Stone Works Valuation within Immovable Cultural Heritage Monuments Restoration

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Abstract. Historic buildings and their stone parts represent both specific functional architectural features of constructions and important aspects of the cultural heritage. They provide important and valuable proof of development, style, and architecture, level of decorative art, and material processing techniques. However, these historic buildings need restoration so that their legacy can be preserved for future generations. The quality of restoration work tends to be closely related to work price. At present, however, prices for the restoration of stone parts of historic buildings are determined intuitively, based on their complexity, uniqueness, and specificity of restoration work. The valuation of restoration work is therefore carried out mainly by the private sector, based on the experience of individual budgeters and restorers. Due to the fact that the limits of the maximum and minimum scope of individual actions are not set, incorrect valuation can occur, which, in the case of subsequent implementation, may damage, or even in fact damages, the restoration activity as such. Based on this, the article deals with valuation of stone works restoration in real historic structures. It introduces and describes the proposal for systematic classification of these types of work, the procedure for setting standards for time units and consequently the proposal of formula structure for calculating costs and prices. The aim of the article is to introduce the use of standardised procedures for pricing of stone works restoration and thereby create a comparative and cost bases in order to make a qualified choice of restoration specialists.

1. Introduction

Historic buildings and their stone masonry parts represent both specific functional architectural features of the buildings and an important part of the cultural heritage. They provide significant and valuable proof of development, morphology and architecture design, level of artistic decoration, and materials processing method.

Work associated with the preservation and use of such buildings, at the level of current knowledge and functional and aesthetic requirements, is associated with the expenditure of significant funds. There are currently approximately 300 national cultural monuments and approximately 40,000 immovable cultural monuments in the Czech Republic.

However, the prices for the restoration of stone masonry parts of buildings are often set only intuitively due to their complexity, uniqueness, and special character of the work. The state of

valuation of restoration work is currently set up mainly by the private sector, based on the experience of individual budgeters and restorers. Due to the fact that the limits of the maximum and minimum range of individual actions are not set, incorrect valuation can occur, which in the case of subsequent implementation may damage, or even in fact damages, the restoration activity as such.

The paper focuses on the presentation of the proposal of systematic classification and categorization of these types of work, on the process of setting time standards, and subsequently on the calculation formula structure and the calculation of costs and prices themselves. The method of setting the standard for a given process is introduced with an example of creating a database of prices of selected restoration stone works.

2. Research methods

Restoration is generally understood as a set of specific artistic, artisanal and technical acts and processes that respect the material and artistic structure of the original. Unlike conservation, however, their preserved appearance can be changed. In the Czech Republic, every restoration, reconstruction, renewal, or maintenance of a cultural monument is governed by the Act of the Czech National Council No. 20/1987 Coll., on State monument care, as amended.

Given that there is still no relevant comparative scientific literature or a specific field-binding procedure for calculating the costs and prices of restoration work, it was necessary, among other things, to gather a large amount of information to develop a methodology. Subsequently, it was essential to compare selected identical implemented individual restoration operations and activities and to interlink the area of valuation of construction production with the area of restoration.

The research methodology for the purposes of creating an applicable "branch calculation formula", had to focus on determining and analysing the following issues:
- Technical documentation of the construction,
- Classification and categorization of stone masonry works for the purposes of restoration,
- Calculation formula structure,
- Performance standard setting,
- Material consumption determination.

Crucial and at the same time the most difficult step for the needs of creating a branch calculation formula was classification and categorization of stone masonry works.

2.1. Classification and categorization of stone masonry works for the purposes of restoration

2.1.1. Types of restoration work

The basic division of restoration work is addressed by Act No. 20/1987 Coll., as amended. Restoration work is classified according to this law into basic structures, namely:
- Paintings,
- Sculptural works of art made of stone, wood, metal, ceramics, terracotta, stucco, plaster, artificial stone, and other artistic materials,
- Arts and crafts.

For the purposes of the addressed methodology, the text is focused solely on the specialization on the stone elements restoration, i.e. in detail, only items 2a and 2b, 3a and 3b given by the classification listed in the Act on State monument care, as can be seen in Table 1.

The specialization of restoration work defines the basic surface treatment and the importance of artistic value. It was, therefore, necessary to further define specific details in order to be able to specify these items of stone restoration, in particular:
- Type of stone,
- Type of complexity of the restored element,

- Possibilities of restoration technology and its complexity and extent of the damage.

Table 1. Classification tool of restoration work [1].

Code	Classification tool items
2a	Polychrome sculptural works of art made of stone, wood, metal, ceramics, terracotta, stucco, plaster, artificial stone, and other artistic materials
2b	Non-polychrome sculptural works of art made of stone, wood, metal, ceramics, terracotta, stucco, plaster, artificial stone, and other artistic materials
3a	Polychrome non-figurative works of art made of stone, stucco, artificial stone, and plaster,
3b	Non-polychrome non-figurative works of art made of stone, wood, stucco, artificial stone, and plaster

2.1.2. Type of stone
Natural building stone for stone products is classified by the standard ČSN 72 1800 Natural building stone for stone products - Technical requirements. The standard divides natural stones - rocks according to their geological origin into igneous, sedimentary, and transformed rocks. For the needs of stone classification in the field of architecture in the Czech Republic, nine groups of stone classifications were used, each of which includes either a single species petrographically or related but similarly used stone types in practice. The types of stone and their comprehensive overview and their classification are based on the overview given in the book by Václav Rybařík: Noble building and sculptural stone of the Czech Republic [2]. It is divided into the following groups: 1 Light intrusive rock (granite); 2 Dark intrusive rock; 3 Trachyte; 4 Sandstone; 5 Opoka, limestone; 6 Marble; 7 Travertine; 8. Marmolite; 9. Table slate.

2.1.3. Type of complexity of the restored element
The elements first divided according to the type of stone were subsequently divided based on the type of complexity of the restored element. This division was made into five basic sections, always for a given type of stone, its placement indoors or outdoors, and graded by the degree of the damage - minor, medium, severe (see Table 2).

Table 2. Division according to the complexity of the restored element [1].

No. section	Description of the complexity of the restored element
1	Flat surfaces
2	Architectural elements of simple geometric shapes, smooth, without plastic decoration
3	Architectural elements with geometric or repeating decor
4	Architectural elements with sculptural decoration - permission of the Ministry of Culture of the Czech Republic for handicrafts made of stone - non-polychrome
5	Sculptural decoration - non-polychrome

2.1.4. Classification code
Based on the above-listed classification criteria, the classification of restoration stone works was proposed. A five-digit alphanumeric code has been designed, with some characters occupied by more letters or numbers. The coding structure is as follows:

Level 0: Restoration group:		SR
Level 1: Group of art and craft elements:	stone	K
	wood	D
	metal	KO
	ceramics	KE

	stucco	S
	artificial stone	UK
Level 2: Type of location:	exterior	E
	Interior	I
Level 3: Stone group:	e.g. Hořice sandstone	41
Level 4: Restoration category:	e.g. architectural elements with geometric pattern 130	

An inventory card with a passport was processed for the exact marking of a specific stone element (e.g. a conical balustrade made of Hořice sandstone). It indicates, on the one hand, the designation of the element verbally, the dimensions of the element, and its unfolded area. The assignment to the classification of work during restoration looks like inventory card No. 001 (see Table 3) as follows:

Table 3. Passport - Inventory card - list of stone elements in the group [1].

Element code according to classification and passportization	Element designation	Element dimensions [m]	Unfolded area [m²]
K-E-41-130-001	Conical balustrade - Schulz part of the cone incl. handrail and trestle	Handrail uw: 1.3 x l (2.9); trestle: uw:1.4 x l (2.9); cones: (uh: 1.25 x average circumference 0.63). ua of the cone approx. 0.9 m² x 17 pcs	23.13

Where: ua: unfolded area, l: length, uw: unfolded width, uh: unfolded height, Pcs: pieces

Tab. 4 shows a section from the model of the classification tool and the label, which is then supplemented by indicative guide prices, which create a price list sheet.

Table 4. Example of work classification and description tool in the price list sheet [1].

Restoration group	Element code according to passportization Item code	Description
SR		**Restoration group**
K		**Stone masonry elements**
SR-K-E		**Restoration group - stone masonry elements - exterior**
K-E-10		Restoration of stone elements - Light granite
K-E-10	K-E-10-110	Flat exterior surfaces (stone masonry, paving, etc.)
K-E-10	K-E-10-120	Simple geometric-shaped architectural elements, smooth, without plastic decoration (cornices, linings, ribs, chambranles, simple arches, etc.)
K-E-10	K-E-10-130	Architectural elements with geometric or repeating ornament
K-E-10	K-E-10-140	Architectural elements with sculptural decoration

2.2. Branch calculation formula for restoration work
The choice of the calculation formula is a basic prerequisite for the calculation. The individual components of the calculation formula and their number depend on the character of production and company organization. The following calculation formula was chosen for the calculation of stone masonry work during restoration, depending on the in-house databases and own valuation documents with regard to the character of work and implementation organizations.

1. Direct material and products	
2. Wages	
3. Levies	
4. Machines	
5. Other direct costs	
6. Direct processing costs	(sum of lines 2 to 5)
7. Direct costs	(sum of lines 1 to 5)
8. Production overheads (here also indirect material)	(the basis for the calculation is 6)
9. Administrative overhead	(the basis for the calculation is 6)
10. Indirect costs	(sum of lines 8 + 9)
11. Profit	(the basis for calculation are lines 6 + 10)
12. Price of construction work	(sum of lines 1 + 10 + 11)

2.3. Determination of performance standards of construction stone works during the restoration
The determination of the performance standard of restoration work was derived on the basis of the determination of the time of individual restoration work activities, which are related to m^2 of the unfolded area of the element. When composing these activities together, the sum of individual times creates a "performance standard" or in other words a "time standard" for various work operations involving multiple activities per 1 m^2 of unfolded area. The research itself was carried out in personal contact with the restorer. The restorers filled in the estimated time in the submitted printed forms. The advantage of this research was its effectiveness, as it led to a full understanding of the researched issues and, last but not least, a discussion on the researched topic. The determination of the "time standard" of restoration work on stone masonry was divided according to individual types of stone into nine groups and five categories of difficulty of access to individual types of stone. The stone restoration time standards are set as the average time required to perform the restoration operation.

Formula (1) was used to calculate the time consumption from the estimated values.

$$VN = \frac{\sum_{i=1}^{n} VN_i}{n} \cdot \gamma \qquad (1)$$

Where: VN … value of the performance standard average per unit of individual restoration activity
n   … number of time values
VN$_i$ … for i = 1, 2 … n is a set of measured time values
γ   … parameter of practical experience (can take values smaller or larger than 1)

Tab. 5 shows the result of one sample of the completed questionnaire. It represents a determination of the time of restoration of flat surfaces for Hořice sandstone (exterior). The estimation was performed by four experienced restorers (A, B, C, D).

2.4. Determination of the wage for stone works during the restoration
The qualification prerequisites of the employee are given by Act No. 20/1987 Coll., on State monument care, as amended. According to this law, restoration work may only be performed by a natural person who is fully "sui juris" and innocent, on the basis of a permit. Estimates of the restorers' wage tariff were based on a questionnaire survey - personal interviews. The wage is determined by the product of the time standard and the wage tariff.

2.5. Calculation of consumption of basic material
The used, proposed material must be included in the restoration documentation, the amount of material is determined on the basis of the relevant technical standard, restoration technology, and professional calculation. The specified quantity of individual materials is valued at market prices, i.e. the price at which the material is purchased from the supplier. Consumption of material was divided into items

corresponding to the description of individual restoration operations (activities). The calculation does not differentiate between the architectural complexity of the work, it only concerns the consumption of the material used, which is the same on both flat surfaces and sculptural works. An example of the calculation is provided in Table 6.

Table 5. Calculation of standard time of the "performance standard" cat. I/group 4P1 - sandstone in min/1 m^2 of the unfolded area [1].

Cat. I – Group 4.P1	RESTORATION OF FLAT SURFACES - EXTERIOR														
	Minor damage 0 - 30% of the area					Medium damage 30 - 60% of the area					Severe damage 60 - 100% of the area				
Item number of restauration activity	A	B	C	D	Ø	A	B	C	D	Ø	A	B	C	D	Ø
1	5.0	7.0	5.0	5.0	5.5	10.0	15.0	15.0	10.0	12.5	20.0	20.0	30.0	20.0	22.5
2	5.0	5.0	5.0	5.0	5.0	7.0	5.0	5.0	5.0	5.5	10.0	10.0	5.0	5.0	7.5
17	20.0	20.0	20.0	20.0	20.0	30.0	30.0	30.0	30.0	30.0	30.0	40.0	30.0	30.0	32.5
18	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Total 1m^2/min	90.0	92.0	95.0	100.0	94.3	357.0	350.0	340.0	367.0	353.5	535.0	570.0	530.0	525.0	540.0
TOTAL 1m^2/hour	**1.5**	**1.5**	**1.6**	**1.7**	**1.6**	**6.0**	**5.8**	**5.7**	**6.1**	**5.9**	**8.9**	**9.5**	**8.8**	**8.8**	**9.0**

2.6. Determination of indirect costs and profit
The amount of indirect costs is highly individual. The proposal mentions the possibility of calculating indirect costs as a percentage surcharge to the base. The percentage surcharge is determined from the restorer's accounting records. The basis for determining indirect costs is optional. In the price proposal, direct processing costs are chosen as the basis.

Profit is the contractor's planned profit. It is mainly influenced by the market situation and company's economic strategy. When using a mark-up calculation, the base is selected as the sum of direct processing costs and indirect costs.

2.7. Price list of restoration stone works
A compilation of a structured database of performance standards and prices of selected restoration stone works represents the result of extensive research. The price list contains direct costs and an approximate price per m^2 of the unfolded area in addition to the classification of the element according to the proposed classification and description tool. These indicative prices are calculated on the basis of the calculation of the number of needs determined for individual items, divided according to the

branch calculation formula. Value added tax (VAT) is not included in the guide prices, neither at the input (materials) nor the output (guide prices).

Table 6. Element material consumption calculation K-E-41-130-001 [1].

Item no. of restoration activity	Material description	Material name	Consumption per m²/kg	Considered area per m²	Unit price CZK/m²	Consumption	Price CZK/m²
1	Scrapers, sandblasting, micro sandblasting			30%			
2	High-pressure steam generator		1.00	100%	14.50	1.00	14.50
3	Biocidal agent	Sanatop likvid	0.15	5%	96.30	0.005	0.323
4	Using wraps with a slightly acidic paste without inorganic acids	Imesta CPU	6.00	30%	817.50	1.20	519.60
5	Distilled water, pulp, cover foil	Arcobel	6.00	10%	453.90	0.40	120.80
6	Micro sandblasting		15.00	0%	502.50	0.00	0.00
7	Lime and cement cleaner	Klinkerreiniger AC	0.07	10%	16.10	0.005	0.06
8	Absorption wrap based on ethylbenzene, xylene and toluene.	Arbocel	6.00	0%	621.90	0.00	0.00
9	Mineral base sealant - a mixture of filler fractions up to 1.5 mm, modified with Roman lime	Petra C, resp, Faso 20	0.70	20%	267.40	0.06	6.88
10	Mineral base sealant	Vapo injekt, Ledan	0.40	10%	760.80	0.02	3.008
11	Mineral base sealant	MAPEANTIQUE I	1.00	10%	657.00	0.04	10.51
12	Flexible sealant	SikaFlex PRO-WF	0.40	10%	177.60	0.01	0.44
13	Mineral sealant coloured in the mass; larger material addition will be made on stainless fittings	Petra C	4.00	10%	1568.0	0.05	19.06
14	Stone, metals, glue, stone inlet			0%			
15	Organosilicon non-hydrophobic consolidator	IFEST OH	1.50	100%	510.30	0.20	13.60
16	Fungicidal solution	Biostop	0.02	0%	42.10	0.00	0.00
17	Pigments - carrier organic silicate - ethanol	BAYFEROX, paraloid B73	0.20	60%	43.60	0.12	4.64
18	Siloxane agent	Imesta IW 29O	0.20	100%	38.50	0.10	1.93
Total (H)							**715.90**

Table 7. Sample part of the price list sheet [1].

Restoration group	Element code according to passportization Item code	Description	Units of measure	Direct costs	Informative price CZK/m²
SR		Restoration group			
K		Masonry stone elements			
SR-K-E		Restoration group – masonry stone elements - exterior			
K-E-10		Restoration of stone elements - Light granite			
K-E-10	K-E-10-110	Flat exterior surfaces (stone masonry, paving, etc.)	m²	1 078.95	1 726.32
K-E-10	K-E-10-120	Simple geometric shaped architectural elements, smooth, without plastic decoration (cornices, linings, ribs, chambranles, simple arches, etc.)	m²RV	1 602.14	2 641.87
K-E-10	K-E-10-130	Architectural elements with geometric or repeating ornament	m²RV	2 972.26	4 832.51
K-E-10	K-E-10-140	Architectural elements with sculptural decoration	m²RV	4 462.48	7 282.64

3. Results and discussion

The article presents only selected results of an extensive survey resulting in the elaboration of a university qualification dissertation thesis, which deals solely with the valuation of masonry stonework restoration within the wide area of restoration work valuation. Nevertheless, its results bring an important contribution to opening up opportunities for dealing with stone construction work valuation during restoration and for continuing the research in the field of construction work valuation during the restoration of all other restoration groups.

The proposed procedure is not an all-solving methodology for the smooth implementation of the calculation of these costs. There are a number of risk factors involved in determining the price of restoration work, which may adversely affect this process. However, using the proposed procedures can positively influence the final result. By using the proposed procedures of the valuation process, it is possible to eliminate the risk of underestimating the price of this specific work and thus protect many historic buildings from their irreversible destruction in the future.

4. Conclusions

The main goal of the issue presented is an introduction of an innovative cycle of determining the method of costs and prices of restoration work in construction activities on historic monuments with an example of a created database of prices of selected masonry stone works restoration. It results in the finding that the calculation system forms an important outline of a well-functioning management system in any market-oriented company. Restoration activity is an area not yet regulated and given that considerable expenditure from public funds is spent on the restoration and reconstruction of historic buildings, it is desirable to continue in the standardization of this process.

Acknowledgments

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