BUILDING MAINTENANCE AND RENOVATION

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Summary

Maintenance and renewal costs for structural objects are a significant part of costs in the life-cycle of structures. Rational owners and construction service engineers try to minimize outlays on maintenance and renewal. However, at the same time it is necessary to respect a certain standard in the condition of a construction, to keep it above a fixed limit given from the type and demands on usage of the existing structural object.

On the market there exist various instruments from the field of facility management, which deal with the problems of maintenance plan setting and structural objects renewal. Software processing and connection to graphic systems is usually very beneficial. The weak aspect of these systems is of course an insufficiently worked-out model of maintenance and renewal, which would realistically describe the ageing of a structural object at the level of individual construction components. From these there follow inaccurate outputs on the level of the technical and economic formations which serve as a basis for user decision-making as to how to further dispose of the structural object.

The aim of the paper is to describe the modelling and optimisation of renewal costs at the level of structural elements. The topic is part of a theory for modelling of LCC constructions. LCC behaviour with individual elements can be captured by a system of periodically repeated renovation matrices. However, every construction which consists of various structural elements brings certain correlations among elements which involve the mutual influence of individual renovation matrices namely within the context of an economical disbursement of financial means on a construction in its entirety.

For the LCC rationale it is necessary to establish the mathematical correlations, which will create a basis for the searching for, and modelling of, a solution for the minimization of costs issued by an administrator (or owner) of a construction.

Keywords: LCC, maintenance, renovation, model, optimization

1 Life Cycle Costs of Structural Elements

The lifetime of the construction is limited not only by its technical but also its economic lifetime. With the technical lifetime the emphasis is put on material characteristics of a construction and the lifetime of the construction, which is dependent especially on the provision of building elements with a long-term viability. It concerns those structures of the construction which have, from the viewpoint of the technical lifetime, principal significance because with their damage (loss of performance of their function) the construction is not functional, threatens to collapse and any repairs become technically and economically extremely demanding.

From the viewpoint of the cost level for repairs it is more effective to remove the construction and build a new one. In the case of the economic lifetime this concerns the period in which it is appropriate to use the building economically. It is usually shorter than the technical. Very often it concerns the loss of economic usefulness which can be connected with the permanent loss of net income with reference to disproportionately high costs and it would seem preferable to remove the building and replace it by a new building and thus re-evaluate the land.

The resulting LCC calculation of the relevant inputs which concern the technical parameters of structural elements and the time period for incurring costs related to them should be an important basis for the decision of an investor, a designer and any future user in choosing an optimum variant of a technical solution for a construction and also looking to ecological aspects and long-term economic consequences. Costs connected with the implementation, use and disposal of a building are divided into 3 basic groups:

- Costs directly related with the technical parameters of a construction– investment costs, repair and maintenance of a building costs, reconstruction costs, costs relating to modernization and disposal of a building,
- Operating costs of a building – energy, cleaning, depreciation etc.,
- Administrative costs related to property management – taxes, insurance, administration of a building etc.

2 Life Cycle of Structural Elements

A life cycle of an element expresses in what time cycle and with what costs it will be necessary to carry out the renovation of an appropriate structural element so that the standard of use is retained and at the same time, that it is not renovated unnecessarily early, when there has not yet been exhausted its use potential.

The first approach is the description of this cycle by the length of the step and to consider that after its expiry the structural element will be completely restored. Giving a more precise principle which better describes the real behaviour and lifetime of structural elements is a system based on the description of a life cycle of a element with the help of a matrix. This matrix expresses the description of the lifetime of a element in such a way that it solves the problem of the description of cycles, where there is not any periodicity of one step for the recommended renovation of elements. The result is that the appropriate matrix represents one periodical step which can be described by any non-periodical cycle.

Variability is not enabled only in the lengths of individual non-periodical cycles but also in their heights. The height is understood as a percentage of costs which must be spent on a given renovation of an element.

As an example there can be given air conditioning where renovation takes place after 15 years but regularly the renovation cost is rotated to the extent of ¼ of elements and completely for the whole system. In this case there is introduced in the renovation matrix a step of 15 years length with the height of 25 % and a second step with the same length but with the height of 100 %, as is shown in Figure 1.

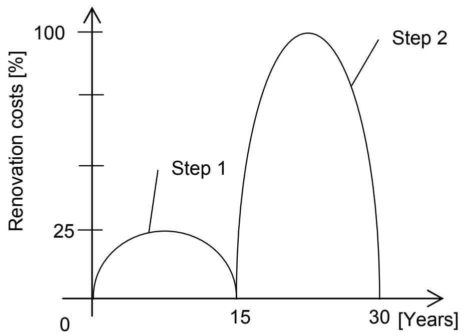

Fig. 1 Example of a scheme of renovation matrix

In the course of the calculation the lifetime matrix cyclically repeats and will create a course for the structural element renovation which is shown in Figure 2.

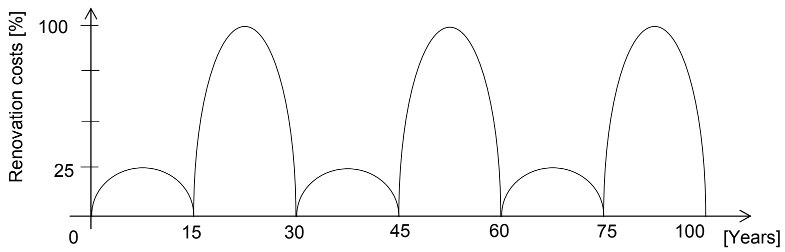

Fig. 2 Scheme of the renovation element expressed by the periodicity of the renovation matrix

3 The principle of designing LCC of structural elements of a building construction

The basic principle of the model pre-set for optimizing steps is establishing linkages among structural elements and determining their behaviour. The linkages can be divided into two groups:

- economic,
- technical.

The economic linkage means cost saving in carrying out the renovation of two or more structural elements simultaneously against the sum of costs spent for the renovation of the same structural elements without mutual time coordination. The savings can be for technical reasons, when for example we use the built scaffolding for the façade renovation and at the same time we carry out the renovation of tinsmith elements. Another reason can be an organizational one when, e.g. during the renovation of a rising main we undertake a part of the painting and facing, as even this can be considered the carrying out of the complete renovation of painting or facing for the whole construction. An economic linkage is discerned by the fact that the use of the linkage is directed by further conditions (which will be stated further on in this chapter)

The technical linkage means a strong connection of the renovation of one structural element with another one, while the linkage is, contrary to the economic linkage, always applied. An example can be the change of roof timbers, when we automatically renovate roof insulation and roof cover. Similar to the economic linkage, the technical linkage also brings total cost savings.

Further parameters of optimization are tolerance limits for deviation from the optimum cycle for structural parts as independent elements. In practice it indicates how much it is possible to prolong or to shorten the length of the renovation step with regard to a worse condition of the structural element possibly involving its pointless preliminary change.

In given types of linkages the elements divide into two groups. Influencing and influenced elements. When defining the linkages it is unanimously determined which of the elements is influenced and which is influencing. The influencing element is not affected by the influenced element, therefore its renovation cycles behave independently of it. The influenced element monitors cycles of the influencing element and according to the type of the linkage and further parameters its cycles of renovation are directly affected by the influencing element.

It is valid that one element can be for a group of elements the influencing element, and at the same time for another group of elements it can be an influenced element. To prevent the cycling of the system of linkages, the elements will be divided into layers where there is valid a rule that the influenced element connects to the influencing element which is at a minimum one hierarchical layer higher. Schematically it is shown in Figure 3.

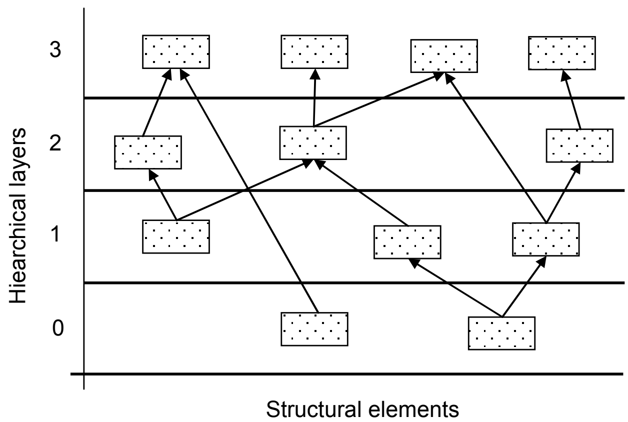

Fig. 3 Scheme of the description of linkages among elements

As has been stated before, technical linkages are always applied. It means that the algorithm solves in the case of an affected element whether there would be in the area of the linkage any prolongation or shortening of the length of the renovation step (in an ideal case the renovation cycles of both elements can transect without further changes). In the following Figure there is seen a scheme of cycles of two elements, which are not bound by any linkage and each behaves according to its own renovation cycle.

4 Conclusions

The set of problems in renovation cycles does not have a uniform approach in the literature. The work summarizes and adds information about renovation cycles on the basis of knowledge in the current literature and experience gained by associates, who have been for many years dealing with the practical implementation of renovation of building constructions. The work introduces the concepts of tolerance zone, the volatility of the renovation length, the length and step of renovation and the renovation matrix. From these definitions there is put together a system describing the behaviour of cycles of renovation of structural elements.

In the field of the mathematical optimization of a model the work introduces the concepts of economic and technical linkages among structural elements. Following on from the mentioned linkages there is introduced a summary of mathematical rules for the rationalization for the design of renovation cycles at the level of individual structural elements within the context of a construction in its entirety.

The rational designing of renovation cycles is not determined just for calculations on already existing constructions, but especially it should be used already at the stage of project preparation when these data have a significant influence on the choice of a project variant with regard to LCC.

The given theoretical relationships and dependencies are inbuilt in SW application Buildpass, which is intended especially for owners (administrators) of the building constructions. The tool is focused on professionally qualified planning of the renovation and maintenance of constructions. The solution of a project is based on reference databases of constructions and structural elements, which will enable the gaining of fast results also for users who are not specialists in this field. On the other hand, the tools allow for going into details and to modify designated models on their own merit. The user himself will choose which area to apply and into what depth of detail he himself will engage in the processing of data.

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