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ADVANCES IN COSTS OPTIMIZATION METHODS – KEY STUDY OF MAINTENANCE AND RESTORATION OF CULTURAL HERITAGE

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Abstract:

The article deals with the issue of restoration and care of cultural heritage buildings in the Czech Republic. The content is focused mainly on the topic of valuation of construction works. Obtaining quality documents is very important for planning reconstruction and maintenance works on a building of cultural heritage. Proper and timely maintenance work is the key to maintaining the value of the building and increasing its viability.

The tool for assessing the economic sustainability of an immovable cultural heritage is a life cycle cost analysis carried out on the basis of relevant input data on the technical parameters of the building, structural elements and equipment, the time period of the occurrence of costs related to them. The analysis becomes an important basis for decision-making by the owner, the designer and the future user on choosing the optimal variant of the technical solution for restoration, also with regard to ecological aspects, cultural and historical value and long-term economic consequences.

Keywords:

Costs, optimization, price analysis, valuation of building reconstruction

JEL Classification: R31

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1 Introduction

The preservation and protection of cultural heritage for future generations is a moral obligation of every generation. Heritage buildings are not only of cultural significance, but also of economic significance. Cultural buildings increase the attractiveness of a given area, help its development and increase economic benefits, especially in the field of tourism and related services.

More than 40,000 national heritage sites are under protection in the Czech Republic.A high number of monuments are in a state of disrepair, where their statics, the functionality of the building envelope, damage to the visual aspect of the building or other possible problems not only of a structural and technical nature may be disturbed. Many monuments are not used either by the public or the private sector, so their condition is gradually deteriorating, and their economic but also cultural and historical value is decreasing (Hromada *et al.*, 2021)

Life Cycle Cost (LCC) represents the total costs incurred in connection with the lifetime of the products. In the case of the construction industry, these are the costs of acquiring construction and engineering objects, the costs of maintenance and renewal of structures and equipment, the costs of operation and the costs of ending the life cycle. In most cases of assessment, these are costs incurred over the economic lifetime of the building. When deciding on the choice of variants, only the acquisition costs are often wrongly assessed, but the operating costs as well as the maintenance and renewal costs are often neglected. It is the costs incurred during the operational phase of the building that make up a significant amount of the life cycle costs of the building. In the case of monuments, the life cycle costs mainly include restoration costs (Schneiderová Heralová, 2019; Eklová *et al.*, 2021).

Restoration in the sense of the act on state monument care means the maintenance, repair, reconstruction, restoration or other modification of a cultural heritage. The term "maintenance" can generally be understood as the removal of unwanted changes to a monument that have occurred as a result of its use (for example, a new coat of paint on the facade of a house). The term "repair" can be defined as removing the consequences of damage to a monument or the effects of its wear and tear (for example, adding part of the roof covering). The term "reconstruction" can be seen as either structural and technological interventions in a monument that bring about a change in its technical parameters or a change in its function or purpose (for example, adaptation of a production building to an exhibition space) or a return to the historically documented or assumed state of a monument, on the basis of professionally substantiated assumptions (for example, the construction of a new roof after a fire), (Eklová, 2020).

The goal of restoration here is to extend the technical life of buildings and preserve historical and cultural value. The costs of operation take on high values. These are costs incurred for the entire technical life of the building, which in the case of immovable monuments is very long (Nowogońska, 2020).

LCCs are usually determined in the pre-investment phase of the life cycle of a construction project and can thus be used to select effective alternative solutions. The LCC indicator is a cost criterion, a lower value is more advantageous for the investor. For LCC modelling, information on the development of costs in individual phases and the possibilities and ways of influencing them, as well as information on the service life of structures and equipment, are decisive. In the case of monuments, LCCs are determined in the operational phase, usually before the intended restoration. They should be used for the selection of an economically sustainable solution, with the maximum potential for preservation of historical and historical value. For investors in the reconstruction of monuments financed from public budgets, the optimized costs of the construction life cycle can contribute to the observance of the 3E principles (efficiency, economy, expediency), which are key to public finance. In the currently valid wording of the Public Procurement Act, life cycle costs are listed as one of the options for applying the basic indicator for the selection of a public contract supplier, "economic value of the offer". For private investors in the reconstruction of monuments, the optimized life cycle costs of the building contribute to achieving a higher value for money (Value for Money) and a shorter payback period. The costs of the life cycle of buildings can also be viewed from a broader perspective and, in addition to the costs related to the rehabilitation, reconstruction, restoration and operation of an immovable monument (i.e., LCC), externalities and social (society-wide) benefits and costs that arise in connection with construction activities and operation of the building in its vicinity. Construction costs conceived in this way are referred to as lifetime construction costs (Macek, *et al.*, 2019; Nadkarni, Puthuvayi, 2020).

Construction is a specific economic sector; its product is unique products - construction works. The construction work is original, and this is even more true for an immovable monument. Economic knowledge is not enough to calculate costs, prepare and implement its restoration, but at least to the same extent, engineering knowledge is needed, covering the area of restoration of monuments, building structures, technical equipment of buildings, technology and construction implementation. Costs must be calculated with knowledge of the technical parameters of structures and equipment, because the structures and equipment used will affect not only the costs of reconstruction or restoration, but also operating costs (e.g., energy consumption) and maintenance costs. The costs of operation and restoration of immovable cultural heritage cannot be universally estimated, they will always differ in the same way that buildings differ from each other. For their estimation, we can use data on comparable buildings to a very limited extent, i.e., comparable in terms of construction, scope, purpose of use, intensity of use (Antuña, 2021).

Cultural heritage buildings in the Czech Republic are used not only by their owner but very often by the general public. It is important to ensure the efficient and targeted use of public funds invested in monuments. To determine the likely costs during the use of the building and to assess the economic sustainability, it is necessary to use life cycle calculation (LCC) tools. In order to properly evaluate this assessment, it is important to know the relevant building input data, the technical condition, the building design, the equipment used and the time scales (Philokyprou, Limbouri-Kozakou, 2015). Using the most accurate input data will allow a correct analysis, which becomes an important basis for decision making. Based on the background information, suitable solution options will be developed, and the optimal option will be selected (Yarrow, 2016; Klapa *et al.*, 2017.

To properly design the financing of the building, it is necessary to know not only the current condition and determine the necessary funding for restoration, but also to focus on long-term sustainable financing that will include the costs of operation, maintenance, and partial restoration during the use of the monument (Espion *et al.*, 2017). Monuments are to a large extent individual buildings that vary from one another and it is not possible to use a single system to estimate costs in a blanket way. It is necessary to approach buildings individually (Nowogońska, 2020; Macek *et al.*, 2019) and to include all details related to each individual building in the calculation (Nadkarni, Puthuvayi, 2021; Antuña, 2021; Philokyprou, Limbouri-Kozakou, 2015). The final estimate of the construction costs for the reconstruction and maintenance of a monument will be based on partial estimates for defined structural elements. The total cost will be the sum of the partial valuations of the structural elements of the building under study (Prudon. 2017; Magrini, Franco, 2016).

2 Goals and methods

The aim of the project is to develop procedures for the design of maintenance and rehabilitation activities, to determine their financial requirements and to enable the owner of the building to make a qualified estimate of the costs (Ruiz *et al.*, 2016a).

The output of the project is software that should allow the simulation of different options and the selection of the most appropriate (sustainable) maintenance and rehabilitation strategy with an emphasis on respecting the cultural and historical value. A procedure has been developed to create a maintenance plan and a proposal of rehabilitation principles that will lead to a sustainable long-term condition, maximizing the lifetime of the building and at the same time being in line with current trends in conservation. The developed tools have been pilot tested in the form of case studies for selected cultural heritage buildings.

The methodology of the project is based on knowledge of historical context, conservation practices, building passporting, structural engineering and building history surveys, valuation of structural restoration and repair, building economics and sustainable asset management. The project is based on a holistic view of the heritage of past generations in the form of immovable assets situated in cultural landscapes (Al-Obaidi *et al.*, 2017; Ruiz *et al.*, 2016b).

3 Results

The project developed a procedure for a maintenance plan for heritage buildings. This maintenance plan is a tool for the systematic planning, implementation and recording of maintenance work in the management of historic buildings. A procedure has been developed to establish a plan for maintenance activities and a proposal for rehabilitation principles that will lead to a sustainable condition, maximizing the lifetime of the building, while being in line with current trends in heritage conservation (Berkowski, Kosior-Kazberuk, 2016; Dvornik *et al.*, 2015; Collette *et al.*, 2014).

The main outputs of the project are:

- MONUREV software for planning maintenance and restoration of cultural heritage buildings.
- Methodology of principles for the rehabilitation of cultural heritage buildings.
- Heritage procedure for maintenance planning of cultural heritage buildings.

The developed tools have been pilot tested through case studies. The project developed 3 case studies for selected cultural heritage buildings. The results of the project were applied and verified in these studies, namely the monument procedure for the creation of a maintenance plan and the MONUREV software application.

3.1 Software MONUREV

One of the main outputs of the project is software that should enable the simulation of different options and the selection of the most appropriate (sustainable) maintenance and rehabilitation strategy with an emphasis on respecting the cultural and historical value.

The proposed MONUREV application is designed in the form of a web interface that is user-friendly and accessible. This application creates maintenance and restoration plans for selected monuments according to the purpose and period of construction. For basic operations with the software, model buildings were selected to serve as templates for the creation of basic (initial) models of this application to newly inserted real objects. For faster and more comfortable work of the users, the application uses a database of type objects, which brings together primary data from the level of structural elements. The user has the possibility to customize the input data to match his specific building as closely as possible.

The basic prerequisite for the creation of the model was a comprehensive analysis of the issue of care of cultural heritage buildings. Links to parametric dependencies and sufficient data bases were created so that the application would provide outputs that would be as relevant as possible to the specific building and a high level of reliability would be achieved. The development of the application was preceded by the collection and analysis of a large amount of information:

- Bid and actual prices of construction work in the Czech Republic (for this purpose the project team obtained price information for a large number of completed construction contracts);
- Basic dimensional characteristics of individual types of buildings (for this purpose the project team collected project documentation (floor plans, sections, views, technical reports) for a large set of historical buildings);
- The service life of individual structural elements (based on analyses of building surveys, service lives were determined assuming routine maintenance).

A challenging process was to create the pricing data base. The unit prices assigned to the structural elements were compiled using so-called micro-estimates. A micro-estimate consists of several items of the price system, where the unit price of a structural element is obtained by summing up the partial prices (so-called guideline prices in the structure of the calculation formula) for all items of the micro-estimate. The micro-estimate unit of account corresponds to the unit of measure of the design element.

The user has four basic outputs:

- Object balance.
- Repair plan for structural elements.
- List of repairs in a given period.
- Repair schedule in a given period.

During its development, the application has been verified and reprogrammed several times. Verification of the generated outputs from MONUREV was performed using the reverse method. The projects that served as input data for the general model were subjected to a backward analysis, where predicted data of the original input projects were generated using the model based on the relevant descriptive parameters of each project. The predicted model data was compared with the actual data of the source projects. The results were then subjected to a hypothesis test on the average agreement of the predicted results with the actual values of the input projects. The testing was performed at a 90% confidence level.

3.2 Methodology of the principles of rehabilitation of cultural heritage buildings

The aim of the project result was to provide a comprehensive overview of rehabilitation principles that can be applied in the context of repairing historic buildings. The developed methodology describes the basic context that influences the approach to the rehabilitation of listed buildings and specifies specific steps of the recommended rehabilitation procedure. Taking into account the conservation aspects, the principles presented are primarily directed towards the conservation of structures and the extension of the service life of existing structural elements, taking into account future use and operation. The preservation of the original forms and functions of the individual structures is pursued as far as possible. The target group of users of this methodology are conservation officers, designers, owners and managers of historic buildings. The methodology provides these users with a basic manual on how to proceed in the preparation and design of rehabilitation measures for the restoration of monuments.

The methodology is based on the general principles of heritage conservation and current procedures for the rehabilitation of the most common failures of historic buildings. The novelty of the methodology lies in the definition of the aspects of monument protection in relation to rehabilitation measures, which usually imply a smaller or larger intervention in protected historic structures. The methodology maps the controversy between the requirements for the structural and technical condition of the building, often associated with the insertion of new and historic operation of the building, and the requirements of conservation to preserve the structural, technical, material, or even shape solutions of older, valuable phases of the building, which are primarily subject to conservation.

3.3 Heritage procedure for maintenance plans for heritage buildings

The aim of the result was to offer a tool for systematic planning, implementation and recording of maintenance work in the management of historic buildings. An additional objective of the heritage procedure was to raise awareness of the importance of ongoing maintenance as the most effective way to ensure the long-term and sustainable preservation of immovable cultural heritage and its heritage and use values.

The heritage procedure introduces the general principles of the development of damage to immovable structures over time, presents the heritage and economic importance of ongoing maintenance and early repairs, and proposes a system for their planning. The system of maintenance planning is based on initial and subsequent periodic inspections and assessment of the condition of the object, maintenance is defined by individual activities, their usual period of performance, professional, time and financial requirements, as well as the interrelationships of individual activities. The monument procedure offers the user a generalized functional system, which is both functional and easily adaptable to the specific object, and which enables the management of a building monument to implement and rationalize the maintenance work steps efficiently in the long term. The monument procedure includes an outline of the most common failures and damages, their causes, and the most common maintenance activities for each structural unit.

3.4 Case studies for application and verification of project results

The studies include an economically and construction-technologically sustainable model for restoration and maintenance. On the basis of the description of the current state and the proposal of alternative options for the further operation of the building, the planned construction-technological solution was proposed, and the costs were quantified.

The following case studies were developed within the project:

1) Case study on the rehabilitation of St. Martin's Church
2) Case study of the overall rehabilitation of the parish of Dobrovice
3) Case study for the reconstruction of the Museum of Sugar, Distilling and Beet Growing

Each of the studies contains a description of the original condition of the building, a proposal for the structural design of the restoration, and photo documentation of the original and current condition of the building. It also includes a cost estimate using the MONUREV software application:

- Generated structural structure of the building.
- Plan for the restoration of the structural elements for the defined period.
- Accumulated costs of the restoration, including a simulation of the effect of inflation on their amount.
- Valuation of construction costs using selected structural elements as an example (using micro-budgeting).

4 Using MONUREV to calculate costs

The MONUREV software application has been developed for the preparation of the maintenance and restoration plan for monuments, which is solved in the form of a web interface. The application is set up to process data at the level of individual structural elements. It uses a database of type objects that can be used for faster estimation to make the work of users easier and more comfortable. For more detailed and accurate outputs, the application guides the user through the steps.

The MONUREV allows you to quickly generate a rough assumption for a maintenance and renovation plan based on only the basic descriptive characteristics of the building, such as the type of building, height, length or number of floors. However, the user has the possibility to refine the model according to the specific condition of the building and its individual structural elements to match the real building as closely as possible. At this stage, the type of structural elements that are assumed for the building are estimated, and the assumed areas of the individual structural elements are also calculated. To these data are linked the renovation prices for each structural element. From these data, it is already possible to generate projected maintenance and renewal plans for the building for the selected reference period.

If the user wants to capture the actual condition of the building and specify the maintenance and restoration plan, then a personal inspection of the building is necessary. From this data it is also possible to modify the maintenance and restoration model generated by MONUREV (specification of structural elements, dimensions, state of wear and tear and, if necessary, the cost of restoration). In the subsequent generation of the maintenance and restoration plans using MONUREV, this will ensure that the rough plan is refined to be closer to the real condition of the object.

4.1 Application input data

The main input data of the application, apart from basic information about the building such as name, location or illustrative pictures, are characteristic data describing the basic features of the building. The building must be described in such a way as to be as close as possible to the real situation and to limit the need for additional modifications.

The following example will show how to work with the program within the case study of St. Martin's Church. For the generation of the maintenance and renovation plan, a typical building from the category of buildings for culture and social buildings was selected, namely a typical museum building. The generative model was supplemented with the following input parameters:

Table 1: Basic input data for the MONUREV application

Basic input data for the MONUREV application that characterize the building	Input data entered into the application during the case study for St. Martin's Church
Year of construction	1850
Length	15.8 m
Width	16.7 m
Height	12.0 m
Height above ground	12.0 m
Roof pitch	48°
Number of stores	2
Store height	3.0 m

The data that is filled into the program in the first phase can be taken from the accompanying report and the drawing documentation of the building or found by an on-site inspection.

4.2 Building structure of the MONUREV application

The following table shows the expected maintenance and renewal design elements for the selected type of object, which were generated after entering the basic descriptive characteristics of the selected object. This is the basic data that the user obtains by filling in the input data. The unit price expresses the cost for the renewal of the respective structural element. The quantity is an estimated parameter that is calculated from the basic measurement characteristics of the object. Total cost expresses the cost of restoring the entire structural element. The values given correspond to a rough estimate based on a generative model. In order to refine the model, the actual dimensions of the individual structural elements are entered in the application or, if necessary, partial structural elements are replaced with other elements corresponding to the actual condition of the building.

Table 2: Generated structural structure of an object using MONUREV

Construction element	Unit price (CZK)	Quantity	Unit of measure	Total cost (CZK)
Basics				
Stone belts	10 925	288	m^3	3 146 400
Vertical load-bearing structures				
Perimeter and load-bearing brickwork without surface treatment ceramic	4 726	1 335,6	m^2	6 312 046
Perimeter and load-bearing brickwork without finish stone regular stones on mortar	9 962	432	m^2	4 303 584
Vertical non-load-bearing construction				
partitions and non-load-bearing masonry	2 970	294	m^2	873 180

brickwork without ceramic finish				
Horizontal load-bearing structures				
timber	2 020	285	m^2	575 700
Surface finishes of vertical structures				
Plaster interior without reinforcement, stucco	994	1 512	m^2	1 502 928
exterior plaster with reinforcement	1 554	1 728	m^2	2 685 312
paintings	107	2 195,3	m^2	234 897
exterior plaster coatings	552	115,2	m^2	63 590
exterior metal coatings	776	108	m^2	83 808
metal coatings interior	599	108	m^2	64 692
wooden interior coatings	684	108	m^2	73 872
coatings wooden exteriors	768	108	m^2	82 944
Compositions of horizontal non-load bearing structures				
Ground layer wood	3 977	240	m^2	954 480
spreading layer grease, thickness 100	2 104	240	m^2	504 960
waterproofing layer waterproofing clay bath	4 755	240	m^2	1 141 200
embankment	1 849	240	m^2	443 760
backfill	663	240	m^2	159 120
plaster finishes with reed reinforcement system	1 766	240	m^2	423 840
surface finishes wooden cladding	1 839	240	m^2	441 360
finishes coatings	684	240	m^2	164 160
Artistic and decorative elements firmly connected to the building				
Plaster and stucco profiles (reliefs)	6 916	168	m^2	1 161 888
plaster and stucco anchored elements (stucco)	8 398	84	m^2	705 432
wall paintings	39 520	168	m^2	6 639 360
ceramic elements	27 911	576	m^3	16 076 736
metal elements	35 939	576	m^3	20 700 864
Roof load-bearing structures				
timber roof truss	4 261	622,7	m^2	2 653 325
Roof sheathing				

ceramic folded roofing	2 028	566,1	m^2	1 148 051
roofing solid sheet copper	3 920	566,1	m^2	2 219 112
battens	263	736	m^2	193 568
soffit boards	763	736	m^2	561 568
plumbing elements sheathing and flashing of walls, attics, cornices and roof elements and gutters copper	1 436	140	m	201 040
plumbing elements gutters copper	2 918	105	m	306 390
plumbing elements copper gutters	1 231	84	m	103 404
Staircases				
load-bearing structure brick vault	11 159	22,9	m^2	255 541
grade stone	14 079	5,2	m^2	73 211
Grade wood	8 142	9,7	m^2	78 977
Fillings of openings				
windows wood window renovation - paint only	7 163	10,5	m^2	75 212
doors exterior wood repairs	22 848	2,4	m^2	54 835
additional structures windowsills wood	1 441	0,1	m	144
Railings				
wooden	9 855	4,7	m	46 319
metal	11 918	4,7	m	56 015

4.3 Valuation of construction costs and rough restoration plan

Construction cost estimation is performed in MONUREV based on a parametric approach. It is a method based on estimating construction costs using selected/input parameters (basic dimensional variables) of the building object. Another fundamental assumption is the division of the building object into structural and technological units (referred to as structural elements in the publication), which are directly linked to the input parameters (e.g., width, length and height of the building). The unit price itself, which is assigned to the defined structural elements, is based on the principle of micro-budgeting. The micro-estimate is composed of selected items of the price system of the CRS, where the unit price of a structural element is obtained by summing the partial prices (so-called indicative prices) of all items. The example of micro-estimates in the following subsection is in the 2022 price level.

The costs shown in the following table correspond to current prices. Actual costs will increase due to inflation. Bednar (Bednář *et al.*, 2022) proves that inflation in the economy is translated by a larger share in construction and housing industry than in other industries and services.

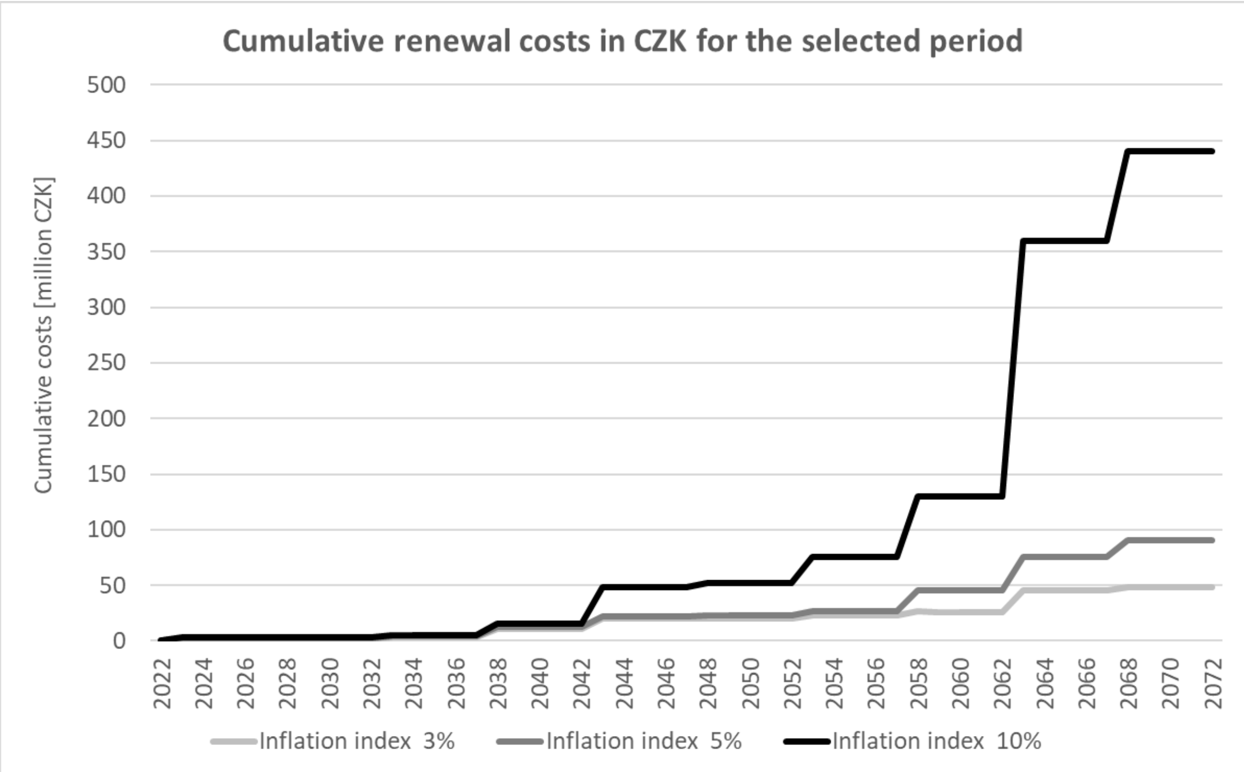
Construction industry is very sensitive to increase of price of inputs and labour costs (Kaderabkova, Jasova, 2020; Hromada, Cermakova, 2021) and has experienced a substantial decline during Covid-19. In this regards Jasova (Kaderabkova, Jasova, 2021) confirms that construction industry suffered from outflow of immigrant workers and low support payments from the government. The following table shows an example of a rough recovery plan over the next 10 years, generated from data entered into the application, only a selection of the generated data is shown.

Table 3: Restoration plan for structural elements

Construction part	Year	Cost (CZK)
Plaster interior without reinforcement stucco	2023	120 234
Plaster exterior with reinforcement	2023	563 916
Paintings	2023	136 240
Exterior plaster coatings	2023	24 800
Coatings metal exterior	2023	29 333
Plumbing elements sheathing and flashing of walls	2023	24 125
Plumbing elements gutters copper	2023	36 767
Plumbing elements copper downpipes	2023	15 511
Load-bearing structure brick vault	2023	38 331
Grade stone	2023	23 428
Timber grade	2023	27 642
Stained glass metal + glass	2023	1 426 425
…		
	Year 2023 total	**5 073 934**
Plaster interior without reinforcement stucco	2028	120 234
Paintings	2028	136 240
Exterior plaster coatings	2028	24 800
Painting of wooden exteriors	2028	43 131
Plaster finishes with reed reinforcement system	2028	89 006
Stacked ceramic roofing	2028	137 766
Stained glass metal + glass	2028	1 426 425
…		
Year 2028 total		**554 883**
Total for the period under review		**5 628 817**

The following chart shows the cumulative total annual costs assumed for the restoration of the building (excluding remediation work), showing the effect of inflation on the actual cost increase. The period chosen is for the next 50 years. Three levels of inflation index have been chosen for comparison: 3%, 5% and 10%.

Chart 1: Restoration plan for structural elements



The preceding chart shows that in the long run the impact of inflation on real costs is substantial, with costs more than ten times higher at a 10% inflation index than at 3%. A graphical representation of the previous table is given in the following chart.

4.4 Maintenance and renewal plan

This part of the project describes the design of periodic and operational activities to ensure the long-term sustainability of the buildings from a technical and economic point of view. The planned construction and rehabilitation works will secure the current state of the historic building after rehabilitation, avoid further deterioration of the building and extend its life and usability for the maximum possible time.

It is advisable to obtain important information about the property on site by visiting the property, where you can get basic but also detailed information. A tour of the St. Martin's Church property revealed:

- It is a single nave building with an apse on the eastern side, a tower on the western side and a sacristy extension to the south-eastern part of the building. During the tour we were able to see all the areas of the church that are not normally accessible. The bell tower and the clock tower were documented.

- Last year, the church underwent a damp-proofing of the exterior masonry and repairs to the roof. Other parts are still awaiting repair. According to the parish priest, only what is urgent is always repaired due to lack of funds. The local parish priest is the administrator of the building and is responsible for other buildings. The management of the buildings is a great burden for him because he has no training in this area and is constantly struggling with the lack of funds for both repairs and proper maintenance.
- The church is a very specific building that has its own specific features. The development of the inspection form was easier than for the other two buildings. The completion of the form was done after the completion of the inspection from the photographic documentation. A maintenance plan was also created for the church and given to the pastor. Due to the relatively poor condition of the church, it would be appropriate to develop a refurbishment plan in view of the available funding.
- Moisture-remediation measures have significantly improved the moisture conditions in which the masonry is located and enabled the start of a continuous process of its gradual drying out. One year after the application, there is a slight improvement in the moisture status of the walls, as well as an improvement in the internal microclimate and a significant reduction in areas of condensation. However, despite the measures taken, condensation persists in the central part of the church floor after the winter period. The internal microclimate management and maintenance regime is the subject of planning for the next stage of the remediation works. The repair of the roof trusses has ensured the strengthening and reinforcement of the supporting structure of the roof cladding. However, the roof covering is original and there are still areas of leakage. Unfortunately, due to lack of funds it was not possible to carry out a complete replacement of the roofing. The next planned measure is now the rehabilitation of the vertical load-bearing walls and the repair of the perimeter and roof cladding of the church.

On the basis of the inspection of the building and the data obtained, a case study was created, which was supplemented with calculations from the program and a methodology and plan for restoration. The study describes the original condition and the proposed construction and rehabilitation work for the overall rehabilitation of St. Martin's Church. The costing of individual structural elements was carried out using MONUREV. The actual cost of the construction and rehabilitation works carried out in 2018 amounted to 1.21 million. If these planned construction and rehabilitation works were to be carried out until 2022, the costs would amount to CZK 1.65 million, excluding VAT. This estimated amount was determined on the basis of the index of changes in the prices of construction works.

5 Discussions and conclusions

The buildings of the cultural heritage of the Czech Republic are very different, whether from a visual or technical point of view, their appearance is very dependent on the period in which they were built, the materials and technologies used. Simply put, historic buildings have higher maintenance and rehabilitation costs than contemporary buildings (Machova *et al*., 2022).

The project includes the development of a methodological approach to assist in building management and decision making. In addition, MONUREV software has been developed to assist with the determination of an optimized cost plan for building restoration and maintenance. The software focuses mainly on historic buildings. One of the outputs of the software is a building restoration plan that can be the basis for long-term planning of building maintenance and help in planning the financial expenditure that will be required for building maintenance.

The project outputs produced, the methodology of the rehabilitation principles, the MONUREV software and the heritage procedure, will help in the planning and management of the building, will provide a basis for increasing the viability of the building and will ensure compliance with current practices in the care of cultural heritage buildings.

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