GEOPAVE MATERIALS TECHNOLOGY

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Technical Note

FACTORS USED IN THE SYSTEM FOR PRIORITISING BRIDGE MAINTENANCE WORKS

INTRODUCTION

This technical note presents a risk management approach to the prioritising of bridge asset maintenance. The risk management system is based on the product of probability of failure and consequence of failure. The system relies mainly on the Level 2 Inspection Reports The factors established to undertake a risk assessment are grouped into those related to the probability of failure (i.e. loading factor, resistance factor, condition factor, inspection factor, exposure factor) and those related to the consequences of failure (i.e. human factor, environmental factor, traffic access factor, economic factor and road class factor). The analysis for both probability and consequence of failure has been simplified in order to make the overall assessment procedure more practical and easy to interpret and implement.

The risk assessment method has been designed to generate an overall numerical score for each bridge considered. This can be used to rate and rank structures. The risk scores generated have no significance in themselves other than to provide a priority ranking of bridge maintenance works. The assessment system can also provide a sub-score, to rank structures on the basis of critical structural elements and operational requirements. The various factors and weightings applied are based on subjective values and engineering judgements, with some sensitivity testing undertaken to ensure that appropriate rankings reflect past bridge maintenance assessments. Sensitivity of the process can be assessed, by changing the relative weightings applied to each factor.

The calculation of the rating and ranking score has been facilitated by the use of a computer spreadsheet able to assess up to 500 bridges at one time. The spreadsheet facilitates the ready entry of VicRoads Database information. The main outputs include: **Summary results** – overall relative score and ranking of each bridge assessed; **Detailed Results** – shows all the parameters used for each bridge; **Criticality results** – overall condition ranking of the individual components of bridges; **Operational requirements** – based on a separate ranking of bridges.

PROBABILITY OF FAILURE

The probability of failure may be expressed as a function of the structural capacity of an element, or the structure as a whole. It is reflected mainly by the state of deterioration or the assessed condition of the structure. The system ranks structures on the basis of risk and safety as follows:
Risk = Probability (of failure) x Consequence (of failure).

Loading Factor (LF)

The loading factor is a function of the vehicle loading to which the bridge is subjected, the design codes used over the years and the age of the structure. For the purposes of the risk analysis, the factors are separately set for rural and urban areas by chronological dates and number of commercial vehicles (CV) carried by the structure.

Resistance Factor (SF)

The resistance factor is related to each individual bridge component and the element's material properties. A rating is applied to each of the bridge components and elements listed in the VicRoads Bridge Inspection Manual. The ratings reflect the resistance of each material element and the weightings reflect the structural importance of the bridge component and the resistance value of the material element. As an example, steel components will have a lower risk rating compared to timber because of their inherent strength and the super structure will have a higher risk weighting than (say) the bearings. The score for each bridge component assessed in the Level 2 Inspection Report is the product of the component and element weightings.

Condition Factor (CF)

The condition factor is related to the observed loss of "strength" or "stability" of the member and its environment as per the Level 2 Inspection Report and the values reported on the condition state for each bridge component. Each condition state is given a weighting. The score for each bridge component will be the product of the % rating for each element in a given condition multiplied by the respective Resistance Factor score, given above. The sum of these values divided by the number of components will provide an overall condition score for a bridge.

Inspection Factor (IF)
The inspection factor reflects whether or not failure can be forewarned and is assigned on whether or not the member is visible and able to be inspected. The inspection factor is a default value of 1 or 2 for any component that is < 25 % visible. This information is obtained from the the structure information sheet in the Level 2 Inspection Report. The inspection factor is used to multiply the condition value for each bridge component.

Exposure Factor (XF)
The exposure factor rates each component depending on its exposure to various environments. This reflects the rate of deterioration. The value comes directly from the Level 2 Inspection report. The bridge condition component value mentioned above (ie the product of condition weighting by the % state and IF) will be multiplied by the exposure factor. Exposure is rated as relatively benign, mildly aggressive, aggressive or most aggressive.

CONSEQUENCE OF FAILURE

The consequence of failure is an evaluation of the impact of failure; whether human, environmental, traffic disruption or economic. As a high degree of effort is required for an advanced analysis, the process of determining the "costs of failure" has been simplified.

Human Factor (HF)
The human consequence factor reflects the seriousness of the injury or death that may be caused by 'failure' of the structure, as reflected by either the urban or rural traffic volumes (AADT) on the bridge.

Environmental Factor (EF)
The environmental factor takes account of the possible disastrous effects that a failure may have on the environment. Without detailed knowledge of chemicals, materials, etc., that are being transported, the factor can be based on whether the locality is urban or rural and on the function of the structure (i.e., railway/road, waterway, carrying major services).

Traffic Access Factor (TF)
The traffic access factor reflects the delay/detour expense (distance) of failure. As traffic volumes have been used to determine the human factor, only detour lengths are considered here, and as with the Human Factor, the limits have been set to suit the specific network such that about 20% of the asset is represented by the five factor values for both rural and urban regions.

Economic Factor (NF)
The economic factor reflects the possible magnitude of the cost of failure to the authority. It is the consequent cost of not taking any action compared to the cost of the remedy. Due to the subjective nature of economic considerations, the economic factor for bridge rehabilitation projects was eliminated from this assessment; and only the economic factor effect for bridge replacement was included. The replacement value is used as it is more readily calculated for a structure.

Road Class (RF)
The Road Class factor has been added to reflect the importance of the road and the consequences in operational terms if there is a bridge failure. The road class relates to freeways, arterials, sub-arterials, others.

FUTURE ENHANCEMENT OF RISK ASSESSMENT METHOD

In addition to the risk assessment, an economic evaluation tool in the form of a computer-based spreadsheet can be incorporated in the future into the system to determine the cost effectiveness of various options based on periodic repairs or rehabilitation treatments considered for a particular structure. The calculations can be based on a life cycle approach and net present worth to arrive at the equivalent annual unit maintenance cost or benefit/cost ratios. This information can be used to further rank bridge maintenance works where there may be several maintenance options for a given bridge. The economic analysis can also be used for a bridge population to determine how to gain best value from a budget allocation and which maintenance treatments provide the most cost-effective solution overall. This assessment is to be used after the selection of bridges with the highest priority rating to select which treatment per bridge will provide the most cost effective solution for either a single bridge or a bridge population for a given budget per Region.

REFERENCES

ARRB TRANSPORT RESEARCH (2002), "Methodology to Priotitise Maintenance Works on Structures", by G. Giummarra and E. Styles.

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