BRIDGE CONDITION ASSESSMENT BY VISUAL INSPECTION – CROATIAN EXPERIENCE

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SUMMARY

Most decisions relating to bridge maintenance are founded on assessments that are based on visual inspections conducted by specially trained engineers, using procedures and aids defined in the management system. Visual inspection is the main tool for bridge condition assessment, and is therefore of crucial significance for planning periodic maintenance activities. Paper shall present the study aimed at harmonizing bridge assessment activities, which was conducted in early 2012 in company Hrvatske ceste – Croatian National Road Authority. Small RC bridges were chosen for this study, since visual inspection is usually only tool utilized for their assessment. Ratings obtained by inspection were analyzed using methods of mathematical statistics. The results point to weaknesses in the current assessment system, while the study itself constitutes a good basis for further improvement of management aids, manuals and procedures for bridge inspection.

Keywords: *Visual Inspection, Concrete Bridges, Bridge Management, Bridge Rating.*

1. INTRODUCTION

Most decisions relating to bridge maintenance are founded on assessments that are based on visual inspections conducted by specially trained engineers, using procedures and aids defined in the management system. To ensure uniformity and objectivity, the inspections are conducted using a standardized procedure which has been developing in Hrvatske ceste since 1995 under the name of HRMOS, and is based on the system used by the Danish Road Directorate [1,2]. The quality and uniformity of visual inspection results greatly depend on the motivation, qualification and equipment of persons conducting these inspections, and the efficiency of management system in the sphere of maintenance planning significantly depends on the uniformity of results obtained by visual inspection, i.e. on the assessment of category of damage, which is directly related to the scope and type of subsequent repairs [3].

Perception is an individual and situation-related category, and is hence not an objective photographic copy of reality but rather the subjective experience and interpretation of the observer. More specifically, perception is dependent on a number of psychological factors, such as expectations, attitude, type of information (e.g. different instructions), quantity of information, insight into the formation process, motivation, sociocultural influences, etc. [4, 5]. This means that findings made by different bridge inspectors cannot be identical. Nevertheless, these differences can be reduced, i.e. a greater objectivity of these inspections can be achieved. The purpose of this study is to evaluate the level of uniformity/similarity in assessments made by engineers in charge of bridge inspections, as these assessments are the basis for planning periodic maintenance activities.

2. BRIDGE CONDITION ASSESSMENT SYSTEM USED ON NATIONAL ROADS

The company Hrvatske ceste d.o.o. operates the national road network 6585 km in length, along which 1538 bridges of more than 2 m in span are located. The inspection of a big number of structures was made in the scope of bridge cadastre establishment in mid-1990s [9].

823 bridges with span over 5 meters were registered in 2010 on the national road network. Out of 718 girder bridges registered, in 587 cases girders are made of reinforced concrete, in 113 cases main girders are formed of prestressed concrete, and in 18 cases main girders are made of an another material (steel in most cases). In addition, 74 arch bridge were registered (34 masonry bridges, 39 concrete and reinforced concrete bridges, and 1 steel bridge), while main girders of the remaining 31 bridges have other static systems (frame, bracing, etc.).

Table 1 *Bridge elements assessed in the scope of the national road management system operated by Hrvatske ceste, with average ratings, situation in 2010*

Element groups	Bridge elements		Average grade
A	Approaches and embankment cones		1,8
B Substructure	B1	Foundations of abutments and piers	1,6
	B2	Abutments	1,6
	B3	Piers	1,4
C Superstructure	C11	Main girders	1,6
	C12	Span structure	1,6
	C2	Expansion joints	2,2
	C3	Bearings	1,4
D Equipment	D1	Pavement + walkway	1,9
	D21	Traffic barrier	2
	D22	Railing	2
	D3	Other	2
Bridge, general rating			1,8

A six-category scale is used in the current bridge assessment system: from category 0 (no damage to bridge or bridge element) to category 5 (extensive damage registered). Categories 1 and 2 are mostly used to depict construction- related defects. The category 3 is used for elements undergoing the deterioration process, while highly deteriorated elements are included in categories 4 and 5.

During general inspection of bridges, thirteen standard bridge elements are assessed, and then the general bridge rating is given. However, only twelve elements are shown in Table 1 as two elements (pavement and walkway) have been reduced to one (D1 pavement + walkway). Bridge classification by general ratings, made in 2010, is shown in Figure 1.

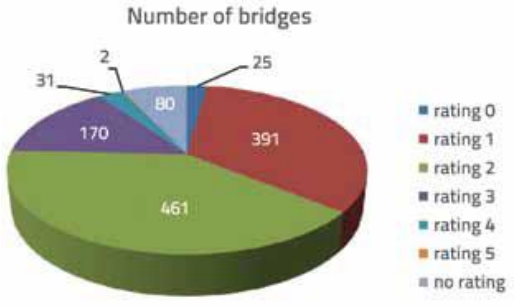

Fig. 1 Condition of bridges on national roads of the Republic of Croatia - situation in 2010

3. US STUDY OF EFFECTIVENESS OF VISUAL INSPECTIONS

The study of effectiveness of visual inspections was made in response to relative uncertainty of results on which the management system is based, i.e. after it was established that there is a great discrepancy of results in case the same structure is inspected by several inspectors. A comprehensive study on this issue was conducted by the Federal Highway Administration's

Nondestructive Evaluation Validation Center (NDEVC) in 2001 [8]. The basic conclusions of the study can be summarized as follows:

1) Most reviewers did not notice any occurrences that would greatly affect bearing capacity and usability of bridge elements,
2) 95% of bridge element assessments/ratings varied on an average by two ratings, while 68% of ratings differed by one rating,
3) some inspectors performed their work with negligence,
4) when inspectors cannot decide for either a lower or a higher ranking, they tend to group ratings toward the middle of the scale,
5) some significant factors that influence ratings are: uneasiness of inspectors because of traffic operated during their work, lack of specialized knowledge, level of lighting etc.,
6) some significant damage was not identified by detailed inspection,
7) inspectors whose ratings are lower than average ratings on one bridge are likely to give similar ratings on other bridges.

4. STUDY CONDUCTED IN CROATIA IN 2012

4.1 Methodology and initial assumptions

Some inconsistencies were revealed following study of the database containing ratings made by bridge engineers in the scope of regular inspections. Concretely, most conclusions from the cited American study can also be applied to our circumstances. This is why a study was conducted to test the work of 15 inspectors, experienced engineers from various Hrvatske ceste units, who evaluated the level of damage on five different bridges. The catalogue of damage, and the grading system used in the study, was intentionally modified with respect to the system used in normal practice, so as to avoid routine ranking. Older reinforced concrete and prestressed concrete bridges were used as the sample, and rankings ranged from S0 (completely undamaged element) to S4 (unusable element). For each of 12 bridge elements, typical defects and ratings associated to them were described in the catalogue given to inspectors before inspection. Photographs of all bridge elements to be tested were also given to inspectors. The inspectors were asked to enter ratings in the form presented in table. Concrete designations of marks assigned to individual elements are given in Table 1. The overall rating of the bridge is considered equal to the worst rating of the ratings for the following elements: span structure, pier with head beam, abutment, foundations (for piers and abutments), and riverbed.

4.2 Test results

Statistical indicators used in the analysis of bridge element results are an average numerical value of the level of damage, standard deviation, median, and mode of statistical redistribution in the group of values [12]. In general terms, the results gained in the course of this study point to a relatively good uniformity, especially if we take into account known problems associated with subjective and qualitative method of visual inspection of bridges. Sporadic cases of significant deviation of ratings are an indication for typical situations in practice. Such cases should be given a special attention through workshops and preparation of a bridge inspection manual.

5. CONCLUSION

Regardless of current technological advances, visual inspection is expected to remain the main aid for collecting data about condition of bridges. This study, and the corresponding analysis of results, point to the possibility of assessing quality of work of bridge engineers, and to types of damage that are difficult to identify and evaluate.

The assessment of general condition of bridges is made by summing up damage identified at individual elements. In reality, bridge condition can generally be considered satisfactory despite a number of smaller defects. Otherwise, the condition of the bridge can be quite alarming even when

local damage is scarce. In this respect, it is necessary to define solid criteria for the assessment of a general bridge condition based on visual inspection. General rating instructions should provide clear guidelines for the registration of visible manifestations of global condition and for heavy damage indicators. Local damage of elements should be given a minor role in the determination of general condition of bridges. In Croatia, some inspections backed by testing are conducted by specialists engaged as contractors for a specific work, while most routine inspections are made by employees of the road network operator. It is highly significant to establish good communication between experts performing similar tasks, so that practical management of this significant and expensive national resource can be improved and harmonized through exchange of practical experience.

6. ACKNOWLEDGEMENTS

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