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REAL ESTATE APPRAISAL USING THE LIQUIDATION COST METHOD – A CASE STUDY

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ABSTRACT

A real estate appraiser, using the liquidation cost method of the mixed approach in order to determine the value of real estate, analyzes, e.g. the value of post-demolition materials and the costs of liquidating components. The paper presents the problem of determining the costs of demolition works, which are correlated with the adopted demolition technology, the method of managing waste from post-demolition materials, and the costs incurred to maintain the occupational health and safety of employees and bystanders. Important elements of determining the demolition costs include the type of demolition waste and the relevant classification subgroup, the used demolition technology, and also the method of managing waste materials. The publication presents a calculation example that concerns the cost analysis of the demolition of a building structure. The demolition was performed using the mechanical method. The presented analyses cover different variants of carrying out works, whereas optimization refers to the different types of equipment used, available employee resources, and the various ways of recycling/managing post-demolition materials (storing, resale or processing). The conducted analyzes allow a multi-faceted approach to the subject matter to be obtained, and also an optimal solution to be selected by the participants of the investment process.

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1. Introduction

Real estate valuation can be carried out using the comparative, profitable or cost approaches, as well as the mixed approach, which contains elements of the previous approaches (art. 152 Act, 1997). A real estate valuer selects the appropriate approach, methods and techniques for assessing real estate, taking into account the purpose of the valuation, the type and location of the real estate, its purpose in the local plan, the condition of the real estate, and available data concerning the prices, income and features of similar real estate.

One of the methods of property valuation is the liquidation cost method. The paper focuses on the analysis of the total costs of demolishing the components of a piece of real estate. Such an analysis takes into account the adopted demolition technology, post-demolition waste management, and the costs of occupational health and safety (necessary to be incurred for the safe execution of works). Depending on the adopted assumptions, different final values can be obtained, which in turn allows an optimal solution for a conscious participant of the investment process to be found.

During the estimation of the costs of liquidation, when taking into account the possibility of recovering some building materials, it is not only the method of demolition, but also the method of managing construction waste that is of great importance. The largest percentage group of construction waste is concrete rubble. The quality of recycled aggregate, and the possibility of its use in new concrete, depend mainly on the properties of the original concrete and the technological treatment of the rubble, i.e. the degree of advancement of the techniques that are used for its processing. The technologies of concrete recycling that are most often described in literature involve the removal of cement mortar from the surface of aggregate (Shima et al, 2005), or the impregnation of the surface of a recycled aggregate (Tsujino et al, 2007). There are more and more studies concerning methods that allow for the comprehensive management of concrete rubble and its re-inclusion in the construction production process (Kalinowska-Wichrowska et al., 2020).

The authors therefore made an attempt to determine the optimal value of the costs of demolishing building objects, which took into account various variants of carrying out works (with the use of various equipment), the available employee resources, and also various methods of recycling and managing post-demolition materials. This aspect is important with regards to real estate valuation when using the mixed approach and the liquidation cost method. By knowing the "history" of the property, it is easier to choose the optimal solution. By having access to the library that was described by (Siniak, 2019), i.e. a regional database containing the characteristics and costs of resources and contractors, as well as the cost of renovation works of structural elements, the work of an appraiser would be a bit less complicated. Building Information Modelling (BIM), which is becoming more and more popular in Poland, helps to facilitate and accelerate the work of engineers, to organize information throughout the life cycle of an asset, to facilitate communication between the designers of different industries working on the same object, and to avoid collisions, etc. BIM is currently considered to be a collaborative process in which the professionals involved in a project use more than a 3D design system (the conception and definition phase of the life cycle of a building object). There are 4D models - scheduling, 5D - cost, 6D - sustainability, and 7D - operations and maintenance. These are tools for designing, constructing and managing buildings and properties throughout almost a full lifecycle of an asset. According to (Nowobilski et al, 2021) - the acronym "BIM" should be comprehensively understood as a process of creating and managing a building's data throughout its entire lifecycle. Therefore, it is possible that, in the future, we will have a model for the last phase of a structure - the liquidation phase.

2. Valuation procedure

2.1. General Principles of Valuation

If the subject of a valuation is a plot with a building structure in unsatisfactory, bad or emergency technical condition (see Podwórna, 2022), an expert, taking into account the purpose of the valuation may analyze the application of the mixed approach liquidation cost method. A property appraiser proceeds to estimate the value of a property after assuming that the object is suitable for liquidation, and also after justifying the legitimacy of the used method in the appraisal report.

Pursuant to Regulation (Act, 2004), the value of a piece of real estate, determined using the liquidation cost method, is equal to the cost of land acquisition, which is lowered by the costs of the liquidation of its components and the value of materials that are left after the liquidation of the land components. The valuation procedure can be presented as follows:

$$V = V_G - C_L + V_M, \tag{1}$$

where:

V - the value of the property determined using the liquidation cost method,

V_G - the market value of the right of perpetual usufruct and ownership, which is estimated using the comparative approach,

C_L - the costs of liquidating components, which are determined using the detailed technique, integrated element technique or indicator technique,

V_M - the value of the materials remaining after the liquidation of the land components.

It should be emphasized that the value of the materials is calculated as a potential value, because these materials are unsold at the moment of demolition (Liu et al, 2012).

The paper omits the problem of determining the market value of the right of perpetual usufruct and ownership, and instead focuses on the analysis of determining the total cost of liquidating a building structure$(C_L - V_M)$.

When determining the value of materials remaining after the liquidation of land components (W_M), it should be taken into account whether the materials can be prepared for their reuse. Such an operation is defined in Act (Act, 2012) *as the recovery of materials by checking, cleaning or repairing, during which products, or parts of products, which have become waste, are prepared so that they can be reused without any other pre-processing*.

The paper (Podwórna & Śniady, 2019) describes in detail the procedure for determining the replacement value of a building when using the cost approach in accordance with § 23 of Regulation (Act 2004), namely:

$$V_O = \left[\sum_{i=1}^{n}\left(J_i \cdot P_{j_i}\right)\right] \cdot (1 + c_a) \cdot c_r \tag{2}$$

where:

V_O - the replacement value of the building object,

i=1,…,n –the number of works J_i, which, depending on the adopted estimation technique, are as follows:

- using the detailed technique - the number of construction works that are necessary to perform,
- using the integrated element technique - the number of integrated elements of construction works,
- using the indicator technique - the number of reference units for which the price has been set, e.g. the volume or usable floor area of a building,

P_{j_i}– the catalogue prices of the relevant unitsJ_i,

c_a–the percentage coefficient of the documentation and supervision costs,

c_r –the regional coefficient.

The costs of demolishing a building can be written in a similar way, with the difference being that in the above equation, in the case of the cost approach for property valuation, construction works are taken into consideration (using the reconstruction or replacement costs method).In the case of the liquidation cost method, however, it is demolition works that are considered. Therefore, Equation (2) may take the form of Equation (3):

$$C_L = \left[\sum_{i=1}^{n}\left(J_{Li} \cdot P_{Lj_i}\right)\right] \cdot (1 + c_a) \cdot c_r \tag{3}$$

where:

C_L - the costs of liquidating components, which were determined using the detailed technique, integrated elements technique or indicator technique,

i=1,…,n – the number of works,

J_{Li} -the number of demolition works that are necessary to perform,

P_{Lj_i}– the catalogue prices of the relevant unitsJ_{Oi},

c_a–the percentage coefficient of additional costs e.g. the documentation and supervision costs,

c_r – the regional coefficient.

It should be noted, however, that the costs of the liquidation of components (C_L) also include:

- waste management costs, understood as (Act, 2012) *the collection, transport or treatment of waste, including sorting and the supervision of the above-mentioned activities, as well as the subsequent management of waste disposal sites, and also activities performed as a waste dealer or waste broker;*
- costs related to occupational health and safety, including, in particular: the costs of maintaining the occupational health and safety of employees hired for the demolition, the costs of securing the demolition site, and the costs of maintaining the safety of bystanders,
- other costs.

2.2. The problem of waste

In Poland, since 2021, waste generated during construction works is no longer classified as municipal waste, which, under previous regulations, required waste records to be kept (even by individuals). Act (Act, 2012) indicates that individuals who produce construction waste are exempt from keeping records of the waste. Selective collection of such waste, broken down into at least the following categories: wood, metals, glass, plastics, gypsum, mineral waste, as well as concrete, brick, tiles, and ceramic and stone materials, is required. This obligation does not apply to households (Act, 2012).According to Polish law regulations, building materials are assigned to group 17, which contains 9 subgroups of materials, i.e. waste from the construction, renovation and disassembly of buildings and road infrastructure, including soil from contaminated areas (Act, 2020). Moreover, some waste that comes from construction activities belongs to category Q16, which is defined in the Act from 2020: any substances or objects that are not included in the above categories (e.g. from service activities, renovation). It should be emphasized that some of the classified wastes are marked as hazardous wastes with the upper index "*", and are subject to a different method of being handled.

In the recovery and disposal of waste, an important element is the selection of appropriate processing technologies that allow for:

- the reuse of waste,
- the use of waste as a source of energy (in its various forms),
- the subjecting of waste to biological or chemical degradation processes.

Some recyclable waste may ultimately be profitable for an investor when the value of the sold demolition materials is greater than the total recycling costs. Recycling costs are valued outlays that are incurred during individual technological processes related to e.g. the transport, processing and sale of the processed product.

It should be emphasized that many of the recycling activities that are used may pose a threat to the natural environment through the emission of gases into the atmosphere and/or the contamination of groundwater or soil. Therefore, they generate additional emission costs.

Waste material must be properly dismantled, safely transported, and then processed or stored. Each waste requires an individual approach, including its appropriate classification in terms of: type, quality and quantity. This is because, on this basis, it is subjected to the fulfillment of requirements of the appropriate formal and legal procedures related to the given waste. It is also important to transfer recyclable waste to appropriate specialized entities. When it is not possible to use the generated waste, it should be stored. The landfilling of waste is associated with the so-called "landfill fee", the value of which depends on the category of waste (hazardous, nuisance, or inert) and the expected period of storage. In addition, the cost of such action is increased by the cost of transporting the material to a landfill, which depends on its location in relation to the site of the demolition works.

A part of the waste constitutes a direct cost, whereas another part cannot be attributed to specific activities. Therefore, these wastes constitute the general costs of demolition. In each case, the cost of waste disposal affects the performance of the contractor on a given construction site. (Anysz & Rogala, 2019).

2.3. The problem of safety

A significant element that determines the costs of demolition works are the costs related to ensuring appropriate health and safety conditions for the performance of works, including the costs of collective and personal protection.

The value of these costs depends on many factors, including (Drozd, 2017):

1. the area of impact of the works, i.e. the area around the investment being implemented, which is defined by the so-called “dangerous zone”,
2. the method of demolition, i.e. manually, mechanically, or using the explosive method, which is closely related to the area of the potential scattering of materials during demolition,
3. the ratio of the gross covered area of the dismantled buildings to the size of the construction site(the greater the density, the smaller the area of free land for the collection of waste, the organization of the workplace for communication roads, etc.),
4. the shaping of the surroundings of the construction site (neighboring buildings, public roads, trees, etc.).

It should be borne in mind that during the demolition of buildings there are numerous risk factors that not only negatively affect the people directly employed for the demolition of the buildings and those who are employed on the construction site, but also bystanders staying in the vicinity of the demolition. The most common risk factors include: dust, noise, vibration, risk of cut wounds, eye damage due to splintering of materials, electric shock, being crushed by falling elements, falling from heights, threats related to media and underground infrastructure, being hit by vehicles, etc. (Rawska-Skotniczny & Margazyn, 2016).

Most researchers analyze individual phases (from the stage of programming to the commissioning or exploitation stage) of a building's life cycle, and also their related costs. Some of them have noticed the need to extend their analysis to the liquidation stage (Plebankiewicz et al., 2016). Depending on the analyzed phase of a building's life, threats may result from, among others (Podwórna, 2022):

– the conception and definition phase:
  ▪ the immediate vicinity,
  ▪ the type of building object,
– the design and development phase:
  ▪ the possible design errors,
  ▪ the construction type,
– the production phase:
  ▪ the possible implementation errors,
  ▪ the used technologies,
  ▪ the used building materials,
– the operation and maintenance phase:
  ▪ the method of using the facility,
  ▪ the changes made to the facility,
  ▪ the technical condition of the facility,
– the liquidation phase:
  ▪ the demolition methods,
  ▪ the experience and knowledge of people directly involved in the demolition works.

3. Case study

When determining the value of real estate using the liquidation costs method (V), a real estate appraiser focuses his attention on estimating the value of the right of perpetual usufruct and ownership (V_G), estimating the costs of the liquidation of components (C_L) and estimating the value of the materials that were left behind after the liquidation (V_M) - see Equation (1). When determining liquidation costs, the amount of construction works that it is necessary to perform (J_{Li}) are estimated. Afterwards, using the available catalogues, the prices of these works (P_{Lji}) are established. The real estate appraiser then analyses local rates (c_r), and additional costs (c_a), e.g.related to securing the area - see Equation (3). It is important to consider local calculation rules, as well as regional market conditions. In addition, an expert estimates the market value of the post-demolition materials that can be recovered. An important element before estimating the costs of demolition is to determine the amount of waste from a given category, as well as the costs of its management in the case of recycling or storage. Only such an analysis (taking into account current prices) can be the starting point for adopting an appropriate variant of calculations. A full calculation of additional costs, which are related to ensuring occupational health and safety in the case of demolition works, is possible after analyzing many factors, including the size of the danger zone, the method of demolition, the ratio of the size of the dismantled objects to the size of the construction site, and the shape of the construction site's surroundings.

The subject of further analysis is the estimation of the optimal value of the total costs of the liquidation of a building object ($C_L - V_M$).

An exemplary analysis of demolition costs for four reinforced concrete office and warehouse buildings with a total building area of 2,050 m^2 and a total volume of 29,813 m^3, which are located in Wroclaw (Poland), is briefly presented below. The height of the buildings ranged from 5 to 23 m. After a preliminary analysis, it was assumed that the optimal method of demolition would be mechanical demolition. Two variants (differing in the size and type of equipment used) were adopted for a detailed analysis. Variant I proposed a demolition using a large-reach excavator with crushing shears, while variant II proposed a small-reach excavator and the employment of two mountaineers for the work. The cost analysis showed that option II generated higher financial outlays related to the occupational health and safety of employees (the work of 6 blue-collar workers was assumed), which included personal protective equipment for the mountaineers (the work of 5 mountaineers was assumed) and also collective protection. Occupational health and safety costs in this type of work include, among others, the construction of appropriate fencing around the construction site, the designation of hazardous zones and landfills, and the organization of social containers for employees (in option I - one container is enough for 6 employees, and in option II - at least two social containers are needed for 11 people, which is over€200 more). An additional criterion for the adopted assessment of the demolition variants was the analysis of the reduction of costs due to the processing (recycling) and reselling of selected recovered materials. These factors were marked as subvariants Ib and IIb. The mining method was omitted in the analysis presented in the article due to the very high costs of both demolition and providing health and safety. The type of the analyzed demolition variants are shown in Figure 1.

	large excavator	*small excavator & mountaineers*
storage	VARIANT **I a**	VARIANT **II a**
recycling	VARIANT **I b**	VARIANT **II b**

Fig. 1. Analyzed variants of the demolition. *Source*: own elaboration.

A brief overview of the estimated values in four demolition variants is presented in Table 1.

Table 1

Costs for four variants of demolition (in Euros)

Variants of demolition	Costs of the liquidation of the components of real estate
Variant Ia (large excavator/storage)	€ 142 000
Variant Ib (large excavator/recycling)	€ 118 600
Variant IIa (small excavator and mountain climbers/storage)	€ 160 900
Variant IIb (small excavator and mountain climbers/recycling)	€ 137 500

Source: based on (Podwórna & Sawicki 2022).

When analyzing Table 1, it was found that the most expensive method of demolition by far, in relation to the costs of liquidation C_L, is variant IIa with small equipment, five mountain climbers and without the recycling of building materials. The most financially advantageous solution is variant Ib, i.e. with large equipment and the recycling of demolition materials.

4. Discussion

The differences in the values presented in Table 1 are large (over € 40,000), and therefore the discussion covers the cost range of individual works. The values of individual costs were subjected to a detailed analysis and presented with regards to prices in Euros(Table 2) and percentages (Table 3). Figure 2 shows the average type of costs.

Table 2

Values of individual costs in terms of Euro prices

Cost component	Variant Ia		Variant Ib		Variant IIa		Variant II b	
Costs of the demolition of building objects C_L	**€**	**142.0**	**€**	**118.6**	**€**	**160.9**	**€**	**137.5**
including:								
costs related to the operation of demolishing equipment	€	44.3	€	44.3	€	53.6	€	53.7
labor costs (including health and safety costs)	€	18.2	€	18.2	€	27.7	€	27.7
costs related to waste, in particular:	€	79.6	€	56.1	€	79.6	€	56.1
·garbage disposal,	€	31.3	€	31.3	€	31.3	€	31.3
·crushing rubble,			€	15.7			€	15.7
·sifting rubble			€	5.7			€	5.7
·the total disposal of rubble	€	44.8			€	44.8		
· the loading of waste and its heap dumping	€	3.5	€	3.5	€	3.5	€	3.5
The value of demolition materials V_M	**€**	**65.7**	**€**	**81.4**	**€**	**65.7**	**€**	**81.4**
including:								
·aggregate			€	15.8			€	15.8
·steel	€	65.7	€	65.7	€	65.7	€	65.7
The value of the total costs of the liquidation of building facilities $(C_L - V_M)$	**€**	**76.3**	**€**	**37.2**	**€**	**95.2**	**€**	**56.1**

Source: own elaboration.

Table 3

Values of individual costs C_L in percentages

Type of costs	**Variant Ia**	**Variant Ib**	**Variant IIa**	**Variant II b**
Costs related to waste	56.0%	47.3%	49.5%	40.8%
Costs related to the operation Of demolishing equipment	31.2%	37.4%	33.3%	39.1%
Labor costs	4.3%	5.3%	8.5%	10.2%
Administration costs	4.6%	5.8%	3.7%	4.6%
Supervision costs	1.4%	1.5%	1.6%	1.6%
Health and safety costs	2.0%	2.2%	3.0%	3.2%
Documentation costs	0.5%	0.5%	0.5%	0.5%
Total	100%	100%	100%	100%

Source: own elaboration.

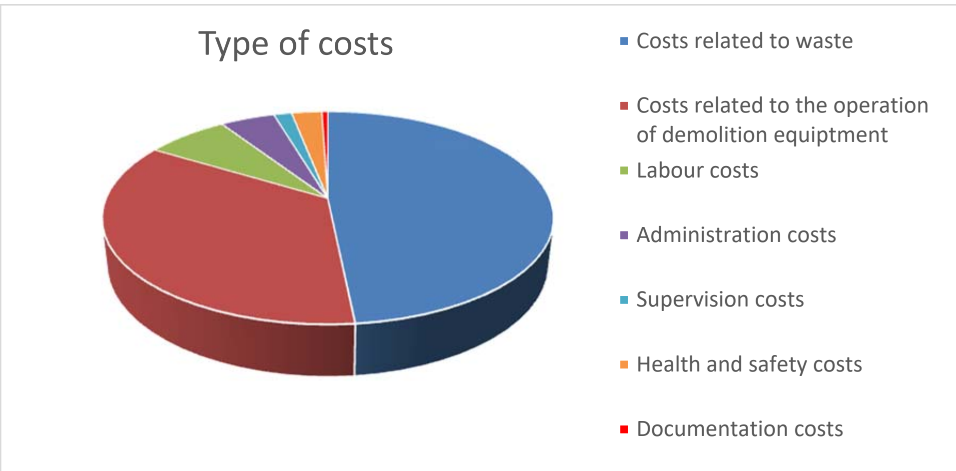

Fig. 2. Average type of costs. *Source*: own elaboration.

When comparing the considered methods of demolition, it can be seen that the most advantageous method in terms of the value of profit is variant Ib i.e., mechanical demolition and the sale of concrete aggregate and steel. In this case, despite the generation of costs related to the crushing and screening of aggregate, no additional costs related to the disposal of rubble are incurred. The screening process is more beneficial for the investor. Variants Ia and Ib are also more favorable in terms of time. Variant I assumed work for 5 days a week, i.e. from Monday to Friday, and in variant II, the demolition works were planned for 6 days a week. This is due to the fact that in variants IIa and IIb, five climbers work on the demolition of the roof of the tallest building for the first week. Therefore, in variant II, the total time for the execution of works is extended by 20%, which in turn results in higher costs related to the ensuring of health and safety (a longer time of works translates into a longer time of renting social facilities, securing the works, protecting the construction site, and others). Moreover, in favor of the implementation of variant Ib is the fact that there is no need to employ mountaineering workers for part of the work, the estimated hourly rate of whom is several times higher than the work of a construction worker - not to mention the significantly higher costs of providing occupational health and safety.

When analyzing the percentages of individual costs, it was found that the largest share in the demolition costs are costs related to the management of construction waste (approximately 50%), followed by equipment and labor costs (40%), with additional costs amounting to up to 10% of the demolition costs.

In turn, the proper management of construction waste may generate an income of 40-70% of the costs of demolishing buildings.

5. Conclusions

Unfortunately, similarly to people, everything ages, including building objects (Podwórna, 2022). The last moment of a building's life is its demolition, but the property then has a second life. Demolition works are often classified as being particularly dangerous, not only due to the adopted technologies of demolition, but also due to the objects being demolished, which may involve various hazards (Rawska-Skotniczny & Margazyn, 2016). Threats can arise at any stage of the life cycle of a building and can be a significant obstacle during demolition works.

To put it simply, it can be assumed that the current demolition prices range from €4-40/m^3 of the building's volume, and differ with regards to the size of the facility, type of demolition material, method of waste management (storage or recycling), demolition technology (manual or mechanized), and OHS costs. The cost of demolition works depends on many factors, including:

- the type and size of the building facility,
- the location (access to the facility, its surroundings),
- the technical condition of the facility,
- the construction technology and materials which the facility is built from,
- the amount and type of waste obtained in the demolition process with regards to:
  - recyclable materials,
  - materials that can only be stored,
  - whether hazardous materials require both special actions and the incurring of additional costs,
- the distance from the demolition site to the disposal or recycling site.

It should be noted that the demolition of a building facility is subjected to the provisions of Act (Act, 1994). This legal act specifies what formalities must be completed before the start of demolition works, e.g. which objects can be dismantled after obtaining a demolition permit, which ones can be dismantled after submitting a notification, and in what situations can demolition works be conducted without any formalities.

According to the research presented in the paper regarding the two variants of demolishing industrial facilities, an attempt was made to optimize the technological and organizational solutions for the task in question. The main difference between the presented variants concerns the number of people employed and the size of the equipment used. In the variant with the use of more workers, 5 climbers were employed in the initial period for demolishing the roof structure of the high-rise building (instead of using an excavator with high-performance demolition equipment). The variant without the mountain climbers had a smaller number of employees, but the demolition equipment had to have better parameters and was thus more expensive. An important element included in the modification of the variants was the consideration of waste management: disposal or processing. Everything was included in the demolition cost analysis.

This study highlighted the fact that a property appraiser, when deciding to evaluate real estate using the liquidation cost method, should take into account all the above aspects when analyzing the value of materials left behind after liquidation and the costs of liquidating land components. The authors proved that the differences in values can be very large, and that the task of a property appraiser is to map the behavior of a conscious and prudent market participant who does not act in a forced situation.

References

Anysz, H., & Rogala, W. (2019). Sensitivity analysis of the contractor's financial effects achieved on a single building site. *Przeglad Naukowy Inzynieria i Ksztaltowanie Srodowiska, 28*(2), 183–191. https://doi.org/10.22630/PNIKS.2019.28.2.17

Drozd, W. (2017). Analysis of cost regression and post-accident absence. *AIP Conference Proceedings, 1863*, 230004. https://doi.org/10.1063/1.4992389

Kalinowska-Wichrowska, K., Pawluczuk, E., & Bołtryk, M. (2020). Waste-free technology for recycling concrete ruble. *Construction & Building Materials, 234*, 117407. https://doi.org/10.1016/j.conbuildmat.2019.117407

Liu, C., Lyle, B., & Langston, C. (2012). Estimating demolition costs for single residential buildings. *The Australasian Journal of Construction Economics and Building, 3*(2), 33–42. https://doi.org/10.5130/AJCEB.v3i2.2917

Nowobilski, T., Sawicki, M., & Szóstak, M. (2021). BIM in Polish public tenders-analysis of selected tender procedures. In: Zembaty, Z., Beben, D., Perkowski, Z., Rak, A., Bosco, G., Solanki, P. (eds) *Environmental Challenges in Civil Engineering*. ECCE 2020. Lecture Notes in Civil Engineering, vol 122. Springer, Cham.https://doi.org/10.1007/978-3-030-63879-5_14

Plebankiewicz, E., Zima, K., & Wieczorek, D. (2016). Life cycle cost modelling of buildings with consideration of the risk. *Archives Of Civil Engineering, 62*(2), 149–166. Advance online publication. https://doi.org/10.1515/ace-2015-0071

Podwórna M., Sawicki M. (2022). Koszty likwidacji obiektu budowlanego z uwzględnieniem bezpieczeństwa pracy (Construction decommissioning costs taking into account work safety). *Przegląd budowlany* 9-10/2022, s.126-129. https://doi.org/10.2478/remav-2022-0016.

Podwórna, M. (2022). The aging of a building versus its life cycle with regards to real estate appraisal. *Real Estate Management and Valuation*. vol. 30, nr 2, s. 84-95. https://doi.org/10.2478/remav-2022-0016

Podwórna, M., & Śniady, P. (2019). The value of a building – decision analysis, *IOP Conf. Series: Materials Science and Engineering* 661. https://doi.org/10.1088/1757-899X/661/1/012115

Rawska-Skotniczny, A., & Margazyn, A. (2016). Rozbiórki budynków i budowli (Demolition of buildings and structures). Wydawnictwo Naukowe PWN SA.

Shima, H., Tateyashiki, H., Matsuhashi, R., & Yoshida, Y. (2005). An advanced concrete recycling technology and its applicability assessment through input-output analysis. *Journal of Advanced Concrete Technology, 3*, 53–67. https://doi.org/10.3151/jact.3.53

Siniak, N., Źróbek, S., Nikolaiev, V., & Shavrov, S. (2019). Building Information Modeling for Housing Renovation - Example for Ukraine. *Real Estate Management and Valuation, 27*(2), 97–107. https://doi.org/10.2478/remav-2019-0018

Tsujino M.,Noguchi T.,Tamura M., Kanematsu M.,Maruyama I. (2007). Application of conventionally recycled coarse aggregate to concerte by surface modification treatment. *Journal of Advanced Concrete Technology*. No 5(1), https://doi.org/10.3151/jact.5.13.

Rozporządzenie Rady Ministrów z dnia 21 września 2004 r. *w sprawie wyceny nieruchomości i sporządzania operatu szacunkowego,*t.j. Dz. U. z2021r. poz. 555.(*Act concerning the valuation of real estate and drawing up an appraisal report*)

Rozporządzenie Ministra Klimatu z dnia 2 stycznia 2020 r. *w sprawie katalogu odpadów,* Dz. U. z 2020 r. poz. 10. (*Actconcerning the catalogue of waste*)

Ustawaz dnia 21 sierpnia 1997 r.*o gospodarce nieruchomościami,* t.j. Dz. U. z 2023r. poz. 344.(*Actconcerning real estate management*)

Ustawa z dnia 7 lipca 1994 *Prawo budowlane,* t.j. Dz. U. z 2021 r., poz. 2351, z późn. zm. (*Construction Law*)

Ustawa z dnia 14 grudnia 2012 r. *o odpadach*, t.j. Dz. U. z 2022 r. poz. 699, z późn. zm.(*Actconcerning waste*).