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Evaluation of Bridges Life Cycle Costs

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Abstract

The paper presents the evaluation method for bridge alternatives assessment. The selection was chosen multicriteria decision making method, where not only criterion cost. Faculty of Civil Engineering deals with the life-cycle costs, and in this area offers a tool to assess the LCC for bridges. In addition, the principle of self-evaluation is further described in more detail above tool designed for skilled setting and evaluation of LCC. Furthermore, the presented method takes into consideration the Czech legislation: Act No. 137/2006 Sb - Public Procurement, specifically §78 - Evaluation Criteria, which states that the main selection criteria for all bids must be either the economic benefits of the proposed bid or the lowest bid cost. The above noted indicates that the LCC may be incorporated into such tendering as part of the economic benefits evaluation. In order to calculate the LCC it is essential to establish a transparent model, which will unambiguously evaluate the proposed bids from the cost-effectiveness point of view. This paper presents the application "Bridgepass", which incorporates pre-defined requirements for the calculation of the LCC, and offers pre-determined weighting criteria for evaluating the proposed solutions of bridges and estimating the overall value of each bid.

Keywords: bridges, Bridgepass, Life Cycle Costs, evaluation, tender.

1. Introduction

The main aim of this paper is to present a method that includes for operational cost considerations within the tendering process of projects, under the Design and Build procurement route, and by doing so to assist in selecting the most effective bid / option. Furthermore, the presented method takes into consideration the Czech legislation: Act No. 137/2006 Sb - Public Procurement, specifically §78 - Evaluation Criteria, which states that the main selection criteria for all bids must be either the economic benefits of the proposed bid or the lowest bid cost. The above noted indicates that the LCC may be incorporated into such tendering as part of the economic benefits evaluation [1].

In order to calculate the LCC it is essential to establish a transparent model, which will unambiguously evaluate the proposed bids from the cost-effectiveness point of view. This paper presents the method, which incorporates pre-defined requirements for the calculation of the LCC [2], and offers pre-determined weighting criteria for evaluating the proposed solutions of bridges and estimating the overall value of each bid. The method uses a web-based tool and enables the bidders to clearly estimate the overall LCC for their bid preparation. In turn the tender committee has in its hands the same tool that allows them to verify independently all results. In our view, the main goal of any like tender should not be rewarding the lowest cost bid, which is most likely to generate - long term - the higher operational costs, but to effectively assess and account for all factors affecting the Life Cycle of an asset in order to enhance its overall economic effect [2].

Hence, the application creates indirectly an overall more transparent tendering process and does eliminate the potential of being unable to check errors and flaws of the submitted bids since the application mandates the same both for the bidder and the reviewer. Ultimately, by including the LCC method in tendering, allows the tender committee (likely the operator) to understand the costing long-term components of the designed assets - in this case bridge structures [3].

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2. Tenders evaluation

The basic evaluation criterion for awarding a public contract in accordance with § 78 paragraph 1 of the Law is the economic advantage of a tender. The economic advantage of a tender is evaluated in relation to the following partial evaluation criteria and the importance [4], which represent a share of the sub evaluation criteria in the overall assessment. Partial evaluation criterion and its importance in the overall ranking:

The total tender price without VAT – 60%
Operating costs (long-term costs of restoration and maintenance of the bridge structure calculated with the Bridgepass application created by the Faculty of Civil Engineering in Prague) – 40%

The subject of evaluation of tenders within the sub-criterion "total bid price" means the price excluding VAT, in Czech crowns. The best evaluated bid will be the one containing the lowest proposed price. Within the sub-criterion "operating costs" is the subject of evaluation the level of technical design of the bridge structure from the perspective of long-term costs and the costs of restoration and maintenance of the bridge structure. Costs of restoration and maintenance of the bridge structure are calculated with the Bridgepass application created by the Faculty of Civil Engineering in Prague.

The best evaluated tender is the one containing technically and legally feasible solution of the bridge structure, which is from the perspective of long-term costs of renovation and maintenance of the bridge structure, the most efficient (i.e. economically the most beneficial from the point of view of the contracting entity) compared with other evaluated tenders. The long-term aspect is related to the period arising from the expiry of the warranty period of the bridge structure to the expiration of the service life of the bridge structure in the duration of one hundred (100) years. [5] When determining the long-term costs of renovation and maintenance of the bridge structure the inflation is not taken into consideration. For the evaluation of tenders within the individual partial evaluation criteria, the evaluation committee uses a scoring scale from 0 to 100. Each tender is assigned a point value within each sub-evaluation criterion, which reflects the success of the tender in the context of the partial evaluation criterion.

The total tender price is evaluated as follows. The most profitable tender (the tender that contains the lowest total bid price) within the sub-criterion "total bid price without VAT", is assigned 100 points. The others are assigned a point value according to the formula 1.

$$POINTS = 100 * (\text{The lowest bid price}) \ / \ (\text{evaluated tender}) \tag{1}$$

The operating costs are evaluated on the basis of the output of the application software Bridgepass created by the Faculty of Civil Engineering in Prague. The evaluation commission prepares the ranking of tenders from the most to the least appropriate and assigns 100 points to the best tender. The best evaluated is the tender, that offers, in comparison with others, the most economical technical design of the bridge structure from the perspective of long-term costs and costs of restoration and maintenance of the bridge structure.

$$POINTS = 100 * (\text{tender with the lowest LCC}) \ / \ (\text{evaluated tender}) \tag{2}$$

The point values of tenders within each partial evaluation criterion are multiplied with their corresponding importance according to the table mentioned above and the results are rounded to two decimal places. Followed by the sum of the rounded values, the point value representing total evaluation of the tender is established. On this basis, the evaluation committee determines the order of tenders.

3. Software solution

The Bridgepass application follows the Buildpass application that was primarily aimed on the evaluation of LCC buildings [6]. Buildpass application dealt also partially with the issue of bridges, but the Bridgepass application covers this issue in detail and even in wider spectrum. This application offers easier handling and availability of LCC evaluation tool.

The Bridgepass application processes the estimated costs of maintenance and restoration at the level of individual structural elements. Each design element has a defined course of these costs, considering the technological linkages to other structural elements of the bridge. The result is dependent on the assessment of structural components and materials that are used. The application returns the sum of the discounted costs of restoration and maintenance for a specified period. This value is taken as the basis for evaluation of the criteria.

There will be a web application, with which candidates could free and anonymously calculate the approximate value during the selection process.

Bridgepass application calculates the costs of renewal and maintenance, which are generated by the following structural elements: abutments, pillars, bridge deck (substructure), bearings, insulation of deck, drainage, roadway, cornice, railings, crash barriers, expansion joints and noise barriers. Structural elements can be entered in the predefined type / material variations [7]. If the candidate uses a material that is not contained in the database, this situation is resolved by adding the element into the database. If there is a combination of materials used for one component, these materials are defined as separate structural elements. Variant solutions of structural elements can be seen in Table 1.

Table 1. Variant solutions of structural elements.

Structural element	**Type of structural element**		**Structural element**	**Type of structural element**
The bridge deck (substructure)	monolithic prestressed		Drainage	fiberglass
	monolithic non-prestressed			galvanized
	prefabricated prestressed			plast
	prefabricated non-prestressed			copper
	steel			stainless steel
	composite steel-concrete		Expansion joints	cantilever expansion joint
	composite reinforced concrete			modular expansion joint
	composite Atmofix			nosing expansion joint
Bearings	elastomeric bearings			mat expansion joint
	roller bearings			buried expansion joint
	rocker bearings			Elastic expansion joint
	pot bearings		Noise barriers	concrete
	spherical bearings			brick
Insulation of deck	asphalt strips			plastic
	asphalt screed			softwood
	asphalt coating			hardwood
	epoxy screed			ceramic
	epoxy tar screed			metal
	polyurethane screed			plexi
	polymer coating			

Bridgepass application is available on the website http://www.cesti.cz/bridgepass/. For evaluation, the structural elements are selected according to the type or material that will be used and after that the area (amount) of the element is filled. After completing all items, the application returns the value of the anticipated recovery of costs of defined bridge construction for a period of 100 years of operation by pressing “Calculation” button.

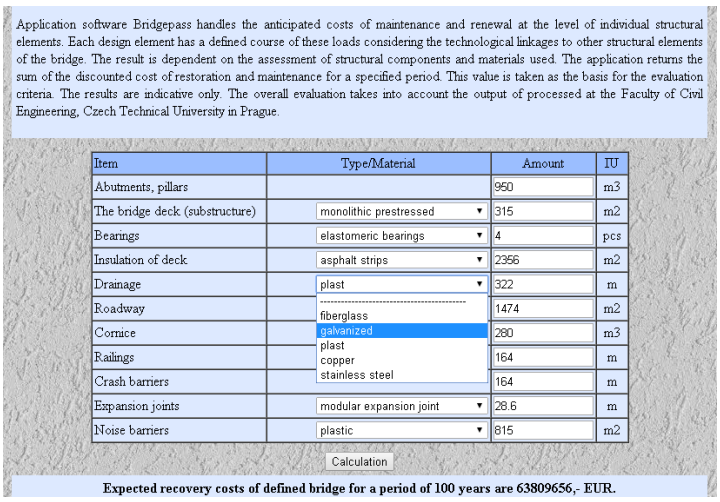

Figure 1. Web interface of the Bridgepass application

4. Conclusions

As an important factor taken into consideration is LCC, which play an important role in building bridges with a lifetime counted for hundred years. The point is not only cheap to build, but also cheap to operate. After that it is necessary to find the best deal that joins these two factors. Successful implementation of LCC cost evaluation using Bridgepass application is an example of what direction can be taken when evaluating public tenders. Of course, the current state cannot be taken as definitive, but there are already suggestions how to improve evaluation methods, mainly about fulfillment of database data of lifespan and prices of individual components. There are companies that have a large database full of information about operation of bridge structures throughout Europe. There is a space for further development and application of methods for assessing LCC bridges.

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