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Method to Support the Renovation of Multi-Family Residential Buildings in a Sustainable Construction Aspect

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Extended Abstract

Achieving the goals of sustainable construction is a decision-supported task when choosing optimal renovation strategies [1-3]. Given the possibility to choose from a variety of measures and actions in the renovation process of buildings, the main problem is to identify the best ones that are effective and reliable in the long term [4-6]. Decision-making in the refurbishment of multifamily residential buildings for the creation of sustainable buildings, requires a broader approach than has been used so far, which takes into account both environmental and economic objectives, social objectives for improving quality of life [7-10] and also technical objectives for maintaining and improving building safety [11].

For this reason, the authors have developed a method to support renovation planning in a long-term and comprehensive manner, i.e. from the assessment of the building to the identification of the optimum extent of renovation. The method consists of several calculation stages, in which, in the initial stages, a multi-criteria assessment of the building's condition is carried out and various repair solutions are developed, together with an indication of the benefits that their application will bring. In subsequent stages, the technological dependencies of the suggested repairs are determined and, on this basis, the possible renovation variants are identified in an established sequential order. At the final stages, a cost-optimal modernization option is selected - to achieve the assumed criteria values taking into account the budget needed to carry out the repairs - and optimisation is carried out to allocate the repairs within the considered time horizon.

To perform the assessment of the building's condition and the benefits of the repairs proposed for the building, multi-criteria MCDM methods [12-14] based on expert knowledge expressed using linguistic terms were used. An innovative optimisation approach based on decision matrices was used to select the optimal modernization option and its allocation within the planned modernization time horizon, allowing for the selection of possible scenarios of repair solutions. Each of them contains the repair/upgrade actions assigned to the site, which must be performed according to a fixed sequence of actions realised by a graph, where the set of nodes represents repair options and the graph arcs represent sequential relations. The optimisation calculations are performed using binary linear programming [15-16] and take into account a number of important factors in the optimisation calculus, including the assumed degree of fulfilment of the requirements for the buildings (the values of the criteria assessments), the time taken to carry out the renovation, the optimum allocation of repairs, financial constraints and the maintenance of the sequence of repairs that results from the technological dependencies that occur between repairs. Considering all the attributes/characteristics of the model constituted a complex computational problem, for which the computational platform of the Matlab programme was used.

The application of the method is shown on the example of a multi-family residential building. The scope of the assessment and renovation of the building was limited to selected building elements (window frames, external wall partitions, balconies, basement walls and entrances to the building). The evaluation of the building was based on 4 criteria relating to the following aspects: economic, technical, social, for which weights were determined using the AHP method. Several repairs were proposed, some of them in two variants of execution. The technological relationships between the repairs to the building were determined and, on this basis, the sequences of execution of the renovation variants were identified. As a result of the optimisation measures carried out, a refurbishment option was generated to achieve (for each criterion) the assumed final assessment. The value of the total building increment and the cost of carrying out the refurbishment were calculated, followed by an allocation of repairs, over a planned time horizon. When applying the method, however, it must be taken into account that it is deterministic and does not include in the planned renovation time horizon either changes due to the ageing of the building or changes in the pre-estimated repair costs.

The developed model is a useful tool that can be used by managers at the maintenance stage of residential buildings. The proposed method supports the planning of renovations in a long-term and comprehensive manner, i.e. from the assessment of the building to the indication of the optimal scope of renovations.

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