Safe management of railway structures - flooding and scour risk (T554)

Background?
Damage to railway structures due to the action of floodwater has resulted in 12 deaths in the last 150 years and over £1 million of damage per year on average. This damage has been the result of scour, removal of the bed or bank of a watercourse or undermining of a structure by the action of flowing water.

Through a process of stakeholder reviews and experience gained over the last 10 years, limitations have been identified with the use of the existing railway structure scour assessment procedure, specifically, its applicability to structures other than bridges with piers and how wider flood-related risks are assessed.

This project follows on from previous work, including a review of the Railway Group Standard GC/RT5143 “Flooding, Scour, Wave and Tidal Action – Managing the Risk” and an earlier RSSB research project, “T112 Impact of scour and flood risk on railway structures”. The review of GC/RT5143 in 2003 brought about the requirement to assess the risk posed to rail infrastructure from a wider range of flood risk scenarios, including flooding, erosion and blockage and not simply limiting an assessment to scour risk. These additional flood risks cannot currently be assessed using the existing assessment procedure (from report EX2502 commissioned by the British Railways Board in 1992, hereinafter referred to as EX2502), which was originally devised for assessing scour risk at structures crossing permanent watercourses. The earlier RSSB project (T112, completed in 2004) identified ways in which assessment procedures could be improved, suggesting additional procedures for other flood risks and for specific types of structure.

This project was commissioned to develop these procedures.

Aims
The aim of the research was to provide an integrated suite of flood risk assessment techniques that are capable of assessing the full range of Network Rail structure types and flood risks. The purpose of this was to provide Network Rail with an easy to use means of achieving the requirements set out in Railway Group Standard GC/RT5143. The research included a review and improvement of the existing EX2502 scour assessment procedure, identifying its limitations and areas requiring improvement.

A further aim in formulating the individual assessment procedures, identified early on in the project, was to integrate each procedure into Network Rail’s current assessment procedures, where possible utilising the same methodology as EX2502 and adopting a comparable scoring system. The desire to supplement existing assessment procedures, rather than replace them, was equally important.

Furthermore, the research project also aimed to evaluate the range of scour monitoring techniques currently available, with a view to assessing their practical use as part of flood risk management on the railway.
JBA Consulting undertook the research project between September 2004 and May 2005, with additional input provided during this period by Network Rail.

Having largely identified the limitations and deficiencies with the existing EX2502 assessment procedure in the earlier project, this project initially looked at the reasons why the procedure was ineffective for certain types of structure. A literature search was completed to identify any recent advances or procedures that would be relevant to the research project. Recent research and technological developments have addressed several of the deficiencies identified for EX2502.

This led to the selection of a number of test structures, specifically chosen to not simply to highlight the deficiencies in the existing assessment procedure, but also to assist in the development of new procedures that would better assess these types of structure.

The test structures primarily included 30 Network Rail structures, identified as being inappropriate for assessment using EX2502. A further 40 structures that were previously assessed using EX2502 and that could be used to calibrate the proposed assessment procedures, allowing comparison between existing and proposed assessment techniques, were also selected. The Historical Bridge Failure Database, created in the earlier RSSB research project, provided a further sample of test structures to check the effectiveness of the proposed assessment procedures.

By a process of refinement and calibration, the flood and scour risk assessment procedures have been formulated. Iterative refinements were carried out as experience was gained in the application of the new assessment procedures.

EX2502 formed the basis of the new scour assessment procedures, with the general principles and methodology of EX2502 retained wherever possible. Specifically, this included the procedure for assessing general scour, and the means of calculating a management category using a priority score. Elements that were
identified as being inappropriate or missing were supplemented or replaced with a more suitable means of assessment. The general principle of calculating individual components of scour, adding these components together and then comparing total scour against the known or assumed foundation depth was retained.

The result has been to improve the assessment procedures wherever possible and allow direct comparison between new and old assessment procedures, whilst supplementing rather than superseding assessment work previously undertaken by Network Rail.

An assessment of scour monitoring techniques was completed following a literature review, with additional consultation with Network Rail and the United States Federal Highway Administration.

**Findings**

The principal findings of the research were the creation of a number of additional scour and flood risk assessment procedures, required to reflect the diversity of Network Rail infrastructure and assess a wider range of structure types at risk from scour and flooding. A review of EX2502 primarily resulted in a clarification in the use of the existing procedure for the assessment of scour to:

- Bridges crossing canals
- Bridges crossing flood plains

Scour assessment procedures, based upon the principles of EX2502, have also been formulated for:

- Retaining walls within watercourses
- Culverts
- Hydraulically long structures (bridges with abutment length >50m)
- Structures with existing scour protection.

These forms of structure are not well represented by the existing EX2502 assessment procedure.

In summary, quantitative scour assessment procedures are now available for all the above structures.

Furthermore, initial qualitative flood risk assessment screening procedures are available for:

- Structure decks at risk from water pressure and debris impact
- Risk to a line from erosion of a river bank on a bend
- Risk of culvert blockage potential

All new assessment procedures are also available in the form of Excel spreadsheets, available from RSSB.

The report also recommends that climate variability be considered and that assessments be made against 200 year return period flood events.

The establishment of a realistic riverbed datum to avoid “double counting” of scour, together with consistent and fixed structure data to link underwater, coring and structural surveys together, are seen as important improvements in risk assessment. Furthermore, from the viewpoint of safety and to ensure structures continue to be inspected and assessed, it is recommended that even after physical scour protection is installed at a bridge, that the structure and its protection is regularly examined.

The main benefit perceived from the research is the ability to assess a wider and more representative collection of Network Rail structure types, for risk arising from scour or flooding. Importantly, the research now provides the means of assessing structures for other flood risk scenarios, not currently possible using
EX2502, to meet the requirements of Railway Group Standard GC/RT5143.

The scour assessment procedures also incorporate a means of assessing the potential impact of debris collection and also provide a more representative assessment of risk rating due to the presence of existing scour protection, by assessing the condition, nature and extents of any protection present and relating it to overall structure risk. A further benefit, arising from a review of the way canal structures are assessed, is potentially to reduce the number of canal structures (typically seen as low risk due to their navigable nature) requiring assessment.

Finally, the role of scour and water level monitoring is also explored: the report provides a summary and appraisal of known or trialled monitoring techniques and details the merits and limitations with each technique. It recommends the use of water level monitoring as an analogue for scour, rather than the use of specific bed scour monitoring devices.

**Next Steps**

Network Rail has been appraised of this research and is keen to agree what further work is necessary to supplement the work undertaken to date. In particular, it would be helpful to establish the impact of implementation of the proposed assessment procedures on the management of railway structures vulnerable to scour and flood risk.

It is envisaged that a further programme of testing and evaluation of the assessment procedures would follow on from this research project. This evaluation would be completed prior to a recommendation for general adoption by Network Rail.