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Research paper

Identification of constraints for an effective application of construction waste management plan in Poland

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Abstract: The aim of this study is to identify the constraints that affect the effective usage of the site waste management plan (SWMP). A substantial review of the literature was carried out to identify the constraining factors that affect the site waste management plan tool. Questionnaires were administered based on a five-point Likert scale and the data were assessed and analyzed using IBM SPSS version 28. The outcome showed that the knowledge of the SWMP is still very low in the Polish construction sector. Only 6% have a written SWMP while 16% have used this tool in their previous project. Hence, the need for the increased awareness of the SWMP as one of the waste management strategies. The lack of adequate monitoring and control of the SWMP, lack of awareness, time required for the preparation of the tool were identified as the top constraints. The solutions identified include; increased level of awareness and education, the inclusion of the SWMP as part of the contract documentation requirement, adequate training of the site personnel, and presence of waste manager.

Keywords: constraints, construction and demolition waste, European Union, recycling, reuse, site waste management plan, waste management

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1. Introduction

The construction industry is a crucial aspect of the socio-economic development of any society. The industry added around 4.3% to the United States of America's gross domestic product (GDP) between the years 2007–2020 [1]. The construction industry is paramount to the European Union (EU) economy. It has provided 18 million jobs, and 9 % of the EU's GDP is ascribed to the industry. The EU construction industry turnover in 2018 was around 1.89 Trillion Euros [2]. Construction tasks consume 32% of the global resources, including water and energy, 25% of timber, and 40% of raw stones and sand are used each year worldwide [3]. The building processes and products have a major effect on the health, safety, and environment (HSE) [4]. Despite the industry's great economic and financial benefits, the activities produce waste at the construction yards, project sites, and other facilities. These wastes have an unpleasant effect on the environment. The manufacture of building products and the processes amount to 40% of extracted materials in the United States of America [5].

Waste management is described as an aspect that comprises the generation, storage, collection, transportation, processing, and disposal of solid waste [6]. According to [7], waste is defined as any material byproduct of human and industrial tasks with no good end value. Construction site waste is a harmless byproduct proceeding from tasks during construction and refurbishment. CDW combines excess materials from site clearance, excavation works, construction, refurbishment, renovation, demolition, and roadwork [8]. The construction industry uses several materials, which are important for the support and growth of the industry [9]. However, some of these materials are non-renewable and hazardous. According to the roadmap for driving towards the 2050 low carbon economy, sustainable construction industry is extremely important for achieving Europe's target of 80–95% greenhouse gas emission [10]. The 70% target of CDW to be recycled by 2020 within the EU, as stated in the Waste Framework Directive (WFD) 2008/98/EC by the member states, has not been achieved [10]. While few of the member states had set up CDW management implementation, less than 50% of the CDW are still recycled. In Poland, it was estimated that about 3,510,000 tonnes of CDW were generated; this included excavated soil from contaminated land [11], while 58% of this generated waste was recycled.

The review of the practices of waste management showed that the current strategies for waste reduction and management of building projects in a highly urbanized city are not effective [12]. Lately, CDW generated from construction works have become a serious problem in most developing nations. It is estimated that on average, CDW make up 15-30% of the total amount of waste that ends up in landfill sites in many countries [13]. At the project level, the waste generated on-site has been estimated to be about 10% of the materials originally purchased [14]. The volume of waste generated is expected to increase up to 2.2 billion tonnes every year by 2025 [15]. In 2016, the EU recorded around 930 million tonnes of waste [16]. 23% of the national waste stream is estimated to be construction and demolition (C&D) waste according to the [17]. The C&D waste levels grew more than 10 times faster from 1990 to 2005 than between 2005 and 2018 [18]. The following research questions need to be addressed:

– How frequent do the contractors and sub-contractors use the site waste management plans?
– What are the constraints that prevent the effective use of the site waste management plans by the construction contractors and sub-contractors in the building and especially demolition projects?
– What are the possible solutions for the effective use of the SWMP?

The objectives of this research is a comprehensive review of site waste management plan, a review of the EU legislation on construction site and demolition waste. The determination of the frequency of usage of the construction SWMP by the contractors and sub-contractors in building projects. The probable solutions to the identified constraints. The results of this study will be valuable to industry practitioners especially the construction team. It will also help government agencies and end-users in designing, choosing, and incorporating the most SWMP in construction projects. The scope of the research is limited to the construction industry registered contractors and sub-contractors under the heading of Polish Association of Construction Employers (Polski Zwiazek Pracodawcow Budownictwa). The quality of expected data from the general contractors or sub-contractors for this survey is high because these construction companies employs professionals with a good knowledge of the subject. Although, the findings and the results are not only restricted to this group.

2. Literature review

Several literature reviews show that past studies are primarily focused on causes of waste, strategies for controlling construction site waste, waste reduction, and implementation of the waste management system. The research of [12], on controlling construction waste by implementing governmental ordinances in Hong Kong, it was discovered that the legal commitments have been mainly allocated to contractors while other members of the construction team have fewer responsibilities. The study showed that existing waste control ordinances allow for the bias distribution of dedications and roles of controlling construction waste among the project participants. The results illustrate that there is a demand for an equalled allocation of responsibilities and commitments among all project stakeholders.

2.1. Definition of construction and demolition site waste

The Construction and Demolition Waste (CDW) is the generalized description of all-waste generated in the construction process, maintenance, demolition and deconstruction of constructed facilities and civil works [19]. The government of Ohio in the United States describe construction and demolition waste (CDW) as those materials products from the changes in construction, demolition, renovation, or repair of any structure e.g. residential buildings, industrial or commercial facilities, and roadways [20]. According to [21], C&D waste management as materials produced by construction projects, for example off-cuts,

damaged materials, temporary and replaceable building materials, and materials that are not part of the finished project, packaging materials, and waste generated by the workforce. Materials produced from the activities of dismantling all or components parts of a structure and removing of buildings and destroyed or damaged as a product of natural or anthropogenic hazards.

2.2. European Union waste framework directives 2008/98/EC

The legislation on waste management in the EU was formulated and is binding on the member states while imperfect waste regulations in Ukraine averts the execution of effective waste management strategies during war period [22]. The issue of environmental protection is one of the focus of the EU with several directives emanating over the last 20 years [10]. The 2008 WFD define the term "waste' and provides some of the fundamental principles for the construction waste management. Some of the principles are:

- The adoption of the waste management plans and preventive implementation programs by the member states.
- The implementation of the waste management hierarchy in the waste legislation and policy of the member countries.
- The management of waste in such a manner that the health of humanity and environmental danger are prioritized.
- The introduction of the polluter payment principle and extended manufacturer responsibility.
- The review and communication of a new target of 70% for re-use, recycling and other recovery of C&D waste by the year 2020.

According to Articles 28(1) and 29(1) of the directive, it is mandatory to establish the waste management plans and prevention with the focus on the waste hierarchy (European Parliament, 2008). The WFD require the separation of waste generated from source instead of the separating a mixed waste. This is in accordance with Article 10(2) of the WFD, which describes waste separation as a prerequisite for a technical, environmental and economical improved practice. The adoption of the WFD by the national law of the member state will consider the cost of natural aggregates, landfill space, awareness of the citizens, participants in the construction sector, and disposal cost. According to [23], several improvements and attempt needs to be make on the EU and national legislation in the unification of data, classification and definition with respect to the CDW generated in the construction industry.

2.2.1. Waste legislation in Poland

The National Waste Management Plan 2022 (NWMP) [24] is an Act of 14 December 2012 on waste (Journal of Laws of 2013, item 21, as amended). The NWMP 2022 refers to waste produced in the Republic of Poland. The waste frameworks division of the NWMP includes; municipal, waste products, hazardous waste, and other waste. The C&D waste is categorized under the "other waste". The NWMP 2022 has been formed and is in force according to the Regulation of the Polish Ministry of Environment on 1 June 2016 (Journal

of Laws item 1206). This is a waste management condition precedence for EU financial views between the years 2014–2020. The NWMP is in line with the WFD and it will further increase the effectiveness of the waste management process. The NWMP 2022 is one of the strategic document adopted at the national level with the following objectives;

- Prevention of negative effects of waste generation on the health and environment by the waste hierarchy.
- Multiplication of efforts to limit pollution and disposal to sea and landfill
- Encouraging the waste management through prevention in the EU.
- Implementation of the EU waste legislation across the member states.
- Reduction of energy recovered to materials that are unsuitable for recycling
- Total alienation of landfill disposal of waste suitable for recovery and recycling
- Provision of quality recycled products from the waste materials.

2.3. Site waste management plans (SWMP)

Site waste management plan (SWMP) is a valuable tool for the aid of construction participants to foresee the type, quantity and management of CDW [25]. The SWMP is a good approach, which provides a powerful method to improve the waste management in the construction site. The SWMP should be designed at the preliminary phase of the project in order to promote waste reduction and recovery. The document helps to identify and implement waste minimization at the design phase, recycling and re-use during the construction phase thereby reducing the volume of rework, demolition and waste moved to landfill. The goal of the SWMP are to set waste diversion targets, prevent flying tipping, adequate waste auditing, segregation, improvement of efficiency and profitability. The SWMP is usually prepared, managed and supervised by the site waste managers. The 6^{th} of April 2008, the SWMP regulations was introduced into the United Kingdom construction industry. The SWMP was defined according to the WFD as the plan that shows the details of collection, transportation, recovery and disposal of waste, including the supervision of the operations and the aftermath of the disposal sites [26].

SWMP is a document that should be simple, concise and comprehensive and can be interpreted easily without ambiguity and can easily be implemented. The SWMP documents shows who is responsible for the resource management within the construction team, it also identify the types of waste generated, how to manage the waste (reduce, reuse, and recycling), the general contractor or sub-contractor who is responsible for the recycling or disposing of the waste and how to quantify the volume of waste generated during the construction process. In 2003, the Hong Kong construction industry witnessed the introduction of the SWMP. However, there have been many negative responses from industry professionals, as it is believed to reduce productivity [27]. In Australia, the inclusion of SWMP in major projects requiring planning approval is an important condition [28]. The SWMP proposes the proportion of waste to be reused and recycled, onsite area for waste storage, methods for waste sorting and reduction as well as the project participants should be in charge of waste transportation from site [13, 29].

3. Research methodology

3.1. Data collection

The commencement of the research was a thorough review of the literature to identify the constraints preventing effective use of the SWMP. The reviews comprise journals, articles, and proceedings that discuss the issue of construction waste management strategies, waste legislation, and the SWMP globally. During the literature review, Eighteen (18) relevant constraints were identified as factors that prevent the use of SWMP, Eight (8) waste management initiatives were identified. These were the inputs for the production of the questionnaire to show if these identified constraints are relevant to Poland. The target respondents are Engineers, Architects, Construction Managers, Project Managers, Foremen, client representatives, etc. The data collected were analyzed using IBM SPSS version 28 and the relative importance index to determine the impact observed by the identified constraints. According to [30], the use of a pilot survey for conducting research is to obtain a level of certainty that the research meets the defined criteria in terms of reliability and quality. This was the approach used to obtain correct information from the construction sector stakeholders.

The questions were collated and modified, and designed in a questionnaire. The refined questionnaire was sent to 50 stakeholders in the Polish construction sector using a meticulous sampling technique. The questionnaire was divided into four (4) sections; section A contains general information. In section B, the respondents were asked about their awareness of the EU directives on waste management and NWMP acts of the Polish law, the preparation, and the inclusion of the SWMP in the construction contract document. Section C covers the constraining factors influencing the use of the SWMP. Section D outlined some of the probable solutions that could enhance the effective use of the SWMP on the construction project.

3.2. Data analysis

The collected data from the construction professionals were analyzed using the descriptive statistics methods in IBM SPSS version 28. The relative importance index (RII) was calculated using the formula in Eq. (3.1) on the five-point rating scale consisting of:

1 – Strongly disagree
2 – Disagree
3 – Neither disagree nor agree
4 – Agree
5 – Strongly agree

$$\text{RII} = \frac{5a_5 + 4a_4 + 3a_3 + 2a_2 + 1a_1}{A \times N} \tag{3.1}$$

where: 1, 2, 3, 4, 5, – Rating scale, a_5 – Number of respondents for strongly agree, a_4 – Number of respondents for agree, a_3 – Number of respondents for neither agree nor disagree, a_2 – Number of respondents for disagree, a_1 – Number of respondents for strongly disagree, A – Highest weight, N – Total number of respondents.

4. Results and discussion

4.1. Description of respondents

The features of the respondents who provided information for the study were evaluated. Table 1 indicates that of the 50 questionnaires sent out to the respondents, the average years of experience is less than 10 years in construction projects. Based on their profession, construction managers and project managers have a high proportion of 26% and 28% of all respondents, respectively. Additionally, structural engineers placed third with 20% of the overall respondents. The architects, mechanical/electrical engineers, construction cost estimators and waste managers represented 26% of all respondents. The foreman held the last position held amongst the respondents as shown in Fig. 1.

Table 1. The years of experience of the respondents

Years	Number of Respondents	Percentage (%)
Less than 10 years	21	42.0%
10–19 years	18	36.0%
20–29 years	10	20.0%
30–39 years	1	2.0%

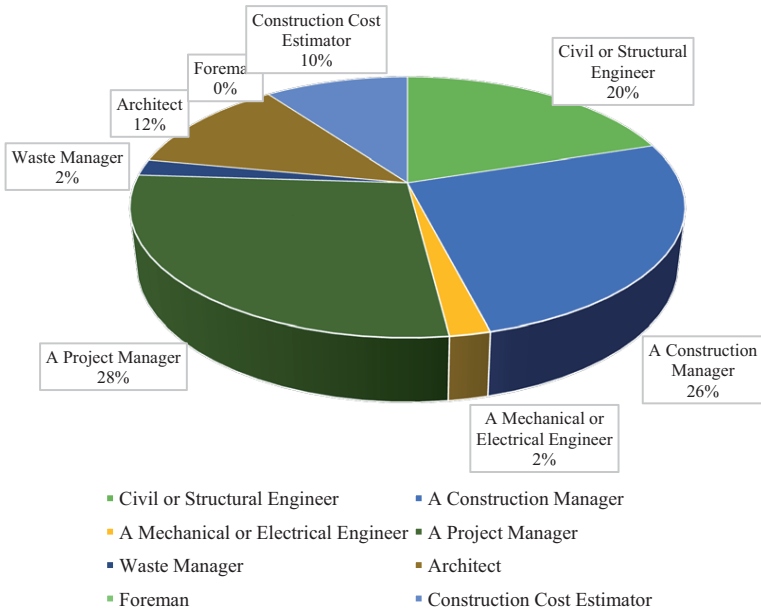

Fig. 1. Professions of the respondents

4.2. Awareness on the European Union WFD and national waste regulation

The level of awareness of the EU WFD was assessed and analyzed in this research. It was discovered that 82% of the respondents are not aware of this directives while 16% of the respondents have a good understanding of the WFD as shown in Fig. 2. Only 1 of the respondents is not sure about the WFD. 54% of the respondents are aware of the Polish NWMP acts while 46% of the respondents are not aware of this acts. This result shows that there is great need for the improved awareness campaign of the EU WFD and Polish NWMP acts if the country is to achieve the 70% target as set by the EU and the Polish ministry of environments.

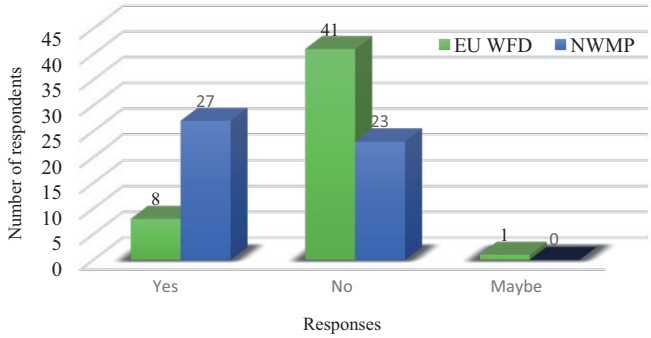

Fig. 2. The awareness level of respondents to the EU waste framework directives and NWMP acts

4.3. Determination of the frequency of usage of the SWMP

The SWMP tool has been developed to aid in the management of waste in the construction project. The frequency of the usage of this tool in the Polish construction sector was evaluated. It was observed that 76% of the respondents have never used the SWMP in the projects carried out by them while 16% of the respondents have used the SWMP tool. It was discovered that some of the organisation does not have the formal or written SWMP as part of the companys' required manual. It was seen from this research that 6% of the respondents have a written SWMP while 58% of the respondent do not have the formal SWMP as part of their organisations' tool. During the tendering process, construction organisations are required to send their bids together with other documents like the programme of work, method statement, health and safety plans. 86% of the respondents in this case have never included the SWMP tools as part of the document required during tendering process while 12% of the respondents have included the SWMP in the tender submitted by their organisation as shown in Fig. 3. Formal training on the waste management is quite important as this will guide the professionals in the direction in which to focus during the construction works. 16% of the respondents have undergone formal training in waste management at one point in time while 80% of the respondents have never received

any formal training regarding management of waste on site. Some of the construction site does not have any personnel assigned to the waste management on the construction site as seen in this research. 70% of the respondents are motivated to reduce waste as part of their job.

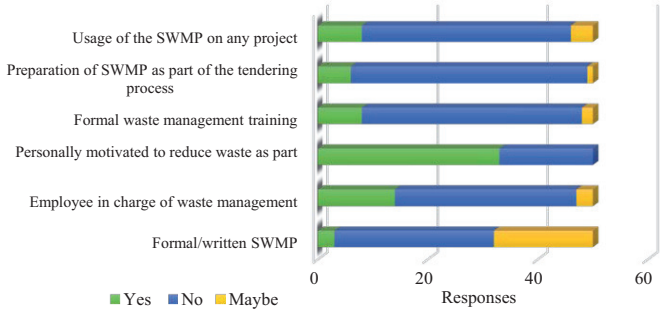

Fig. 3. The frequency of usage and others information on the SWMP

4.4. Identified constraints affecting the effective use of SWMP

The use of SWMP is desirable by the construction organisations but there are several constraints preventing the use of this tools. Some of the identified constraints during this research is shown in Table 2. The lack of monitoring and control of the SWMP has been identified as first among the major constraints affecting the use of the SWMP with RII of 0.8522. The overhead cost of developing and managing the site waste management plan tool is high and the organizations are unwilling to add extra cost to the construction project which will reduce their profit. The lack of awareness, time required for the documentation of the SWMP, lack of training for site personnel and poor operation of the site waste management plan are other constraining factors identified by the respondents. Materials purchasing by sub-contractors, lack of planned implementation and lack of financial rewards for site personnel have the lowest RII though, they are considered as part of the factors affecting the use of the SWMP.

Table 2. The constraints affecting the use of SWMP

Constraints	Strongly agree (5)	Agree (4)	Neither agree nor disagree (3)	Disagree (2)	Strongly disagree (1)	Total	Total Number (N)	$A \times N$	RII	Rank
Lack of financial rewards for site personnel	45	76	54	6	1	182	50	250	0.728	15
High overhead cost of managing the site waste management tool	70	64	48	6	1	189	50	250	0.756	13

Continued on next page

Table 2 – *Continued from previous page*

Constraints	Strongly agree (5)	Agree (4)	Neither agree nor disagree (3)	Disagree (2)	Strongly disagree (1)	Total	Total Number (N)	$A \times N$	RII	Rank
Absence of waste management policy/ strategy on site	70	68	48	6	0	192	50	250	0.768	11
Absence of waste manager	70	76	45	4	0	195	50	250	0.78	9
Undefined waste management responsibilities on site	75	80	39	4	0	198	50	250	0.792	7
Lack of training for site personnel	90	68	42	2	0	202	50	250	0.808	4
Materials purchasing by sub-contractors	35	88	48	8	1	180	50	250	0.72	16
Design considerations and specifications	35	100	42	6	1	184	50	250	0.736	14
No commitment/direction from site management	65	84	36	6	0	191	50	250	0.764	12
No Penalty/fees for defaulters	65	84	45	2	0	196	50	250	0.784	8
Absence of on-site sorting facilities	90	80	21	10	0	201	50	250	0.804	5
Time required for the documentation of the SWMP	95	80	24	4	1	204	50	250	0.816	3
Lack of planned implementation	60	84	30	8	0	182	50	250	0.728	15
Poor operation of the site waste management plan	80	76	42	2	0	200	50	250	0.8	6
Poor information by the site workers	60	84	48	2	0	194	50	250	0.776	10
Lack of awareness	90	92	21	4	0	207	50	250	0.828	2
Bad attitude	85	76	36	4	0	201	50	250	0.804	5
Lack of monitoring and control of the SWMP	105	84	24	0	0	213	50	250	0.852	1

4.5. Suggested solutions to the effective and increased usage of SWMP

The effective utilization of the SWMP is of great benefit to the construction sector. Hence, the evaluation of the proposed solutions to the increased usage of the SWMP tool. The identified solutions were evaluated and analysed. The increased level of awareness and education was topmost in the suggested solutions with RII of 0.8560. The inclusion of the site waste management plan as part of the contract requirement, training for site personnel,

presence of waste manager, proper information to the construction workers and government involvement and certification were among the top rated solutions by the respondents as shown in Table 3 and Fig. 4.

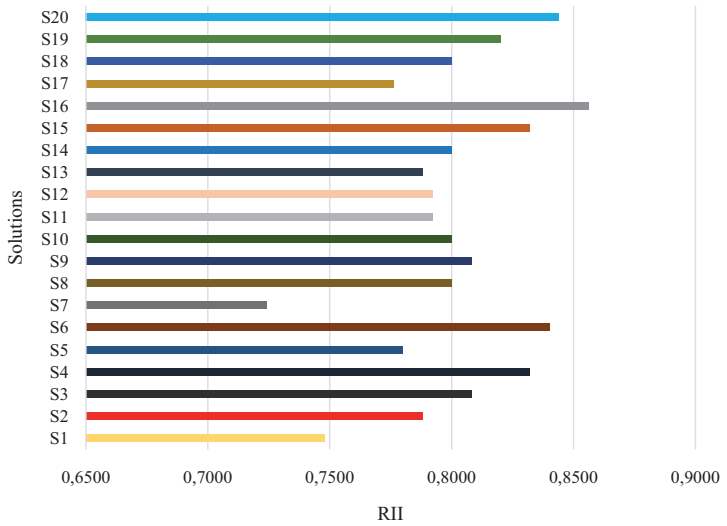

Fig. 4. Representation of the solutions to the constraints of SWMP

Table 3. Proposed solutions to the constraints of SWMP

Codes	Solutions	RII	Rank
S1	Financial rewards for site personnel	0.7480	12
S2	Reduction of overhead cost of managing the site waste management tool	0.7880	9
S3	Waste management policy/ strategy on site	0.8080	6
S4	Presence of waste manager	0.8320	4
S5	Clear waste management responsibilities on site	0.7800	10
S6	Training for site personnel	0.8400	3
S7	Materials purchasing by sub-contractors	0.7240	13
S8	Effective design considerations and specifications	0.8000	7
S9	Adequate and increased commitment/ direction from stakeholders	0.8080	6
S10	Increased penalty/fees for defaulters	0.8000	7
S11	Presence of on-sorting facilities	0.7920	8
S12	Time required for the documentation of the SWMP	0.7920	8
S13	Pre-planned implementation procedure	0.7880	9
S14	Effective operation of the site waste management plan	0.8000	7

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Table 3 – *Continued from previous page*

Codes	Solutions	RII	Rank
S15	Proper information to the construction workers	0.8320	4
S16	Education and increased level of awareness	0.8560	1
S17	Good attitude to waste management strategies	0.7760	11
S18	Proper monitoring and control of the site waste management plan	0.8000	7
S19	Government involvement and certification	0.8200	5
S20	Inclusion of the site waste management plan as part of the contract requirement	0.8440	2

4.6. Awareness strategies to be adopted

The circulation of information regarding the waste management strategies like the SWMP should be encouraged by the government and the top management of various organisation. On-site campaign, corporate social responsibility, increased taxation and levy, and product labelling have been rated top as the most important awareness strategies that the organisations and government need to consider. Others are massmedia commercials e.g. TV, Radio and Print, use of social media as shown in Fig 5. The use of billboards was rated lowest among the respondents.

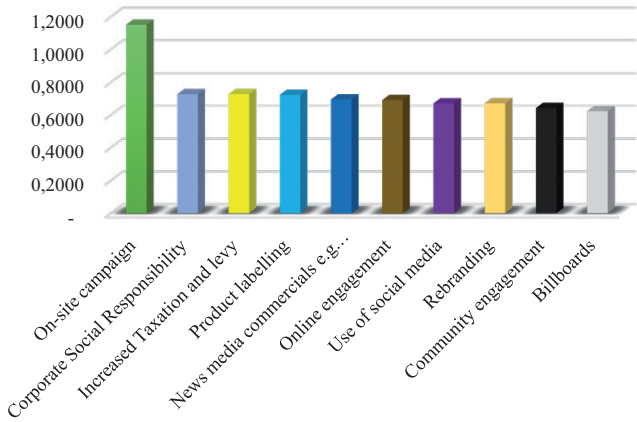

Fig. 5. Awareness strategies and the RII

5. Conclusion

The purpose of this research was to identify the constraints that prevent the use of SWMP tool in the construction projects. A review of literature were used to identify these constraints. Eighteen (18) constraints were listed, evaluated and analyzed using descriptive

statistics. According to the results of the extensive analysis, it can be concluded that the usage of the SWMP in the Polish construction industry is low due to the impact of the constraining factors identified in this research. Some of the factors are; lack of monitoring and control of the SWMP, lack of awareness, lack of contribution from management, extended duration of time required for the documentation of the SWMP etc. The knowledge and frequency of usage of this tool is very low considering the number of construction projects that are currently ongoing in the country. The twenty (20) probable solutions identified are education and increased level of awareness, inclusion of the site waste management plan as part of the contract requirement, training for site personnel, presence of a waste manager, involvement of the management and proper information to the construction workers are some of the solutions. Ten (10) awareness strategies were identified and it was noted that on-site campaign and corporate social responsibility were rated higher above others. The use of the SWMP will be a unique tool for the management of construction waste. This will help in the reduction of the waste sent to the landfill and improve the waste market streams. Further research can be carried out in the evaluation of the time and cost required for the production and management of the SWMP. The analysis of the volume of waste generated for typical projects can be studied as this could help in the proper planning of the project.

References

[1] Statista Research Department, "Value added of U.S. construction industry as a percentage of GDP 2007-2020". [Online]. Available: https://www.statista.com/statistics/192049/value-added-by-us-construction-as-a-percentage-of-gdp-since-2007/. [Accessed: 20 February 2022].

[2] Statista Research Department, "EU-28: Employed persons in the building construction industry 2008-2019". [Online]. Available: https://www.statista.com/statistics/763219/total-employed-persons-in-building-construction-industry-eu/. [Accessed: 20 February 2022].

[3] U. Kulatunga, D. Amaratunga, R. Haigh, and R. Rameezdeen, "Attitudes and perceptions of construction workforce on construction waste in Sri Lanka", *Management of Environmental Quality: An International Journal*, vol. 17, no. 1, pp. 57–72, 2006, doi: 10.1108/14777830610639440.

[4] M. Behera, S. Bhattacharyya, A. Minocha, R. Deoliya, and S.J.C. Maiti, "Recycled aggregate from C&D waste & its use in concrete – A breakthrough towards sustainability in construction sector: A review", *Construction and Building Materials*, vol. 68, pp. 501–516, 2014, doi: 10.1016/j.conbuildmat.2014.07.003.

[5] C. Kibert and R. Ries, "Green building education and research at the University of Florida", in *Proceedings of the 45th ASC International Annual Conference*, T. Sulbaran, Ed. Gainesville, Fla, Florida, USA, 2009.

[6] S.H. Fauziah and P. Agamuthu, "Trends in sustainable landfilling in Malaysia, a developing country", *Waste Management and Research*", vol. 30, no. 7, pp. 656–663, 2012, doi: 10.1177/0734242X12437564.

[7] O. Ortiz, J.C. Pasqualino, G. Diez, and F. Castells, "The environmental impact of the construction phase: an application to composite walls from a life cycle perspective", *Resources, Conservation and Recycling*", vol. 54, no. 11, pp. 832–840, 2010, doi: 10.1016/j.resconrec.2010.01.002.

[8] Environmental Protection Department (EPD), "Strategic Landfills". [Online]. Available: http://www.epd.gov.hk/epd/english/environmentinhk/waste/prob_solutions/msw_strategic.html. [Accessed: 28 September 2021].

[9] C. Knoeri, C.R. Binder, and H.J. Althaus, "Decisions on recycling: Construction stakeholders' decisions regarding recycled mineral construction materials", *Resources, Conservation and Recycling*, vol. 55, no. 11, pp. 1039–1050, 2011, doi: 10.1016/j.resconrec.2011.05.018.

[10] Eurpean Commission, "Strategy for the sustainable competitiveness of the construction sector and its enterprises, communication from the commission to the European Parliament and the council", 31.7.2012 COM(2012) 433 final, Brussels, 2012.

[11] Deloitte, "Construction and Demolition Waste management in Poland – V2 September 2015". [Online]. Available: http://ec.europa.eu/environment/waste/studies/deliverables/ CDW_Poland_Factsheet_Final.pdf. [Accessed: 10 March 2022].

[12] V.W.Y. Tam, L.Y. Shen, I. Fung, and J.Y. Wang, "Controlling construction waste by implementing governmental ordinances in Hong Kong", *Construction Innovation*, vol. 7, no. 2, pp. 149–166, 2007, doi: 10.1108/14714170710738522.

[13] B. Mcdonald and M. Smithers, "Implementing a waste management plan during the construction phase of a project: A case study", *Construction Management and Economics,* vol. 16, no. 1, pp. 71–78, 1998, doi: 10.1080/014461998372600.

[14] P.M. Guthrie, S.J. Coventry, and A.C. Woolveridge, *Waste minimization and recycling in construction: Technical review*. London: CIRIA, 1999.

[15] Transparency Market Research, "Construction waste market – global industry analysis, size, share, growth, trends, and forecast 2017–2025". [Online]. Available: https://www.transparencymarketresearch.com/construction-waste-market.html. [Accessed: 25 September 2021].

[16] C. Arenas, Y. Galiano, C. Leiva, L.F. Vilches, F. Arroyo, R. Villegas, and C. Pereira, "Development of a fly ash-based geopolymeric concrete with construction and demolition wastes as aggregates in acoustic barriers", *Construction Building Materials*, vol. 134, pp. 433–442, 2017, doi: 10.1016/j.conbuildmat.2016.12.119.

[17] Bureau of Transportation Statistics, "Municipal solid waste and construction & demolition debris". [Online]. Available: https://www.bts.gov/archive/subject_areas/freight_transportation/faf/faf4/debris. [Accessed: 25 September 2021].

[18] *National Waste Prevention Program Annual Report 2019*. Environmental Protection Agency, 2020.

[19] M. Mália, J. de Brito, M. Duarte Pinheiro, and M. Bravo, "Construction and demolition waste indicators", *Waste Management and Research*, vol. 31, no. 3, pp. 241–255, 2013, doi: 10.1177/0734242X12471707.

[20] OhioEPA.gov, "Definition of Construction and Demolition Debris". [Online]. Available: https://ohioepa.custhelp.com/app/answers/detail/a_id/2317/~/definition-of-construction-and-demolition-debris. [Accessed: 20 April 2022].

[21] T. Napier, "Construction waste management", Whole Building Design Guide (WBDG). [Online]. Available: https://www.wbdg.org/resources/construction-waste-management. [Accessed: 9 April 2022].

[22] O. Lymar, "Waste from demolition, construction and damaged buildings during wartime", Ukrainian Institute of the Future, 2022. [Online]. Available: https://uifuture.org/publications/vidhody-vid-znesennya-budivnycztva-ta-poshkodzhenyh-budivel-u-vijskovyj-chas/. [Accessed: 24 October 2022].

[23] V.S. Paola, D.R.M. Mercedes, and S.A.G. Alicia, "European legislation and implementation measures in the management of construction and demolition waste", *The Open Construction and Building Technology Journal*, vol. 5, pp. 256–161, 2011, doi: 10.2174/1874836801105010156.

[24] *National Waste Management Plan 2022. Annex to the Resolution No 88 of the Council of Ministers of 1 July 2016 (item 784)*. Warsaw, 2016.

[25] K. Kabirifar, M. Mojtahedi, C. Wang, and V.W. Tam, "Construction and demolition waste management contributing factors coupled with reduce, reuse, and recycle strategies for effective waste management: A review", *Journal of Cleaner Production*, vol. 263, pp. 121–265, 2020, doi: 10.1016/j.jclepro.2020.121265.

[26] "Directive 2008/98/EC of the European Parliament and of the council of 19 November 2008 on waste and repealing certain Directives", European Parliament, 2008.

[27] V.W.Y. Tam, "On the effectiveness in implementing a waste-management-plan method in construction", *Waste Management*, vol. 28, no. 6, pp. 1072–1080, 2008, doi: 10.1016/j.wasman.2007.04.007.

[28] M. Hardie, S. Khan, A. O'Donell, and G. Miller, "The efficacy of waste management plans in Australian commercial construction refurbishment projects", *Australian Journal of Construction Economics and Building*, vol. 7, no. 2, pp. 26–36, 2007, doi: 10.5130/ajceb.v7i2.2988.

[29] C. McGrath, "Waste minimization in practice", *Resources, Conservation and Recycling*, vol. 32, no. 3–4, pp. 227–238, 2001, doi: 10.1016/S0921-3449(01)00063-5.

[30] A.A. Fashina, M.A. Omar, A.A. Sheikh, and F.F. Fakunle, "Exploring the significant factors that influence delays in construction projects in Hargeisa", *Heliyon Journal*, vol. 7, no. 4, 2021, doi: 10.1016/j.heliyon.2021.e06826.

Identyfikacja ograniczeń dla skutecznego stosowania planu gospodarki odpadami budowlanymi

Słowa kluczowe: ograniczenia, odpady budowlane i rozbiórkowe, unia europejska, recykling, ponowne wykorzystanie, zakładowy plan gospodarki odpadami, gospodarka odpadami

Streszczenie:

Celem niniejszego artykułu opracowania jest identyfikacja ograniczeń, które wpływają na efektywne wykorzystanie zakładowego planu gospodarki odpadami (SWMP). Dokonano gruntownego przeglądu literatury w celu zidentyfikowania czynników ograniczających, które wpływają na narzędzie planu gospodarowania odpadami na terenie zakładu wytwarzającego odpady. Następnie przeprowadzono badanie ankietowe z formularzami, w których zastosowano pięciostopniową skalę Likerta. Pozyskane dane zostały poddane ocenie i analizie przy użyciu systemu IBM SPSS wersja 28. Wyniki badań ankietowych pokazały, że w polskim sektorze budowlanym wiedza na temat SWMP jest nadal bardzo niska. W kolejnych badaniach tylko 6% i 16% badanych podmiotów posiada program SWMP i odpowiednio używało tego narzędzia w którymkolwiek ze swoich poprzednich projektów. Wynika stąd potrzeba zwiększenia świadomości SWMP jako jednej ze strategii gospodarki odpadami. Jako główne ograniczenia uznano brak odpowiedniego monitorowania i kontroli programu SWMP, brak świadomości, czas potrzebny na przygotowanie narzędzia. Zaproponowane rozwiązania obejmują; podniesienie poziomu świadomości i edukacji, uwzględnienie SWMP jako elementu wymogu dokumentacji kontraktowej, odpowiednie przeszkolenie personelu budowy oraz obecność osoby zarządzającej odpadami.

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