AHP Based Contractor Selection Procedure for Highway Infrastructure Projects in Serbia

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Abstract

The recently published papers reveal that the cost and time overrun on highway construction projects are global problems. The need to assess and control projects in terms of the iron-triangle goals of management (cost, time, and quality/performance) is emphasised, especially for the projects financed from international funds. Among other efforts, it is necessary to minimize the risks of contractor's failure. Therefore, the assessment of the potential contractor's competencies within the bidding process is one of the key check points prior to the construction phase. Instead of the prevailing practice of contractor selection using mainly the lowest bid, different types of criteria should be considered, all of them subjected to the specific project's goals. The relative importance of these criteria is difficult to determine and quantify. Various mathematical models that rely on multi-attribute ranking are available for solving the problem. In this paper Analytic Hierarchy Process (AHP) is suggested and the approach that determines criteria weights and contractors selection during bidding process is proposed. Based on this approach a baseline framework for selection of contractors for future use on highway infrastructure projects in Serbia is proposed. The preliminary results show that there is a potential to facilitate the objectives and rationalize the decisions during bidding process in open procedures on highway infrastructure projects.

Keywords: bidding procedure, contractor selection, highway infrastructure, AHP method

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1. Introduction and background

Procurement of infrastructure projects is rightfully labeled as highly risky, meaning that delays and budget overruns on these projects happen very often. Even though in the past decades there has been an outburst of methods used for improving procurement, there has been no improvement in the success rate of these projects. Many authors described current bidding procedures and emphasized contractor selection as one of the important critical points for reaching the projects goals in terms of time, cost and quality (Hatush and Skitmore, 1997; Watt et al., 2010). In this respect an appropriate model was sought by them to help decision makers and to increase the chance of reaching the project goals (Hatush and Skitmore, 1998; Cheng and Heng, 2004; Watt et al., 2010, Plebankiewicz, 2009; Jaskowski et al., 2010).

In an effort to help the borrowers with the procurement and to ensure the success of projects financed by them, international financing institutions such as the World Bank (WB), the European Investment Bank (EIB), the European Bank for Reconstruction and Development (EBRD) and the EU Commission, issued their own procurement guidelines. WB guidelines are more elaborated in this paper as they have been frequently used on projects in Serbia. The main award criterion for the contractor selection throughout these guidelines is the lowest bid price.

Public procurement law in Serbia is in line with the EU directives. According to Serbian public procurement law, the lowest price or the most economically advantageous bid are the two possible award criteria. Nowadays, the criteria most economically advantageous bid has been recognized by the EU Commission and the Europian Investment Bank and incorporated as an award criterion in their guidelines (EU Commission PRAG, 2014; EIB Guide, 2011).

Even though repeatedly criticized both by researchers and practitioners (Bower 1989; Holt et al., 1994; Hatush and Skitmore, 1998; Wong et al., 2000), lowest price continues to be the prevailing criteria for ranking of bidders when it comes to procurement of construction works. Since, infrastructure projects are mainly connected with the public sector, reason for using lowest price as the criteria may be found in difficulties of public justification of selection using "best value for money" bid rather than the lowest price bid. On the other hand, Contractors when faced with shortage of works are more likely to enter low price bids to stay in business in the short term hoping that they will raise additional income through claims or by cutting costs (Hatush and Skitmore, 1998).

The need for the development a highway infrastructure in Serbia, as a developing country heading towards EU, is indisputable. In 2009, Government of Serbia founded a company “Koridor 10” Ltd (which later grew and changed its name into “Koridori Srbije” Ltd) for the purpose of tendering and management of construction works. The company is responsible for construction and finalization of the remaining motorway sections on the pan European Corridor X, (E75 and E80) through Serbia, and construction of motorways on E763 and M 21 road.

There are currently 30 construction projects and 200 km of highways under the supervision of Koridori Srbije Ltd. The works are financed from the loans provided by the WB, EIB and EBRD. Although financed by different institutions, procurement of all projects was in accordance with the International Competitive Bidding (ICB) procedures recommended by WB for borrowers operating in the public sector where the lowest price was the only award criteria (WB Guidelines, 2011). According to the construction execution review for 2014 issued by Koridori Srbije, in the period from 2009, only a minority of projects were completed or will be completed in next two or three months, while the rest suffer from serious time delays and, low rate of progress (Koridori Srbije, business and financial plan, 2015).

Authors of this paper were active participants in the bidding process where the contracts were awarded on the lowest bid price basis. They also witnessed the execution of these projects. Since 2009, on some projects contractors have bankruptcy and contracts were terminated, on others final warnings (notice to correct) before contract termination were issued. Non of the contracts have been completed within the contractual deadlines. The authors propose a modification of the current bidding procedures by introducing two phases, the eliminating and the ranking phase. Eliminating phase comprises questioning of whether the criteria which are currently used to demonstrate the adequacy of the bidder's proposal meet the minimum of the requirements set in bidding documents. Ranking phase compares the bids proposals in order to determine most economically advantageous bid or "best value

for many bid" by considering other criteria (financial issues, general and specific experience, technical proposal and expertise) besides the bid price criterion.

The current evaluation procedure involves preliminary examination, ranking and post qualification of bids. Preliminary examination of bids needs to determine its eligibility and responsiveness to the bidding documents, where the bids that are not responsive are not being considered further. Ranking is comparing of bids in order to determine the bid with the lowest price, while post qualification analyzes whether the bidder whose bid has been determined to offer the lowest evaluated cost has the capability and resources to effectively carry out the contract as offered in the bid. This is determined by a set of criteria and sub criteria displayed in the bidding documents. If the bidder does not meet the criteria, the lowest price bid is rejected and the similar examination is done for the next lowest evaluated bidder. The bidder who meets all the criteria requirements and offers the lowest price is awarded with the contract.

The criteria serve to demonstrate the overall financial position and profitability of bidder, bidder's participation on previous projects, especially if they are similar to the project that will be executed, its capability of planning, organizing and controlling a project and consistency of his offer with requirements stipulated in bidding documents. The criteria which is being used for post qualification with the minimum of requirements as recommended by the WB are shown in Table 1 in columns 1 to 4 (WB Standard Bidding Documents (SBD), Procurement of Works & User's Guide, 2015).

Table 1. List of criteria used for post qualification on a Serbian infrastructure project (financed by WB)

1) Criteria	2) Sub-criteria	3) Description and minimum requirements	4) Type of criteria
Eligibility	Nationality	Borrower's country not having prohibited commercial relations with Bidder's country .	Eliminating
	Conflict of interest	Bidder shall not have conflict of interest.	Eliminating
	Bank ineligibility	Not having declared ineligible by the Bank.	Eliminating
	Government owned entity	Legally and financially autonomous and operate under commercial law .	Eliminating
	Ineligibility based on UN resolution or Borrower's country law	Not having declared ineligible by UN or Borrower's country law .	Eliminating
Historical contract non-performance	History of non-performing contracts	Non-performance of a contract did not occur within the last five years prior to the deadline for application submission.	Eliminating
	Pending litigation	a) Pending litigation in total are less than 20 % of the Bidder’s net worth and shall be treated as resolved against the Bidder. b) All claims are less than 20 % of the accepted contract amount of the contract c) No pending litigation with the Employer.	Eliminating
Financial issues (C1)	Historical financial performance	Submission of audited balance sheets for the last three years. A Bidder’s net worth needs to be positive.	Eliminating & Ranking
	Average annual turnover	The Bidder's average annual turnover within the last three years shall be equal or more than the expected annual turnover if this contract is awarded to Bidder.	
	Financial resources	The Bidder must demonstrate access to, or availability of, financial resources other than any contractual advance payments to meet the overall cash flow requirements for this contract and its current commitments.	
Experience	General experience (C2)	Experience under contracts in the role of contractor, subcontractor, or management	Eliminating & Ranking

		Contractor for at least the last five years.	
	Specific experience on project of similar value (C3)	Participation as contractor, management contractor, or subcontractor, in at least one contract within the last five years, with a value which corresponds to 70-80% of this contract value, that have been successfully and substantially completed and that are similar to the proposed Works.	Eliminating & Ranking
	Specific experience – key activities (C4)	For the above or other contracts executed, a minimum experience within the last five years in the following key activities that reflects the majority (70-80%) of Works' scope (i.e. earthworks and rock excavation, asphalt and concrete production and placement, construction of bridges.	Eliminating & Ranking
Technical expertise	Key personnel (C5)	The Bidder must demonstrate that it has the personnel for the following key positions: project manager 15 years (7 on similar projects), site managers and engineers 10 years (5 on similar projects).	Eliminating & Ranking
Technical proposal (AHP C6)	Site organization Method statement Programme of works Equipment Subcontracting Traffic management plan Environmental management plan Quality assurance plan Sources of material procurement Cash flow Personnel	The Bidder's technical proposals must be made on the basis of a conceptual design or performance specifications set out in the bidding documents. It needs to describe the organization, work methods and processes, scheduling, ability to ensure the requested quality and to mobilize enough personnel and equipment to execute the project, plan of material procurement, traffic and environmental management plan. All of this needs to be provided in sufficient detail and fully in accordance with the requirements stipulated in bidding documents.	Eliminating & Ranking
Financial proposal (C6)	Bid price	Value of bid	Ranking

The proposed method considers these criteria through the bidding process. The first, eliminating phase in majority corresponds with the preliminary examination phase. The proposed addition is to use the criteria in the eliminating phase alongside with the eligibility and bid responsiveness requirements. Minimum of requirements set for each of the criteria would be used as a threshold. All the bids that exceed the threshold are being considered and compared further in the ranking phase but now instead of using the lowest price as the only criteria the elimination criteria are also used for ranking candidates. Considering that these criteria have both the qualitative and quantitative indices, this makes the selection of contractor's a multi-criteria problem.

Many techniques are proposed and applied as a solution (Hatush and Skitmore, 1998; Cheng and Heng, 2004; Plebankiewicz, 2009; Jaskowski et al., 2010). Because of its wide application in construction project management Analytical Hierarchy Process AHP is, as decision making method, widely used for multiple criteria decision-making (MCDM) in construction project management. (Saaty, 1990; Kamal et al., 2001; Chun-Chang Lin et al., 2008; Jaskowski et al., 2010). Some areas of construction project management where AHP method is used are contractor selection (Kamal et al., 2001; Jaskowski et al., 2010; Abudayyeh et al., 2007), technology selection (Skibniewski and Chao, 1992), equipment

selection (Shapiraand Goldenberg, 2005), analysis of causes of disputes in the construction industry (Cakmak and Cakmak, 2013).

2. General description of AHP Method

AHP is MCDM method where the process factors are hierarchy organized. Vertically, objective is on the highest level, with criteria, subcriteria and alternatives on lover levels, respectively, as it is showed on the hierarchical structure on Figure.1.

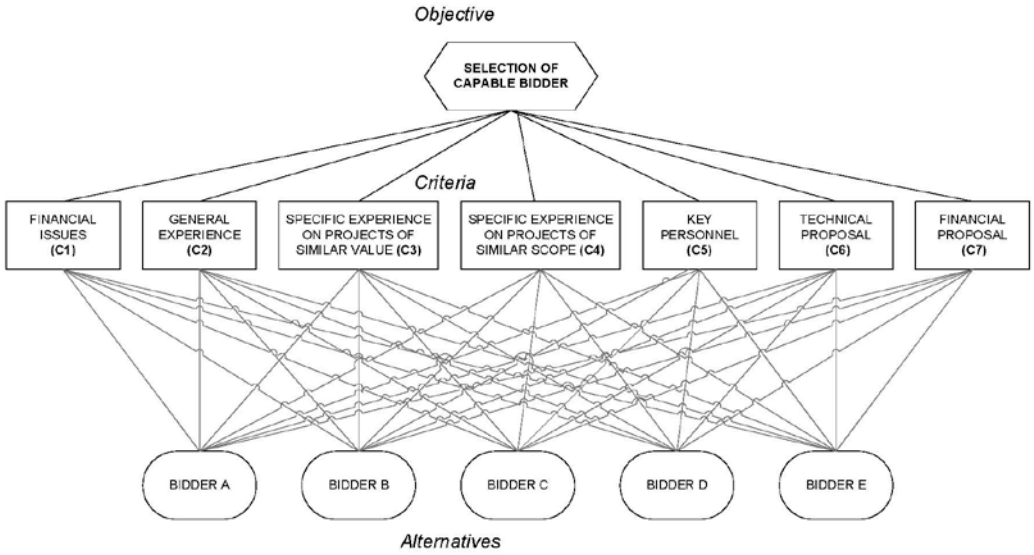

Fig.1. Hierarchical decomposition of an example

For each level − the criteria, subcriteria and alternatives, elements are compared in pairs. It means that one unfamiliar with the methodology of AHP can compare two elements from the same level according to verbal description scale. Fundamental scale used to compare the elements consists of verbal judgments ranging from equal to extreme (equal, moderately more, strongly more, very strongly more, extremely more). Corresponding to the verbal judgments are the numerical values (1, 3, 5, 7, 9) and intermediate values (2, 6, 8). (Saaty, 1990) Saaty's scale is given in Table 2.

Table 2. Saaty's fundamental scale

Intensity of importance on an absolute scale	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance of one over another	Experience and judgment strongly favor one activity over another
5	Essential or strong importance	Experience and judgment strongly favor one activity over another
7	Very strong importance	Any activity is strongly favored and its dominance is demonstrated in practice
9	Extreme importance	The evidence favoring on activity over another is of the highest possible order of affirmation

2, 4, 6, 8	Intermediate values between two adjacent judgments	When compromise is needed
Reciprocals	If activity *i* has one of the above numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i	
Rationales	Ratios arising from the scale	If consistency were to be forced by obtaining n numerical values to the span matrix

Comparison results of n elements belonging to Saaty's scale and AHP hierarchical structure levels are comparison matrices. These matrices ensue vectors priority or $\omega = (\omega_1, \omega_2, \ldots \omega_n)^T$, ω is the eigenvector of corresponding matrix. Vector priority involves normalized values which determine importance of the elements – weights of the elements which are compared. This is the method for determination of the priority vector of criteria, the priority vector of alternatives, and as the final result the priority vector of the objective. The priority vector of objective ranks alternatives respect to the importance of the criteria. (Saaty, 1990)

3. Example with results and discussions or research plan

The numerical example is conducted through AHP model in this paper. The main purpose of AHP model is to support ranking which is proposed in this paper as the second phase in the process of selection of contractor in bidding procedures. Here AHP is used in the procurement of an infrastructure project − construction of nearly 6 km of highway with 6 bridges and an overpass. This project is financed by the Government of Serbia and managed by the company Koridori Srbije Ltd.

The AHP model consists of five alternatives and seven criteria. The alternatives represent a contractors which passed the eliminating phase in the open procedure. The criteria are proposed by the authors in the following way: C1 −financial situation, C2 − general experience, C3 − specific experience, C4 − key activities, C5 − key personnel, C6 − technical proposal, C7 – bid price. Some criteria from Table 1 are eliminating (Yes/No), and here are proposed those which can be assessed.

C1 − financial situation involves contractor's sound financial position and profitability, here is considered minimum average annual construction turnover within the last three years;

C2 − general experience under construction contracts for the last five years;

C3 − specific experience − under this criterion minimum value of contracts which are similar to the proposed works and which were successfully completed within the last five years is required;

C4 − key activities − under this criterion minimum construction experience for the key activities in the last five years is required;

C5 − key personnel – for key positions minimum years of work experience and minimum number of years on similar positions are required;

C6 − technical proposal – equipment of certain type and characteristics and minimum number of pieces are required;

C7 – total bid price.

Judgments of the elements and comparasion were provided by the independent experts. This example includes group of three experts which have a great number of years experience in tender procedures.

Each expert compares and assigns pairs of elements belonging to AHP hierarchical structure levels. Comparison results of the criteria are comparison matrices. In the Table 3 comparison matrix for the experts has been showed. The priority vectors of criteria follow as it is explained in general description of AHP. Considering the experts' equal participation, the final priority vector of criteria (criteria weights) are solved by the arithmetic mean method in Table 4 (Cho and Cho, 2008). In criteria ranking bid price has the main priority with 56%, and the second is key activities with 18,9 %, while general experience has the lowest priority.

Table 3. Experts criteria judgments

Criterion number		Expert 1	Expert 2	Expert 3
1	2	1/3	1	1
1	3	5	1	2
1	4	7	9	9
1	5	5	3	3
1	6	3	2	2
1	7	9	9	9
2	3	3	1	3
2	4	5	9	9
2	5	3	3	3
2	6	3	2	3
2	7	9	9	9
3	4	2	9	5
3	5	1/3	3	2
3	6	1/3	2	1
3	7	8	8	8
4	5	1/3	1/3	1/3
4	6	1/3	1/5	1/5
4	7	7	8	8
5	6	1/3	1/3	1/3
5	7	9	9	9
6	7	9	9	9

Table 4. Criteria weights

ω_1	ω_2	ω_3	ω_4	ω_5	ω_6	ω_7
0,0273	0,0253	0,0651	0,1894	0,0821	0,0467	0,5641

Further, the experts assign the alternatives for each criterion respecting the goal. Judgments for all pairs of alternatives considering the criterion are elements in the comparison matrix. Eigenvectors of all these matrices (for all criteria) rank importance of alternatives in accordance with the corresponding criterion and they are given per columns in result matrix in Table 5. This matrix ensue the final priority vector of alternatives, that is showed in Table 6.

Table 5. Ranking matrix alternatives per criteria

	C1	C2	C3	C4	C5	C6	C7
A1	0,309	0,146	0,401	0,511	0,468	0,306	0,23
A2	0,046	0,49	0,059	0,054	0,067	0,09	0,235
A3	0,461	0,154	0,218	0,277	0,261	0,185	0,193
A4	0,138	0,154	0,206	0,103	0,138	0,233	0,147
A5	0,046	0,058	0,116	0,054	0,067	0,185	0,195

Table 6. Ranking alternatives list

A_1	A_3	A_2	A_4	A_5
0,318	0,222	0,170	0,145	0,144

In this example contractor – A2 is the first on the ranking list considering criterion with highest importance C7 – bid price. Also, considering the criteria which follow the price on the criteria weights list, the contractor named alternative A1 has better characteristics than contractor – A2. Finally, Table 6 ranks alternatives where contractor – A1 has the first position. In the considered example of decision making, contractor A1 is the best solution, although his price was not the lowest.

4. Conclusion

The model presented in this paper takes into consideration other criteria besides the widely used lowest bid criterion for the contractor selection, thus making it a multi-criteria problem. AHP method as a decision support system was proposed and used for assessing the contractors in the ranking phase of the bidding procedures. In this paper, evaluation on the base of experts judgments using procurement of one infrastructure project financed by the Government of Serbia was conducted. Except bid price, criteria related to the contractor's financial situation, experience, key personnel and technical proposal was taken into account in the numerical example. It was estimated that the bid price participates with over 50% in the selection, but solution with much better other characteristics meaning contractor's specific experience and key personnel could have high importance. Result of the conducted numerical example is the contractor with a little higher bid price than the lowest, but with significantly better other proposed criteria. This result is proposed having in mind the project goals: cost, time, and quality.

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