In the literature review, the authors summarize the findings of different studies on construction waste, waste management and environmental pollution and protection in the construction industry worldwide and Latvia. The second part describes the main research methods of the authors' questionnaire survey. In the results part, the authors present and discuss the main findings of the questionnaire survey focused on the current situation and knowledge of employees in Latvian construction company associated with construction waste management. Conclusions summarize the main findings of the research and include some recommendations for better practice.

Literature Review. Construction activities are mainly associated with risks of air, water, soil, noise and vibration pollution (Norulaini et al., 2014). Air, water, noise and vibration, as well as soil pollution caused during construction processes negatively impact on the environment and its natural ecosystems, as well as on humans at a global level (Tah and Abanda, 2011). According to Jain et al. (2016) research, 23% of air pollution, 40% of drinking water pollution and 50% of global waste are generated by the construction sector. The impacts of the construction sector also contribute significantly to global warming, which causes global climate change. Construction waste is defined as waste generated as a result of construction, renovation and demolition of buildings, as well as leftovers and damaged materials generated during the construction process or materials used temporarily on the construction site.

Construction waste mainly consists of wood and metal residues, concrete debris, boards, asphalt, slate, roofing materials, gypsum panels and other inert materials generated during the construction, renovation and demolition process (Zvirbule, 2016). However, construction waste may also contain substances that are hazardous to the environment and human health (e.g. chemicals). Properly disposed of, they cause soil and subsoil contamination. After that, groundwater could be polluted as a result of precipitation (Zvirbule, 2016). Besides, statistics show that construction waste occupies huge landfills due to significant volumes and that the construction sector generates the highest percentage of waste in Europe. For a comprehensive understanding and identifying the impact of construction on the environment, it is necessary to analyze the entire life cycle of a construction, from its creation to demolition (see Figure 1).

Figure 1 can see that, in general, a building has an impact on the environment at all stages of its life cycle, not just during the construction phase. It can also be concluded that natural resources, energy and other raw materials are consumed at all stages of the construction life cycle, the consumption of which has an impact on the environment and including various types of pollution. The greatest impact on the environment (including pollution) is generated during the site preparation, construction and demolition phases. It is also noted that construction can have both direct (polluting emissions, degradation of ecosystems) and indirect (extraction of natural resources, production of used raw materials for construction) environmental impacts. The main sources of pollution during the construction life cycle are harmful gases, noise, dust, chemicals, various types of solid and liquid waste, which cause air, water, noise and vibration, as well as soil and soil pollution, respectively (Couto and Mendonca, 2011).

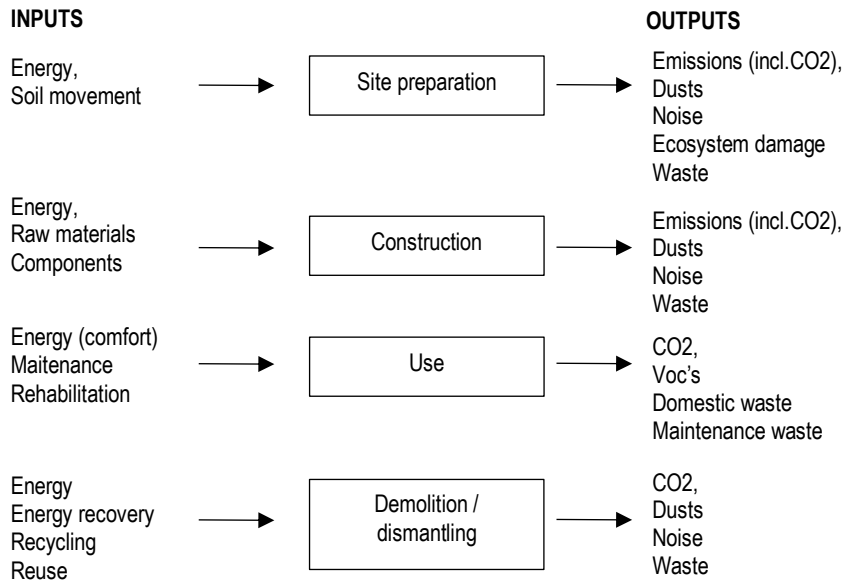


Figure 1. Environmental impacts of construction in its life cycle

Source: developed by the authors based on (Couto and Mendonca, 2011).

For applying pollution abatement techniques and solutions, it is important to assess and plan the amount and hazard of pollutant emissions during construction. Studies show that predicting emissions is complex enough because there are not enough reliable modelling programs and guidelines available to predict them. Several studies emphasize the importance of determining direct emissions from the use of construction equipment and transport (gas, dust, chemicals) (Sandanyke et al., 2016 a,b), while others emphasize the importance of determining indirect emissions from, for example, the production and extraction of construction raw materials. (Yan et al., 2010). Studies show that simply reducing direct emissions or using recycled raw materials at the project level will not reduce pollution sufficiently (Mao et al., 2013). For adequate assessing the causes and extent of pollution and accordingly develop solutions to reduce it, the implementers of any construction project must first carry out in-depth research and planning. In-depth research carefully analyzes the pollution model during the construction process to gain a full understanding of the practical solutions and technologies to be used to reduce pollutant emissions (Mao et al., 2013). Activity research helps to identify pollution emissions, while in-depth analysis helps to reduce pollution (Sandanyke et al., 2016). Following the summarization of literature, it could be stated that waste is considered to be one of the largest pollutant emission streams in construction. The significant environmental impact of existing construction projects necessitates the development of new technologies and innovations for the further implementation of the construction process (e.g. optimization of material recycling, reduction of energy consumption on-site and reduction of waste) (Yusof et al., 2016; Fuentres et al., 2013). Holman (2017) concluded that it would be much more profitable and effective to practically reduce the amount of waste at the initial stage of generation. Many authors note that environmental management systems are very effective in reducing the environmental pollution in the construction industry (Selih, 2007; Tambovceva, 2010; Tambovceva and Geipele, 2011; Campos et al., 2016). Following Section 4, Paragraphs one and two of the Waste Management Law, in Latvia, waste

management is performed without endangering human life and health. At the same time, Waste management may not adversely affect the environment, for example:

- 1) pose a danger to water, air, soil, as well as plants and animals,
- 2) cause annoying noises and odours,
- 3) adversely affect landscapes and specially protected nature territories
- 4) to pollute and litter the environment (Waste Management Law, 2010).

In some regions of Europe and the United States, where there are insufficient natural resources for the production of concrete, the recycling of construction debris began as early as the early 1970s. Also, the insufficient number of landfills, the growing awareness of the seriousness of pollution and construction debris as a potential resource in the 1980s led to the opening of several sorting and recycling plants. Today, the recycling of construction waste is considered to be the most environmentally friendly solution, followed by disposal and incineration. However, in most European countries, the field of construction waste recycling is relatively new, dating back only to the 1990s (Ulubeyli et al., 2017).

Green innovations (GI) defined as «hardware and software innovation that is related to green products or process, through energy-saving, pollution-prevention, waste recycling, green product designs, and corporate environmental management» (Chen et al., 2006). GI can be classified into Green Product Innovation (GPDI) and Green Technology Innovation (GPSI).

GPDI defined as «the innovation that is related to environmental innovation, including innovation in the products that are involved with energy-saving, pollution prevention, waste recycling, no toxicity, and designing green products» (Chen and Lui, 2018; Chen and Chang, 2013; Chen et al., 2006). GPDI is always about the development of new products, so an organization must select materials that cause the least pollution, use the least amount of material in the product, and take care of the ability to recycle, reuse and disassemble the product. This group of innovations may be applicable to new construction materials and products development. But it is not connected with the aim of this research.

GPSI defined as «innovation is the process that relates to energy saving, pollution prevention, waste recycling, and no toxicity» (Chen and Lui, 2018; Chen and Chang, 2013; Chen et al., 2006). The GPSI measurements also consist of three elements. The first is, the manufacturing process effectively decreases the emission of hazardous substances or waste. The second is, the manufacturing process reduces the use of water, electricity, coal, and oil. The third is, the manufacturing process decreases the consumption of raw materials (Alhadid and Abu Rumman, 2014; Guoyou et al., 2013). The use of existing resources for the recombination process or recycling process means to reduce the level of waste. The reduction of waste or efficiently utilize resources reduces the adverse effect on the environment during the production process.

For effective managing the waste generated during the construction process and, accordingly, to prevent environmental pollution, a number of measures must be applied under the waste management hierarchy:

- 1) waste planning;
- 2) waste sorting and recycling;
- 3) waste storage;
- 4) waste collection and disposal.

Within the framework of waste planning, it is important to assess the type of waste generated on the construction site and the amount of each type of waste generated. It would allow identifying nearby waste managers who would be able to manage such types of construction waste to provide sufficient collection and sorting facilities, the appropriate staff training for proper waste sorting. In turn, the appropriate waste collection and transfer times for waste managers should also be planned and reporting forms and procedures developed (Cox, 2016).

Construction waste can be not only disposed of in a landfill but also sorted and used to produce new products. Sorting can be done both on-site and handed over to a suitable waste manager for sorting, which facilitates the process for the builder (Holman, 2017). In the context of waste sorting, it is important to separate hazardous waste from non-hazardous waste, to sort non-hazardous waste by type, and never to mix recyclable or reusable waste with food waste. Waste bins for each type of waste must also be provided on-site. Containers must be of a suitable size to accommodate different sizes of waste. The amount of waste to be sorted must be reduced already at the construction site, for example, by reducing the amount of concrete to be prepared to avoid residues. It is also possible to reduce the amount of metal scrap by ordering bars of the required size from the supplier. It is possible to ask manufacturers to reduce the amount of packaging for durable construction materials (Cox, 2016). One solution to improve waste management on-site would be to develop specific waste management guidelines or specific waste management plans directly at the waste site, i.e. construction site. However, each situation on the construction site must be assessed individually - the size of the construction site, the availability of the green area, population density, etc. Before deciding on appropriate waste management on a construction site, the builder must consider economic, environmental, social and health factors and risks. Permits or licenses may be required in some cases (European Commission, 2016). Many documents provide specific, best practice advice or description of activities to help with the prevention and reduction of waste as well as recycling of materials on construction sites (Resource Efficient Scotland, n.a.; Walga, n.a.; RecycleCoach, 2016). In general, it must be admitted that waste sorting and recycling in Latvia is still poorly developed, and currently, the biggest problem in the country is construction debris, including both its accounting and the relevant regulatory framework. For example, in Estonia, 1.2 million tons of construction waste was collected in 2012, while in Latvia several times less. By 2020, Latvia had a goal to recycle 75% of construction waste (Graudins, 2014). Given the above, to reduce the pollution caused by construction waste, it is important to monitor waste flows and manage construction waste within the construction site. At the same time, it can be stated that waste management within the construction site is possible. For example, at the study site in Brazil, waste streams were initially identified and managed on-site. The results showed that 83.7% of all waste generated was reused or recycled (Rothbucher and Bastos, 2017).

Methodology and research methods. When evaluating equivalent studies (Geetha and Ambika, 2015; Li and Wang, 2016) in the field of construction waste, the following methods were chosen to achieve the goal of the study:

1. Analysis of Statistical data.
2. Questionnaire creation and conduction a survey.
3. Interviews with waste management companies, including construction waste management companies personal.

Statistical data are available in Latvia and Europe, however, official statistics are always outdated, in Latvia available with a lag of 1.5-2 years, but in Europe even more. Nevertheless, the overall trend can be traced.

The method chosen to achieve the research goal is a survey. The chosen method is suitable for both qualitative and quantitative research. With the help of a survey, it is possible to gather a large amount of information in a relatively short time. The results obtained at the same time can be analyzed relatively more objectively in comparison with the results obtained in other studies (Ponto, 2015). The most commonly used data collection methods in the survey - questionnaires, as well as interviews (Quinlan, 2011).

The survey was conducted within the framework of the study from March to April 2019. Following the authors' possibilities, the survey was conducted within the framework of the «new project» or construction of multi-storey apartment buildings. The intensity of land built-up plot in such buildings is lower because

the project is required in combination with parking in the area. Thus, such projects have relatively few space constraints during construction. It means that there is enough free space available for construction waste containers in the construction site area, which would not be possible in a dense construction area with minimal free space for construction work.

According to the literature, the sample population is the minimum number of survey respondents required for the results to be attributed to the identified general population (Welman and Kruger, 2003). For ensuring a representative sample, all employees involved in the construction process are included in the study sample. A set of objects for which a researcher wants to know statistical information is called a general set (Collis and Hussey, 2009). The general group of the research is the employees of the construction company involved in the construction process ($N = 30$, where 21 specialists are on the construction site and 9 specialists in the office). According to the sample size calculators available on the Internet, 29 respondents can be considered as a representative sample (n) if the total sample size (N) is 30 employees (assuming a confidence interval of 90%, a standard error of 4%) (CustomInsight, 2019; SurveyMonkey, 2019b). The sample size should reach a percentage of 97% of the total population. The achieved sample size ($n = 30$) within the study as a whole makes up 100% of the representative sample set. Following the method and purpose chosen in the study, a structured questionnaire was developed within the data collection. The questionnaire consists of 12 questions. The questionnaire confirms to the respondents that the survey is confidential, and the results of the study will be analyzed only in summary form. The developed questionnaire mostly contains open-ended questions, to which the respondent is asked to provide his/her answers. Open-ended questions provide qualitative and varied data for the study. In this case, it is possible to find out the respondents' opinion on a topic that is unfamiliar to them and seems complicated. Open-ended questions are useful in studies that do not have a large population, nor do they require extensive static analysis. At the same time, the respondents' contribution to the answers is more thoughtful and more valuable to the researcher (SurveyMonkey, 2019a). The questionnaire also includes two closed-ended questions that measure employees' knowledge and attitudes, forcing them to rate their answer on a 10-point scale. Closed-ended questions in questionnaires make it easier for the researcher to process the data and analyze the results (Reja et al., 2003). Questionnaires were handed over to employees working at the specific site, as well as representatives of subcontractors, as well as part of the questionnaires were handed over to employees who work in the company's office, relatively exposed to the construction site environment daily. At the same time, it should be noted that some of the office workers have previously worked directly on construction sites and are practically familiar with the current situation. The questionnaires were handed over to the respondents in different ways. Questionnaires were distributed at the construction site as employees gathered and explained the purpose and significance of the survey. Questionnaires were sent to the staff of the office by e-mail with a request to print them out and return them completed. Some employees filled it in. Some sent it back electronically to e-mail. That kind of contact with the respondents has allowed evaluating the answers correspondence to the employee's position level in the company. Data preparation involves processing, coding, data entry, and is the activity that ensures the accuracy of data and its transformation into forms suitable for analysis (Cooper and Schindler, 2011). The data obtained within the survey framework were processed, entered and prepared for analysis to get research aim and tasks. Statistical analysis of the data obtained within the research questionnaire was performed using the Microsoft Excel application.

Results. For analyzing the flow of unsorted construction waste in Latvia, the authors have reviewed data on construction waste and its mixtures. Figure 2 shows the amount of construction waste collected: classification codes 170101 (concrete), 170102 (bricks), 170103 (tile, ceramic) and 170107 (concrete, brick, tile, tile, ceramic mixtures that do not contain hazardous substances) and can therefore be used for recycling.

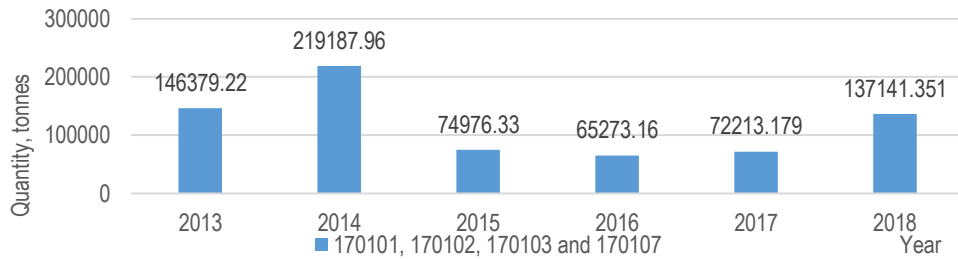


Figure 2. Amount of construction waste collected (classification codes 170101, 170102, 170103 and 170107) during the period from 2013 to 2018

Source: developed by the authors based on (LEGMC, 2020).

Figure 3, in turn, shows the amount of wood, glass and plastic (classification codes 170201, 170202, 170203) in construction waste collected.

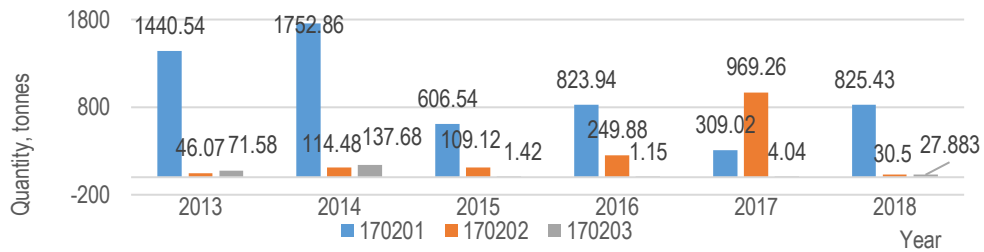


Figure 3. Amount of construction waste collected (classification codes 170201, 170202, 170203) during the period from 2013 to 2018

Source: developed by the authors based on (LEGMC, 2020).

It should be noted that in accordance with the guidelines of the Latvian waste management policy, those involved in the waste management system and industry (both producers and managers) must take measures to ensure that as little waste as possible ends up in landfills and is disposed of (VARAM, 2013). The decrease in the amount of unsorted construction waste collected could be explained by the increase in the percentage of sorted construction waste.

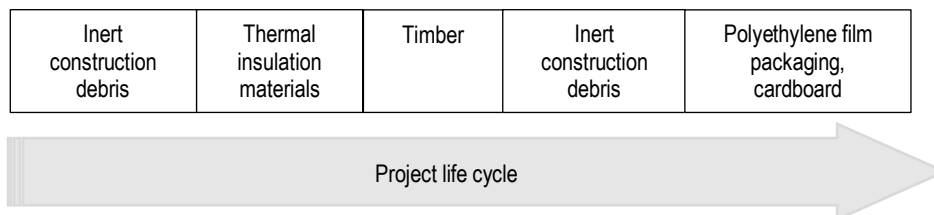


Figure 4. Scheme of identified construction waste according to construction stages

Source: developed by the authors.

The authors of the research found a connection between the generated construction debris and the stage of construction readiness (see Figure 4):

- 1) initially, when a building frame is built, the construction waste consists of solid building materials, such as concrete blocks, concrete, reinforced concrete;
- 2) the next stage, when the building is insulated, is related to the quantitatively large amount of thermal insulation material waste;
- 3) after the completion of the building frame, timber is actively used, and a mixture of construction waste is created, which consists of plasterboard, stone wool, metal profiles, paint packaging, tiles, etc.;
- 4) at the end of the construction of a building, construction waste mainly consists of equipment packagings, such as cardboard and polyethylene films.

Besides, it should be noted that such stages are more typical in the construction of new multi-apartment residential and public buildings. For example, the composition of waste generated during the construction of civil engineering will be different in stages. It can be stated that the majority of the respondents (21 from 30) carry out work on the construction site and thus are directly exposed to pollution on the construction site and can be considered both polluters and pollution reducers at the same time. When asked whether the employer has informed the employees about environmental pollution problems caused by the construction process, the majority of the respondents indicate that yes (24 out of 30). In turn, 6 (20%) respondents point the lack of information on the part of the employer about the construction process impact on the environment. Compared to the current topicality of the problem, this is a surprisingly large number of respondents. Given that environmental protection is currently emphasized and updated in the media and other public information resources, it is surprising that so many respondents are still unaware of the environmental pollution caused by the construction process. In the opinion of the authors of the work, it is possible that the employer, when instructing employees at work, did not place emphasis on environmental protection, or did not even address such a topic in the briefing. Given that this is the first question of the questionnaire, the respondents have analyzed it before answering, probably in a different way than the authors wanted to ask.

When answering the question whether the respondents face pollution caused by the construction process in the workplace, there is a balance between the respondents' answers (16 against 14). In the author's opinion, the result can be explained by the fact that a part of the respondents works in the office and really do not really face the environmental pollution in nature. Although the staff work in the construction industry and in the construction company, and some have higher education in the field of construction, their direct work is not related to physical work on the construction site, so there is no exposure to, for example, dust or excessive noise. An example is a construction project manager. The duties of such a specialist include comprehensive knowledge of the construction process and supervisory functions. Meanwhile, the involvement in the execution of construction works is minimal.

It should be noted that Question 3 of the questionnaire («Please name, in your opinion, at least 3 sources of pollution in construction?») identifies the problem respondents' knowledge of the construction process pollution. It is because no respondent named more than three sources, while some of them mentioned only one source. In almost all respondents' answers, dust was mentioned as one of the main sources of pollution in construction. Dust is observed at any stage of construction until the finish is completed. Therefore pollution caused by construction is primarily associated with dust for respondents. Besides, respondents mentioned unused paint and construction chemical residues as sources of pollution; construction machinery exhaust gases; construction material surpluses. It can be concluded that the respondents did not fully understand the question of the questionnaire because the polluting emissions caused by polluting activities are named. At the same time, the authors asked a question in the questionnaire to find out the employees' knowledge about the sources of pollution, which are, for example, concreting works or interior finishing works. That conclusion points to the employees' misunderstanding/lack of awareness of the causes and results, as well as the possible need to ask answers examples to understand the question purpose better when asking such a question.

A large proportion of respondents (67%) say that construction waste is generated as a result of their work process. Not all persons on the construction site are considered to be directly generating construction waste, such as a loader, driver, etc. At the same time, it should be noted that these persons also cause other types of environmental pollution, such as exhaust emissions (air pollution) from road transport. The generation of construction waste is clearly related to the specifics of the respondent's work and the technologies used. According to the authors, respondents who indicate that no construction waste is generated in their work process work in the office. At the same time, an in-depth assessment of the situation, even if no construction waste is generated directly by the office staff, may have an indirect impact on construction waste, given that they are specialists in, for example, planning the amount, size and technology on the construction site.

When asking to indicate their knowledge about waste management in the construction process on a 10-point scale, the majority of respondents (30%) indicated the highest rating - 10 points (see Figure 5).

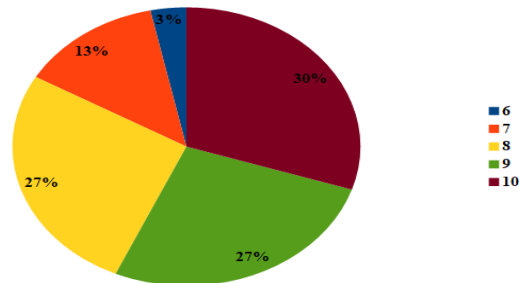


Figure 5. Personal assessment of knowledge about construction waste management in a 10-point system

Source: developed by the authors based on survey results.

It should be noted that the analysis of such an issue is very important to judge the self-assessment of employees. It is very interesting to link this question with question 1 of the questionnaire, which asked the respondents to answer the following question: «Has the employer informed you about the problems of environmental pollution caused by the construction process?». In total, 6 respondents had indicated that their employer had not informed them. At the same time, the personal self-assessment of knowledge on this issue was not lower than 6 points for any of the respondents. In the author's opinion, this indicates that the information was obtained outside the employer's company. This distribution of the answers provided in the answers is to be assessed positively and theoretically, indicates that construction workers have an understanding of the field of waste management. At the same time, such self-assessment does not guarantee that the knowledge of employees is of high quality and its correct application in practice. The average rating of comprehension answers is 8.7 points.

When answering the question about the awareness of construction waste sorting options, the vast majority of respondents (28 out of 30 respondents) indicate that they are informed about construction waste sorting options. This distribution of answers is very positive, as it indicates the employees' understanding that construction waste is of different types and can be recycled, etc. important issues for the industry. From the personal experience of the authors, it should be noted that employees are aware that in Western European countries such as Germany, Denmark, Sweden, etc., waste sorting before recycling is mandatory (instructed by the labour coordinator before starting work with an example from abroad). At the same time, regulatory enactments and experience in Latvia do not impose an obligation to sort waste already within the construction site, as well as employees, are not currently acquainted with such a process on the construction site.

When answering the question about the provision of special waste sorting containers/bins on the construction site, an overwhelming majority (28 out of 30 respondents) indicated that the employer had not provided special containers/bins for waste sorting. When compiling the questionnaire questions, the author's plans initially included the idea of interviewing several construction sites. Taking into account that as a result, the survey was conducted at one construction site and one company, the results of the answers are predictable. In the opinion of the authors, the positive answer of two respondents regarding the provision of sorting possibilities is related to the fact that a household waste container has been installed on the construction site, the existence of which the respondents most likely considered as an opportunity for waste sorting.

Analyzing the answers to question 8: «If it were possible to sort waste according to the type of waste management, how would it affect your job responsibilities?», it can be stated that none of the answers indicated the employee's forecasts for lengthening and complicating the work process. All answers should be assessed with a positive attitude, which indicates the readiness of people to put the sorting process into practice or at least to try. The vast majority of respondents indicated that sorting construction waste would not affect their work process.

Two respondents acknowledged that waste is already being sorted. The question did not indicate a specific type of waste in the wording of the question. Thus, it is possible that these respondents indicated the waste that is sorted at their place of residence or company office. It should be noted that the company's office provides the possibility to sort waste according to the type of waste. At the same time, in the opinion of the authors, if employees had to sort construction waste already within the construction site, the attitude towards sorting would be more negative, as employees would face the need to separate materials to be recycled/reused. For example, metal should be separated from wood or wood from polyethylene and placed in specially designated areas. Besides, it should be noted that the impact of construction waste sorting on the construction process may be most difficult to explain to those who have been working in construction for a long time (for example, since Soviet times) and have extensive experience. Thus, it is difficult to change people's habits.

When answering the question related to the assessment of personal interest in the reduction of waste pollution in construction on a 10-point scale, the majority evaluates it as very good or 8 points (see Figure 6).

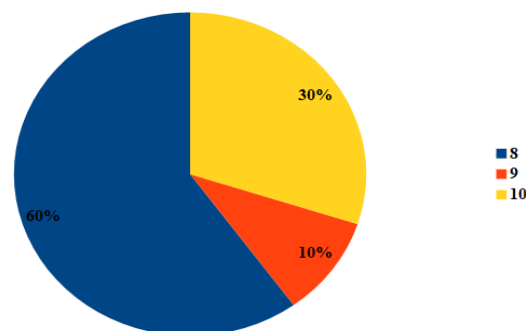


Figure 6. Assessment of personal interest in reducing waste pollution in construction in a 10-point system

Source: developed by the authors based on survey results.

According to the authors, this is one of the most important questions of the survey. This question provides a general idea of how the respondents relate to the problem and to the reduction of pollution in

the early stages of its emergence. It is positive that the answers to this question also reveal the respondents' desire to participate in reducing pollution. Under linking this issue to the previous question on the possible impact of sorting on job responsibilities, it should be noted that employees may not be sufficiently educated about the nuances of sorting, which includes a careful breakdown of waste by type. In this case, the author's experience should be noted that the complete waste container will always be the one closest to the entrance to the construction site. It confirms the assumption that proper planning plays an important role in reducing pollution, including the promotion of waste sorting (Resource Efficient Scotland, (n.d.); European Commission, 2016). The authors' attention is also drawn to the distribution of answers, because, given that the survey is anonymous, the authors would expect someone to rate the desire lower, for example, on a scale of 3 to 5 points.

Evaluating the respondents' answers to question 10 of the questionnaire: «By what means/measures, in your opinion, would it be possible to reduce pollution in the construction process?», The authors conclude that the answers received are different. A large majority of respondents indicate that it is not possible to reduce pollution during the construction process. Some respondents point to a reduction in material waste. Respondents' answers also include financial instruments such as tax policy and financial incentives, state or municipal support; cleanliness. According to the authors, the answer «cleanliness» could mean dust emissions, because during construction processes, especially in summer, dust is constantly generated, for example, during the construction of the building frame they are released into the atmosphere, while during the interior they settle on surfaces where it is possible to collect and dispose of. When answering the question of the questionnaire: «What would motivate you to pay attention to «greener thinking» when working in construction?». The majority of respondents indicated a clean environment or a clean Latvia, respectively indicating that environmental issues are relevant to the respondents. At the same time, those respondents who work on the construction site, answering question 12 of the questionnaire: «Please briefly describe what, in your opinion, should be changed in the Latvian construction environment to reduce pollution during the construction process?», Indicate that the construction environment in Latvia cannot be changed. Respondents working in the office, meanwhile, point out that staff education or intellectual work with people should be carried out, explaining the causes and consequences of the problem. Analyzing the answers provided by the respondents and evaluating the personal experience, the authors believe that the answers provided are generally positive and exceed the expected ones. The answers about the personal interest in reducing waste pollution in construction are especially positive, because of the authors expected two opposing views on this issue - some that would be particularly interested, and some - little interested. However, the survey data do not provide information on how much employees are aware of the nuances of construction waste sorting. The results of the survey also show that employees have an insufficient understanding of the sources of pollution caused by the construction process, because the results of the survey show polluting emissions, but their sources are not mentioned.

Reducing pollution is an important precondition for a sustainable society. Based on the literature review and the research, the authors distinguish three levels of pollution management and potential for innovations (see Figure 7). At Level 1 of Pollution Management, which aims to prevent pollution, the following tools can be used to develop non-pollution solutions, such as alternative solutions that do not have a significant impact on the environment. It is also important to educate supervisors and workers about the risks of contamination in the construction process. It is also necessary to get acquainted with the regulatory framework that regulates pollution and sets guidelines for pollution management and limit values. Pollution management can also bring financial benefits to the contractor, for example by implementing environmental management systems, reducing energy costs or providing financial benefits at the national level to contractors who implement appropriate pollution prevention and reduction programs.

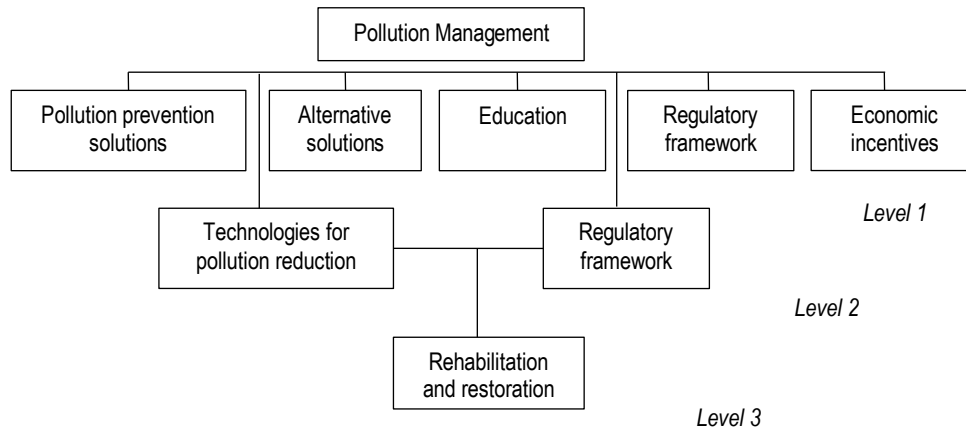


Figure 2. Pollution management concept

Source: developed by the authors.

Level 1 of pollution management is the most recommended and environmentally friendly solution. Level 2 of pollution management refers to cases where pollution has already occurred as a result of the process. In this case, it is necessary to provide appropriate technologies for the reduction of pollution, so that the limit values specified in regulatory enactments are not exceeded, and the damage is caused. Meanwhile, pollution management level 3 refers to cases where pollution has already caused irreversible changes in the environment, and the site needs to be rehabilitated and restored (MrGScience, 2015).

Conclusions. The results show that there is a huge potential for innovation because the current situation is far from ideal. The collection of sorted construction waste on construction sites currently is practically impossible, as the industry points to the human factor in the waste sorting process. Even a small amount of incorrectly sorted material requires re-control sorting on the waste sorting line, without excluding this step. Although the data obtained within the framework of the survey clearly indicate the interest of employees in sorting construction waste already on the construction site, waste industry companies currently consider such a practice impossible also due to the influence of other side factors related to economic considerations. In the survey results, there is a noticeable difference between the answers of employees who are employed on the construction site and those involved in construction work but perform functions mainly in the office. The reason for this division is most likely the difference in the level of education. Most respondents mentioned construction dust as the main pollutant in the construction site. The institutions responsible for policy planning and supervision shall not develop measures for the management of construction waste related to the approaching end of the service life of buildings built during the Soviet Union. In the event of demolition, a large amount of construction waste will be generated, from which economic benefits can be derived.

National policy planning documents have set a target of 70% recycling of construction waste. Still, there is no support mechanism to reduce the generation of waste itself from the outset or to encourage the choice of materials produced from recycled waste. There is no standardization system in Latvia that would allow the use of recycled construction waste in construction. Specialists do not see obstacles to developing such. The development of standardization would open up new business opportunities that would reduce the negative impact on the environment.

In Latvia, there are no common guidelines for co-operation for the joint development of sectors and reduction of environmental pollution in the activities of institutions supervising environmental issues and

construction. Authors provide some suggestions. It is necessary to develop a normative framework for the implementation of the construction waste certification system to promote the reuse of construction waste in construction as efficiently as possible. Institutions responsible for policy planning in the field of waste management and construction are recommended to develop methodologies or guidelines for waste management (including sorting) within the construction site. Thus, the companies would have access to a universal methodology for waste sorting that helps reduce human factors and sorting defects. Involving social networks, «influencers», media in educating the public on issues related to the impact of construction processes on the environment, the possibility is ensured that information reaches a wider circle of the public, including construction workers. The benefits are as follows the employees become more educated on environmental issues through self-study, as well as residents are able to identify violations and report to the responsible authorities.

It would be useful to introduce financial instruments to promote the use of recycled construction waste. These could be subsidies - tax rebates, exemptions or reductions, direct transfers (grants, soft loans) or indirect transfers that could be obtained by a company that recycles or uses recycled construction waste.

Author Contributions: conceptualization, T. T. and V. U.; methodology, T. T. and V. U.; formal analysis, T. T., V. U and J. I.; investigation, T. T., V. U and J. I.; writing-original draft preparation, T. T., V. U and J. I.; writing-review and editing, T. T.; visualization, T. T.; supervision, T. T.; project administration, T. T.; funding acquisition, J. I.

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Інновації в управлінні відходами будівництва: досвід Латвії

У статті проаналізовано проблематику охорони навколишнього природного середовища (НПС), екологічноорієнтованого управління та впровадження зелених інноваційних технологій у будівельній галузі. Зазначено, що будівельна галузь має значний негативний вплив на стан НПС. Авторами наголошено, що забруднення повітря, води та ґрунту, шум і вібрація, спричинені в ході будівельних процесів, негативно впливають на НПС та природні екосистеми, а також суспільство на глобальному рівні. Будівельні відходи, що утворюються в процесі будівництва, реконструкції та знесення, займають значні території звалищ, а також містять небезпечні речовини для НПС та здоров'я людини. У статті систематизовано результати досліджень щодо можливостей більш ефективного управління будівельними відходами. Розглянуто досвід компаній, які працюють у будівельному секторі та впроваджують інноваційні підходи з метою зменшення негативного впливу на НПС. Вихідні дані для дослідження сформовано на основі аналізу результатів опитування населення щодо рівня освідченості у поводженні з відходами будівельної галузі Латвії. Головною метою дослідження є систематизація аргументів та контраргументів щодо сучасних проблем управління будівельними відходами та потенціалу інноваційного розвитку в Латвії на основі результатів проведеного опитування. Для практичної реалізації всіх етапів дослідження проведено огляд літератури, аналіз статистичних даних, створено анкету, проведено опитування населення та співбесіду з компаніями, які займаються переробкою відходів. Дослідження проводилось з жовтня 2019 року по липень 2020 року. За отриманими результатами виявлено значний розрив в ефективності управління будівельними відходами між компаніями в Латвії. У ході дослідження встановлено, що працівники зацікавлені у сортуванні відходів на будівельних майданчиках. Однак, практичну реалізацію збору відсортованих відходів не реалізовано через низький рівень екологічної свідомості та культури працівників. У свою чергу, компанії з утилізації відходів вважають дану практику неможливою через вплив низки економічних факторів. За результатами дослідження авторами наголошено на необхідності розроблення єдиної нормативної бази для впровадження системи сертифікації будівельних відходів, що забезпечить ефективне впровадження інноваційних рециклінгових технологій у будівництві.

Ключові слова: відходи будівництва, управління технологічними інноваціями, екологічний менеджмент, Латвія, сталий розвиток.

Manuscript received: 04.02.2020

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