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Acceptable Reliability Levels for Existing Road Bridges

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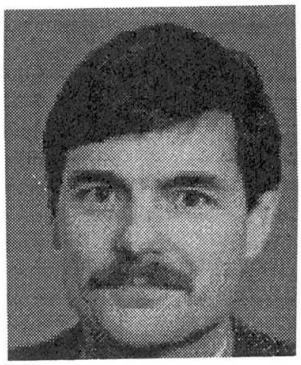

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Abstract

When analysing existing bridges practising engineers are often facing the problem that repair is very expensive for a bridge not having the structural reliability as required according to the code of practice. Intuitively one may conclude that if the code of practice leads to an optimum reliability level for the design of new bridges a minor decrease in this reliability level is acceptable before an extensive repair of an existing bridge shall be carried out. The point is that at the design stage the expenses involved in increasing the structural reliability will in many cases be relatively marginal as the structures easily can be altered. The same increase in reliability for an existing bridge will, however, in general be relatively expensive or even not economically feasible.

On the other hand it has been argued that the required reliability for an existing bridge must be the same as for a new bridge because the society will not accept a lower reliability even though it is demonstrated that such a decision would be cost optimal.

In this paper a rational way of defining the acceptable reliability level for an existing structure is presented along with practical values and examples. The approach is based on the statistical decision theory, and it is not required that the reliability for design of a new bridge necessarily shall be used for an existing bridge.

The problem of determination of acceptable reliability levels has for existing structures been treated in several other publications. The present paper is focusing on road bridges and emphasis is put on the use of economical values for construction and repair that are relevant to this type of structures.

It is demonstrated that assuming that the design practice is optimal the social failure costs associated with road bridges are very high. The high failure costs can only be explained by the psychological factors associated with the collapse of a bridge.

In the paper cost benefit studies assuming a variety of repair costs and failure costs are presented. With the economical values for construction and repair that are relevant for road bridges and the safety levels of this type of structures it is found that only a rather small decrease in structural reliability of a bridge should be allowed before repair is initiated.

If the same failure costs are associated with existing bridges as with similar new bridges, only a small decrease in reliability should be allowed before repair is economically feasible. As a rough rule of the thumb: If the reliability of an existing road bridge decreases with $\Delta\beta=0.5$ repair should be initiated.

If the repair costs are very low, repair is optimal even if the decrease in reliability is marginal. If the repair costs are very large, repair can in some situations be postponed, but it is worth mentioning that it is found that even if the repair costs is equal to the cost of constructing a similar new bridge it is found that repair is optimal if the reliability of the bridge is decreased with less than $\Delta\beta=1.0$.

If lower failure costs associated with an existing bridge are accepted compared to the failure cost of a similar new bridge, repair can in some situations be postponed. However, even if the failure costs of an existing bridge are judged to be only 20% of a similar new bridge (which is an extreme case), repair should be performed if the reliability decreases with $\Delta\beta=1.0$.

Considering Danish road bridges that are to be repaired for structural reliability reasons, a decrease of $\Delta\beta=1.0$ is only a small decrease. Loosely a decrease in reliability of $\Delta\beta=1.0$ is approximately equivalent to a decrease of 10% in carrying capacity for such structures.

Consequently the main conclusion of the present paper is that only a rather small decrease in carrying capacity of an existing road bridge should be allowed before repair is initiated.

It is emphasised that the paper is dealing with the larger repair works. The numerous minor and repetitively repair works are not considered. Furthermore, the problem concerning the upgrading of bridges to a higher load level is not treated. However, the general methods used in the paper can be applied also to these problems.