MULTICRITERIA DECISION MAKING OF STRUCTURE TYPE BRIDGE SELECTION

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Summary

Construction costs should not be the only one criterion for variant selection of bridge construction type. Life cycle costs calculation for each variant is necessary to proper decision making about variant selection. The cheaper variant in construction phase can be economically less advantageous during usage phase than the variant with higher investment costs but lower operating costs [4]. The paper deals with the question how to evaluate and compare the life cycle cost of bridge objects. Life cycle costs of bridge are derived mainly from the bridge construction type (coupled, steel, monolithic, prefabricated – prestressed, not prestressed). A detailed calculation of costs is at the level of individual structural elements of the bridge [2]. Each structural element has its own life cycle and maintenance and renewal costs. However, structural elements interact, which has an impact on the individual life cycles for structural elements. The paper presents a tool for calculating life cycle costs of bridges in the level of structural elements and their relationships.

Keywords: Bridges, LCC, Tender, Construction Variant, Construction Elements

1 Introduction

The paper presents the method of evaluation of alternative solutions bridges. The selection was chosen multicriteria decision making method, where not only one criterion (cost) as it usually is. Faculty of Civil Engineering deals with the life-cycle costs, and in this area offers a tool to assess the LCC [3]. In addition, the principle of self-evaluation is further described in more detail above tool designed for skilled setting and evaluation of LCC [5].

2 Evaluation criteria

To choose the best variant solutions were chosen three basic criteria:

- the total bid price without VAT – weight 70 %,
- the cost of maintenance and renewal of the bridge – weight 20 % 0,
- extension of the warranty period above the minimum guarantee period – weight 10 % of which:
  - extending the length of the warranty period on the asphalt pavement layers (above the minimum warranty period of 10 years) – 25% weight,
  - extending the length of the warranty period on the supporting structure of the bridge and visible (above the minimum warranty period of 10 years) – 40% weight,

- extending the length of the warranty period on the waterproofing of bridges (over a minimum warranty period of 10 years) – 35% weight.

2.1 The total bid price

The best bid (bid that contains the lowest total bid price) within the sub-criterion "total tender price without VAT" will be given 100 points. The others will be assigned a point value according to the following formula (1):

$$\text{points} = \frac{\text{lowest total bid}}{\text{evaluated bid}} \times 100 \tag{1}$$

2.2 Costs of maintenance and renewal of the bridge

Based on the output application software Buildpass processed Faculty of Civil Engineering CTU in Prague establish a ranking of the tenders evaluation committee from the most to the least appropriate and assign the best offer 100 points. It would be best evaluated bid, which will be compared with other offers a most economical level of technical solutions the bridge from the perspective of long-term costs and the costs of rehabilitation and maintenance of the bridge. Points will be awarded according to the following formula (2):

$$\text{points} = \frac{\text{bid with the lowest LCC}}{\text{evaluated bid}} \times 100 \tag{2}$$

2.3 Extension of warranty period above the minimum warranty period

Each bid at the sub-criteria "Extending the length of the warranty period on the asphalt pavement layers", "extended warranty on the structural design of bridges", "extended warranty on waterproofing bridges" will be assigned point value fixed multiple of 100 and the ratio of the number of months of the warranty offered by these technologies or objects exceeds the minimum warranty period of these technologies or objects of 10 years and the difference of twice the minimum warranty period of these technologies or objects of 10 years, ie 20 years. If the value offered by the bidder for any of the following sub-criteria will be longer than the minimum length of the warranty period of 10 years, will offer candidates in the relevant sub-criteria scored 0 points. If the value offered by the bidder for any of the following sub-criteria will be longer than 20 years, the candidate receives a bid within the relevant sub-criteria of 100 points. Volumes sub-criteria will be multiplied by their respective weight according to the above table and then the sum of the point value will be detected partial evaluation criterion "extended warranty".

3 Determination LCC bridges

Cost recovery and maintenance of the bridge will be calculated Buildpass applications created Faculty of Civil Engineering CTU in Prague. Application software Buildpass processes defined cycles of renewal and maintenance of the bridge components. Cycles are linked with the volumes of the components. Each design element has a defined length and degree of recovery cycle costs to be spent in each cycle. This is expressed as a percentage of the amount of the adjustment and constructed is generated from the original cost [1]. In

Table 1 lists structural elements and their various modifications of the model which the bridge is drawn up.

Tab. 1 *Construction elements*

<table>
<tr><th>Construction element</th><th>Type</th><th>Construction element</th><th>Type</th></tr>
<tr><td>Excavation</td><td></td><td rowspan="5">Drainage</td><td>fiberglass</td></tr>
<tr><td>Deep foundations</td><td></td><td>galvanized</td></tr>
<tr><td>Foundations</td><td></td><td>plastic</td></tr>
<tr><td>Isolation of soil moisture</td><td></td><td>copper</td></tr>
<tr><td>Abutments, piers</td><td></td><td>stainless steel</td></tr>
<tr><td rowspan="7">Deck (carrier Functions)</td><td>monolithic prestressed</td><td>Roadway</td><td></td></tr>
<tr><td>monolithic non-prestressed</td><td>Ledge</td><td></td></tr>
<tr><td>mounted prestressed</td><td>Railing</td><td></td></tr>
<tr><td>steel</td><td>Guardrail</td><td></td></tr>
<tr><td>composite steel-concrete</td><td rowspan="6">Bridge conclusions</td><td>comb conclusion</td></tr>
<tr><td>reinforced composite</td><td>lamella conclusion</td></tr>
<tr><td>coupled Atmofix</td><td>seal the joint with unit</td></tr>
<tr><td rowspan="5">Bearings</td><td>elastomeric bearings</td><td>carpet conclusion</td></tr>
<tr><td>roller bearings</td><td>subsurface conclusion</td></tr>
<tr><td>rocker bearings</td><td>elastic conclusion</td></tr>
<tr><td>pot bearings</td><td rowspan="9">Noise barriers</td><td>concrete</td></tr>
<tr><td>spherical bearings</td><td>brick</td></tr>
<tr><td rowspan="7">Isolation deck</td><td>bitumen</td><td>plastic</td></tr>
<tr><td>asphalt screed</td><td>softwood</td></tr>
<tr><td>asphalt coating</td><td>hardwood</td></tr>
<tr><td>epoxy screed</td><td>ceramic</td></tr>
<tr><td>epoxy-tar squeegee</td><td>metal</td></tr>
<tr><td>polyurethane squeegee</td><td>aluminium</td></tr>
<tr><td>polymer coating</td><td>plexi</td></tr>
</table>

Application software Buildpass based on definition type bridges, which belongs to the structural elements. Defined the following types of bridges: monolithic concrete non--prestressed monolithic prestressed concrete, assembled from components non-prestressed concrete, assembled from components of prestressed concrete, steel-concrete composite, composite reinforced concrete, steel-concrete composite – Atmofix, steel. After selecting the type of the bridge based on the submitted applications are technical solutions Buildpass generated data acquisition rates expected the bridge. These data are automatically generated the expected volumes of components appearing at the cost of restoration and maintenance of the bridge.

4 Conclusions

For large investment projects can not only take into account the cost, but to evaluate the total life cycle costs. In recent years, the situation in this respect is improving and effort in deciding this fact into account. This paper presents one of the tools that are actively used in decision making in the selection of investment options of major bridges. It is very important that the state administration authorities used a methodology taking into account the long-term benefits and costs associated with the spending of public funds. Enforcement of this project in practice shows that the trend is set to the right direction, but it's still the issue when announcing procurement is still in its infancy and needs to be promoted.

Acknowledgement

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