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## Forecast for Terms of Culvert Inspection and Repair

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### Abstract

Culverts which were built in different years, by different organizations and of different types of materials are one of the most important elements of railways and highways. The culverts work jointly with the foundation and roadbed grounds, thus degeneration processes in pipes and culverts has a direct influence on the safety and reliability of the transport object they belong to.

Consequently, importance of the technical condition estimation and forecast increases. The repair of the underground objects requires significant financial expenses that can be avoided by proper forecast for terms of culver repair.

The method of the forecast for terms of railway and highway culverts inspection and repair based on fuzzy logic is presented in this paper. The degradation rate that depends on the culvert age and technical condition is obtained as a result.

The considered approach allows planning the terms of culverts inspection and repairing reasonably, that significantly increases the safety of the transportation objects and decreases the maintenance expenses.

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## 1. Introduction

The pipes and culverts are very important components of the railway and highway system. They let the water through the roadbed and preserve it from the erosion. The failure of such construction may lead to the interruption of the functioning of the significant part of the road. This will cause serious financial expenses because the disorder in the water offtake leads to the traffic suspension or speed limit may be required till the end of the repair.

The federal highways of a common use total length in Russian Federation is estimated by the Federal road Agency “Rosavtodor” as 1,396 million km. The total length of the railway lines is 87 thousand km. Normally, there are one or two culverts per kilometer of the road. The culverts inspection is an expensive and resource-intensive process. At the same time, any defects or deformations which appear in culverts have strong influence on the safety and reliability of the transportation object the culverts belong to.

The forecast for the culvert condition allows defining the terms of the inspection and repairing correctly. That will help to increase the intervals between the inspections, and rationally distribute the resources and thus to decrease the maintenance expenses.

## 2. The method of the culvert condition scoring.

The culvert condition estimation usually consists of two steps. On the first step the culvert is inspected by methods of the direct observation (visual, video) and methods of nondestructive monitoring (radar, sonar, ultrasound, acoustic emission), telediagnosics. On the second step the observation result data is converted to the culvert condition scores.

The culvert condition estimation is based on the “Instruction for the railway structures condition and maintenance estimation in Russian Federation” [1]. According to this document the culvert condition and maintenance estimation is performed by the system of the scores.

The main point of the culvert condition scores method is to assign a score to every observed defect with respect to the defect gradation system. After that all the scores are summed and culvert condition can be estimated.

Defect categories, basic scores (BS) and risk coefficients depend on the defect characteristics [1, 2]. The reduced culvert condition score is computed by formula [1]:

$$K_{BS}^* = K_{BS}^{*1} - (N_I \alpha_I + N_{II} \alpha_{II}) \quad (1)$$

where  $K_{BS}^{*1}$  - culvert base score [1];

$\alpha_I, \alpha_{II}$  - risk coefficients of the I and II category;

$N_I, N_{II}$  - the number of the observed defects of the I and II category ;

There are following quality indication for the reduced condition scores of every culvert:

«excellent» for 4.5 - 5.0;

«good» for 3.5 - 4.5;

«fair» for 2.5 - 3.5;

«poor» for 2.5.

However, if there are no defects on the culvert “poor” score is not a reason to impose special limits on the road.

## 3. Determination of the culvert degradation speed using a fuzzy logic.

In actual practice using of the condition score methods is rather imprecise and subjective because it significantly depends on the opinion of the monitoring specialist. Moreover, condition score methods does not allow to estimate the correlation between the culvert condition and its age which is necessary for making a reasonable decision about the terms of the repair or next monitoring.

According to the studies in this area [4...11] the most objective results for the current engineering structures condition estimation which was done by the results of the different observations and also for the terms forecast can

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