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# Selected aspects of determining of building facility deterioration for real estate valuation

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**Abstract**

Deterioration of real estate and forecast of the remaining period of its service life are important parameters for the real estate valuation process. In the literature we can find several formulas which determine the deterioration degree depending on the period length of building facility service life. However, as shown by the analysis conducted in this paper, the authors obtained the mixed results depending on the taken approach. Thus, the following questions arise: what to look for when choosing a formula and what degree of risk is associated with the determination of the deterioration degree. It is well-known that the deterioration is influenced by many factors. However for its determination it is required knowledge about its course, character and period of previous service life, carried out repairs, major repairs and modernizations, as well as used materials and durability of a building facility. From the perspective of the analyzes, it seems appropriate to take further researches towards developing of a procedure that will allow to select one of the available formulas, due to the pre-determined parameters (e.g. the quality of building facility maintenance).


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*Keywords:* building facility deterioration, life cycyle, deterioration degree, real estate valuation process.

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## 1. Introduction

Regardless of the school of the real estate valuation, real estate deterioration, and practically building facilities deterioration, as the components of real estates, is an important parameter under all approaches.

In the comparative approach – deterioration is usually a very important feature, which differentiates the compared real estate's; in the income approach – deterioration affects the forecasted profitability of real estate; in the cost approach – deterioration is a measure of the value loss of buildings and other building facilities resulting from their technical condition, functional state and environmental factors.

The determination of deterioration degree requires knowledge about the course, character and period of the previous service life, carried out: repairs, major repairs, and modernizations, as well as building facility durability, or (in the case of detailed techniques) – about the durability of some particular elements of a building and used materials. The quality of carried out construction work and design defects affect the technical deterioration.

The determination of the assumed durability (understood as the left, expected period of service life), in particular for building facilities that are in use, is objectively difficult and requires both the theoretical knowledge and the construction experience.

The time methods are most commonly used methods, which take various forms depending on the degree of building facility maintenance. However, these forms have some estimated character and express the overall trend for the group of building facilities with the similar age and the similar structure. In contrast, the method which are more time-consuming and which require more working time effort such as the visual method, the limit states method or the economic indicators method give a more accurate picture of the building facility deterioration.

In the economic dimension, the deterioration degree is related to the maintenance costs of service life efficiency of a building which, under its life cycle, are subject to change resulting from both the growing needs of maintenance, repair as well as the prices volatility of the building production factors.

The aim of this paper is a review of considered in the literature categories of building facilities deterioration and analysis of the concept of measuring of the deterioration degree (on the background of their life cycle) from the point of view of usefulness for the real estate valuation process.

## 2. Types and causes of deterioration of building facilities

Deterioration means a loss of the estimated value of a real estate resulting from its technical (physical), functional (utility) and environmental deterioration. Deterioration of building elements is the result of many factors, including: design mistakes, assembling defects, materials defects, and incorrect service/maintenance of a building facility. However, the process of element deterioration is caused by the aging of materials over the years, changing of materials structure as a result of their work, damage due to external factors. The life cycle of each element is different because they deteriorate unevenly. In the following works [1, 2, 6, 7, 11-13, 15, 24-28] the problem of determination of the deterioration degree and its impact on the cost of life cycle of a building facility is broader and more specifically discussed.

Table 1. Causes of deterioration [Source: authors' work]

| Technical deterioration | Functional deterioration | Environmental deterioration |
|---|---|---|
| • age of a building facility,<br>• durability of used materials,<br>• quality of construction/assembling work,<br>• usage and service life conditions.<br>• design mistakes,<br>• maintenance/repair management, etc. | • comparison of used (in a given case) design utility solutions to the currently preferred ones (estimation of modernity)<br>• comparison of workmanship standard and furnishing in the technical equipments,<br>• results from the special purpose obstructing or preventing changes in the use. | • doing or planning changes in the real estate environment causing a nuisance in the use of the property, such as: construction of industrial plants in the neighbourhood of the estimated real estate, roads with heavy traffic, tram lines, unregulated watercourse, etc.,<br>• conducting or planning in the area near a real estate mining activities causing permanent damage to the property,<br>• destroyed effects of ecologically harmful |

| | |
|---|---|
| | environment on the durability of building facilities and the quality of the land. |

The determination of deterioration degree requires knowledge about:

- carried out: repairs, renovations and modernizations, as well as building facility durability,
- the durability of some particular elements of a building and used materials.
- the course, character and period of the previous service life.

The quality of carried out construction work and design defects affect the technical deterioration.

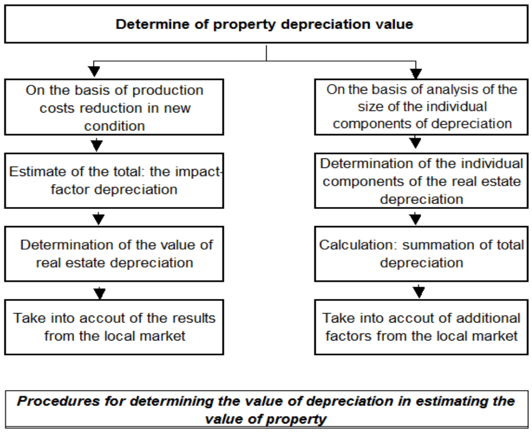



Fig. 1. The basis for determining the value of real estate deterioration; [Source: [24]]

## 3. Rules for determining the deterioration degree of building facilities

### 3.1. *Durability of element/building and deterioration degree*

Building facilities consist of many elements, which are characterized by varying degrees of technical deterioration. The duration of service life is also linked to a lot of factors and diversity of their interactions. All these factors cause difficulties in predicting durability and course of service life. The analysis requires knowledge about behaviour of building elements, materials and equipments during their service life as well as the knowledge about their service life periods. This knowledge allows making the optimal choices at the designing stage. It is necessary that the structural elements have the longer durability than the assumed building facility durability. The durability of finishing elements and equipment elements is usually shorter because they require more frequent replacements or repairs during their service life [2]. The term "durability" means the ability of a building facility to maintain the established service life requirements within the specified period of time, whereby it is required the lack of excessive maintenance costs and lowering of the functional value of a building facility. In contrast, the durability is related to the term "deterioration". The concept of deterioration is related to the loss of the estimated value of a property due to the technical (physical) and functional (utility) and environmental deterioration. The technical deterioration refers to the age of a building facility, the durability of used materials, designing mistakes and quality of construction/assembling work, usage and service life conditions. This results in a value decrease of a property. The lower durability, the faster determination, and hence the frequent repairs or replacements if necessary. This, in turn, affects the lifecycle costs of a building [20-21].

### 3.2. Methods of determination of deterioration degree

The commonly used methods of the determination of building technical deterioration do not always meet the users' expectations, because the obtained results are only the estimated values. Depending on the chosen method of solution they might be burdened with lower accuracy, require a lot of work and expert opinion in the field. Currently, the new methods are being sought which (when considering the technical deterioration of building facilities) will determine its current value and will assess the future changes. The time methods are the most widespread and the most commonly used, they take various forms depending on the degree of building facility maintenance. Such form of determination of the technical deterioration may be approximate and reflect the overall trend expressed mostly for a group of building facilities with the comparable age and similar structures. The time method is based on the assumption that the technical deterioration increases in time and fundamentally depends on the maintenance accuracy of materials used in a building facility.

In the literature and in practice the following formulas are used for measuring of the technical deterioration (including the time methods): Ross, Eytelwein, Unger, Romstorfen) and the functional deterioration.

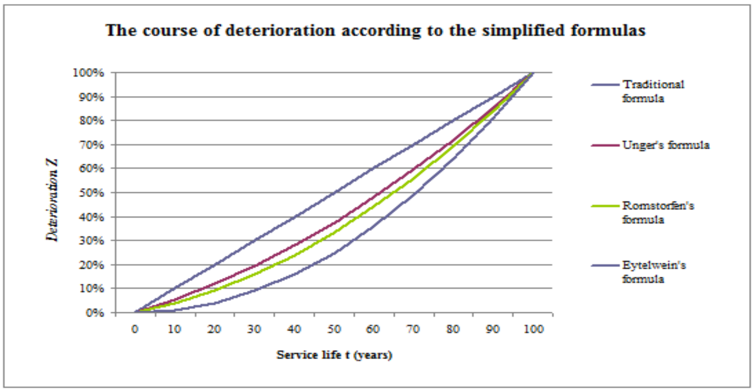



Fig. 2. The course of depreciation according to the simplified formulas
[Source: authors' work]

### 3.3. Determination of the expected period of further service life

The theoretical deterioration rate, however, often diverges from the deterioration $Z_0$ which can be concluded based on the analysis of a building facility. The determination of further period of service life is possible using all formulas.

Thus, using a rule of proportionality, $Z=t/T$ in case when after $t$-years of service life the deterioration is $Z_0$ it can be inferred that, in the same way of service life, the modified period of durability is:

$$T_m = \frac{t}{Z_0}$$

and therefore the expected period of further service life can be estimated as:

$$t_p = T_m - t = t \cdot \left( \frac{1}{Z_0} - 1 \right)$$

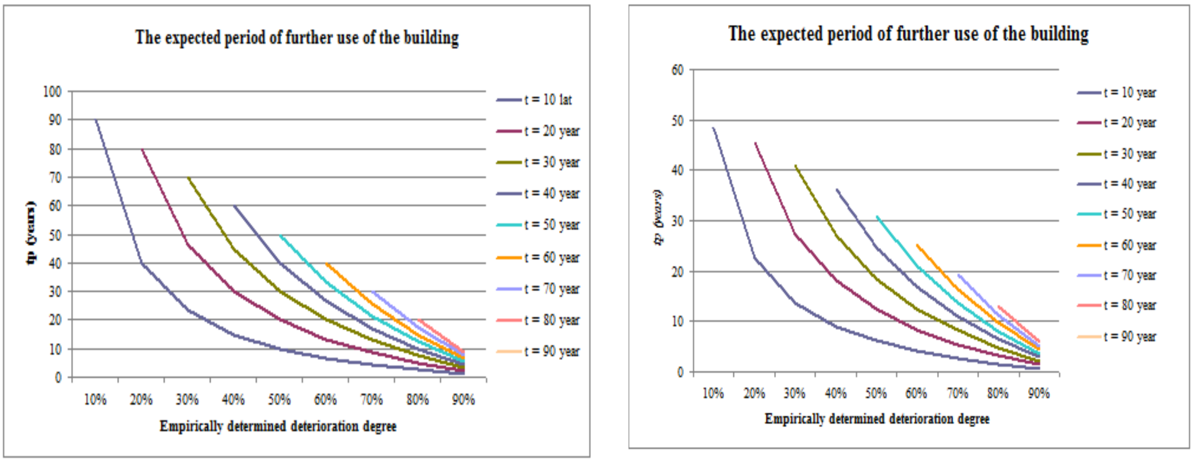
The expected period of further service life is (in this case) the difference of the hypothetical durability period ($T_m$) and the existing period of service life (t): $t_p = T_m - t$

In the case of the other formulas, the calculation is done similarly, wherein because of the forms of the parameters it is required each time the solution of the quadratic equation – the results of the calculations are presented in the following table. In contrast, the dependences presented in the second column of Table 2 are shown in Figure 3 and in Figure 4.

Table 2. Formulas for determining of deterioration; [Source: authors' work]

| **Formula to determine deterioration** | | **Expected period of further service life** |
|---|---|---|
| 1 | | 2 |
| **Traditional** (bad maintenance of building) | $Z=\frac{t}{T}$ | $t_p=t\cdot\left(\frac{1}{Z_0}-1\right)$ |
| **Unger** (average good maintenance of building) | $Z=\frac{t\cdot(t+T)}{2T^2}$ | $t_p=t\cdot\left(\frac{1+\sqrt{1+8Z_0}}{4Z_0}-1\right)$ |
| **Romstorfen** (more than average good maintenance of building) | $Z=\frac{t\cdot(2t+T)}{3T^2}$ | $t_p=t\cdot\left(\frac{1+\sqrt{1+24Z_0}}{6Z_0}-1\right)$ |
| **Eytelwein** (very careful maintenance of building) | $Z=\frac{t^2}{T^2}$ | $t_p=t\cdot\left(\frac{1}{\sqrt{Z_0}}-1\right)$ |

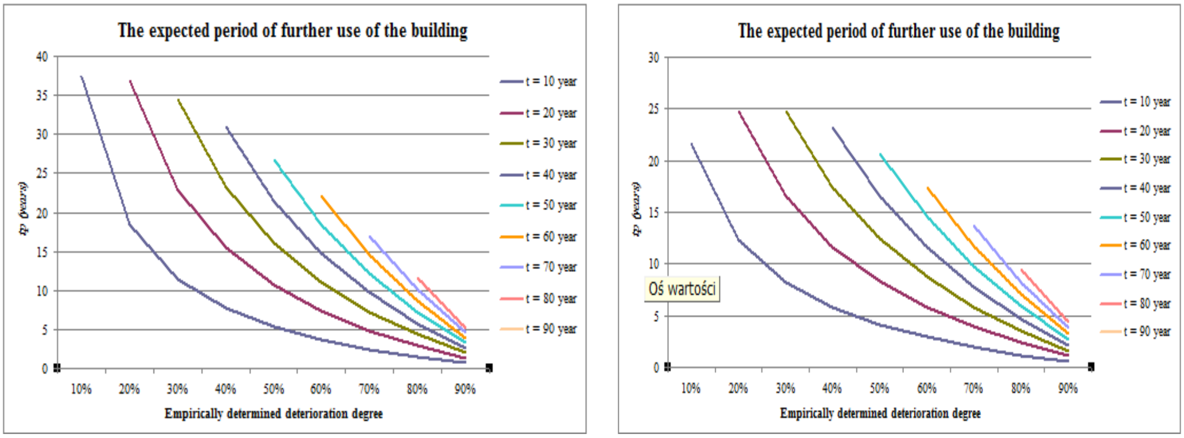
Symbols:
$Z$ – calculated deterioration degree
$Z_0$ – detected deterioration degree
$t$ – existing period of service life
T – duration period
$t_p$ – expected period of further service life




a) Traditional formula

b) Unger's formula

Fig. 3. Expected period of further service life of a building determined by using: a) traditional formula, b) Unger's formula; [Source: authors' work]




a) Romstorfen's formula b) Eytelwein's formula

Fig. 4. Expected period of further service life of a building determined by using: a) Romstorfen's formula, b) Eytelwein's formula; [Source: authors' work]

## 4. Risk in determining deterioration degree

The problem of risk is relatively often raised in the case of construction projects due to the randomness of the phenomenon. The literature presents numerous examples of the risk analysis [3, 5, 8-10, 14, 17-19, 22-23]. The elements of risk can be found in estimation of time and cost of construction work, but also in a situation when the further period of building service life must be predicted. It is extremely important in the real estate valuation. Analyzing the Figure 5 we can see a significant discrepancy among the results using the various formulas. To illustrate the differences the authors determined the expected period of the further service life for the existing service life of 30 years. The significant differences in estimation are shown to 70% of deterioration. For t=30 and at 40% deterioration degree the further period of service life (depending on the formulas) ranges from 17-45 years.

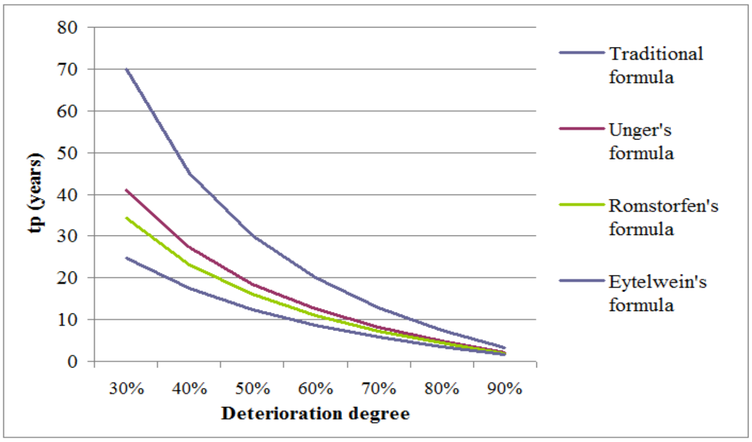



Fig. 5. Comparison of expected period of further service life of a building determined by using different formulas (for t=30 years ): a) Romstorfen's formula, b) Eytelwein's formula; [Source: authors' work]

## 5. Conclusion

The determination of deterioration degree of a building as well as the further period of its service life require the knowledge of the past service life, the number and frequency of carried out repairs, the environment in which the building is located, etc. The preliminary analyses show that these factors have a significant impact for estimation. The most restrictive in predicting a further period of service life of the building ($t_p$) is the Eytelwein's formula as opposed to the traditional formula. The result $t_p$ for the traditional formula in 30% of the deterioration for the assumed existing period of service life at t=10 years is 23 years, and at t = 30 years is 70 years. In contrast, the Eytelwein's formula for the same parameters determines 8 and 23 years, respectively. Therefore, it seems important to establish a procedure allowing the choice of a particular formula in relation to the predefined criteria, e.g. number of repairs, repairs values or quality of used materials in terms of their durability.

## References

[1] A. Dziadosz, The influence of solutions adopted at the stage of planning the building investment on the accuracy of cost estimation, Procedia Engineering 54 (2013) 625–635.
[2] J. Dębowski, Problematyka określania stopnia zużycia technicznego budynków wielkopłytowych [online]. Kraków: Wydawnictwo Politechniki Krakowskiej, 2007.
[3] O. Kapliński, Risk Management of Construction Works by Means of the Utility Theory: a Case Study. Procedia Engineering 57 (2013) 533-539.
[4] O. Kapliński, The Utility Theory in Maintenance and Repair Strategy. Procedia Engineering. 2013, 54, 604-614.
[5] O. Kapliński, Risk analysis of construction projects: From risk identification to contingency timetable. SEMC 2010: The Fourth International Conference on Structural Engineering, Mechanics and Computation, Cape Town, South Africa, 6-8 September 2010. [w] A. Zingoni (Ed.), Advances and Trends in Structural Engineering, Mechanics and Computation, CRS Press Balkema, Taylor & Francis Group, London 2010. Abstract: 268, paper CD: 1051-1054 (ISBN 978-0-415-58472-2).
[6] T. Kasprowicz, Proces analizy koncepcyjnej, projektowania, organizacji i realizacji przedsięwzięć budowlanych, Czasopismo Techniczne. Technical Transactions, z. 1-B, 177-189, 2010.
[7] P. Knyziak, Propozycja nowej metody określania zużycia technicznego budynków, Problemy naukowo badawcze budownictwa, tom V, Wydawnictwo Politechniki Białostockiej, Białystok 2008, s.573-580.
[8] D., Kuchta, D. Skorupka, Project risk management taking into consideration the influence of various risk levels based on linguistic approach. World Scientific Proc. Series on Computer Engineering and Information Science 7; Uncertainty Modeling in Knowledge Engineering and Decision Making - Proceedings of the 10th International FLINS Conf. 7, (2012)1093-1098.
[9] E. Marcinkowska, M. Rejment, Effect of risk on economic efficiency of overcladding system, Journal of Civil Engineering and Management 12 (3) (2006) 247-253.
[10] W. Meszek, A. Dziadosz, Wpływ nieefektywności rynku nieruchomości na dokładność opisu wartości nieruchomości za pomocą liniowych modeli regresji wielorakiej, Budownictwo i Inżynieria Środowiska, 2011, Vol. 2, No. 4.
[11] Z. Orłowski, N. Szklennik, Analiza wartości użytkowej budynku w funkcji czasu, Technical Transactions, Civil Engineering, 1-B (2010) 303-312.
[12] Z. Orłowski, Wybrane aspekty właściwości uzytkowych budynku w okresie jego eksploatacji, Przeglad Budowlany, 10 (2011), 36-43.
[13] S. Owczarek, Z. Orłowski, N. Szklennik, Koncepcja systemowej oceny zużycia budynków, Prace Naukowe Instytutu Budownictwa Politechniki Wrocławskiej 87. Studia i Materiały 18, Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław 2006, 341-346.
[14] J. Pasławki, M. Róźdżyńska, Flexible approach in infrastructure design buffer Parking Case Study, Procedia Engineering, 57 (2013), 882-888.
[15] M. Prystupa, Problematyka oceny stanu technicznego obiektów budowlanych w wycenie nieruchomosci, VIII Konferencja Naukowo-Techniczna, Cedzyna 2004.
[16] M. Rejment, A. Dziadosz, Selected aspects of construction project selection including risk estimation, Technical Transactions, Civil Engineering, 1-B (2014) 221-228.
[17] S. Shevchenko, L. Ustinovichius, A. Andruskevicius, Multi-attribute analysis of investment risk alternatives in construction, Technological end Economic Development of Economy 14 (3) (2008) 428-443.
[18] D. Skorupka, Modelling of risk in the building projects, Operations Research and Decisions, Wroclaw University of Technology, Wrocław 3 (2006) 133- 143.
[19] Z. Turskis, M. Gajzler, A. Dziadosz, Reliability, Risk Management and contingency of construction processes and projects, Journal of Civil Engineering and Management 18(2) (2012) 290–298.
[20] E.K. Zavadskas; A. Kaklauskas, N. Kvederyte, Multivariant Design and Multiple Criteria Analysis of a Building Life Cycle, Informatica, Vol. 12, No. 1 (2001), pp.169–188.
[21] E.K. Zavadskas; A. Kaklauskas, A. Andrukevičius, P Vainiūnas, N. Banaitienė, Model for an integrated analysis of a building's life cycle, in CDVE 2005, Lecture Notes in Computer Science 3675: (2005) 218–226.

[22] E.K. Zavadskas, L. Ustinovichius, A. Stasiulionis, Multicriteria valuation of commercial construction projects for investment purposes, Journal of Civil Engineering and Management 10 (2) (2004), 151-166.
[23] E.K. Zavadskas, Z. Turskis., J. Tamošaitiene, J., Risk assessment of construction projects, Journal of Civil Engineering and Management 16 (1) (2010) 33-46.
[24] R. Źróbek, Tcheoretical and methodical aspects of assessing of real estate depreciation, Studia i Materiały Towarzystwa Naukowego Nieruchomości, JOURNAL OF THE POLISH REAL ESTATE SCIENTIFIC SOCIETY Olsztyn, 17 (1) (2009), 81-92.
[25] S. Źróbek , R. Źróbek, Some principles and procedures of the cost approach to real estate value, Selected aspects of the cost approach in proprty valuation, THE POLISH REAL ESTATE SCIENTIFIC SOCIETY, Scientyfic Monograph, Olsztyn, (2011), 25-40.
[26] PN-ISO 15686-1. 2005 Budynki i budowle. Planowanie okresu użytkowania. Część 1: Zasady ogólne.
[27] PN-ISO 15686-2. 2005 Budynki i budowle. Planowanie okresu użytkowania. Część 2: Procedury związane z przewidywaniem okresu użytkowania.
[28] PN-ISO 15686-3. 2005 Budynki i budowle. Planowanie okresu użytkowania. Część 3: Audyty i przeglądy właściwości użytkowych.