Risk Management of concrete road bridges subject to de-icing salts and the possible implications of climate change

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0. CONTENT

1. INTRODUCTION - The need to manage risk

- In the UK 31.5% of all local authority bridges are of concrete construction
- By deck area, even larger figure of 35.5%

- Reinforcement corrosion is most serious cause of deterioration of concrete bridges

- Primary causes of metallic corrosion – carbonation & chloride ingress
- Leading to cracking, delamination & spalling of concrete

1. INTRODUCTION – The need to manage risk cont.

- Roads & bridges de-icing agent most commonly sodium chloride
- Roads & bridges receive same quantities
- Sodium chloride must when spread go into solution to be effective
    - Below -5 to -7^{o}C solution not formed rapidly
    - Below -15^{o} C not saturated
    - Melting snow & ice can reduce effectiveness

- *Predicted climate change in UK with warmer wetter winters could lead to altered corrosion rates – how do we manage that potential risk?*

2. The effect and / impact of climate change on corrosion rate

- Corrosion processes are complex
    - Materials, geometry, condition & environment
- Two key factors are climate & contaminants
    - Humidity, temperature, contaminants – increased corrosion rates
- Road bridges – a major contaminant is chloride
    - Quantity of de-icer and frequency depends on temperature & precipitation

2. The effect and / impact of climate change on corrosion rate cont.

- Climate has an important effect on corrosion rate
- Average UK temperature is increasing - winters will be warmer and wetter
    - Corrosion acceleration
- Salt will continue to be present
    - May be required less frequently – BUT may be more frequently reapplied

3. Current monitoring processes for concrete road bridges

- Management of Highway structures – A Code of Practice

- All requirements for the management of highways structures
    - All UK highways structures are subject to de-icing salts

- Method comprises a data led approach
    - Leads to analyses, assessments & processes
    - Compilation & maintenance of a database / inventory
    - Development of works programmes

3. Current monitoring processes for concrete road bridges cont.

- Current practice comprises cyclical inspection regimes
    - Routine surveillance, General, Principal, Special and Safety Inspections
- General Inspections – 2 years
    - Calculation of CPI, BCS for the structure, BSCI for the stock
    - BSCI of 100 =100% potential retained

      60 = 40% potential lost
- Principal Inspections – 6 years
    - Direct, close access to structure

4. Proposed risk management processes

- BD 63/07 sets out detailed inspection requirements
    - Risk based approach to planning an inspection regime is allowed BUT seldom used
- No current accepted risk management mechanism

- ***Why should low risk structures require the same inspection regime as higher risk structures?***

- Differing asset owners have varying views
    - HA Interim Advice Note 171/12 provides a systematic approach

4. Proposed risk management processes cont.

- Visual inspection is the core of most inspection regimes
  - Access, traffic management, seasonal restrictions, accuracy, reliability
- TRL has investigated image based GI
  - Benefits of development include:
    - Simplified access
    - complete hi-res image of whole structure
    - remote sharing of images
    - automatic quantifiable data / data interpretation
  - 3-D interactive models

5. Innovative methods of managing risk operationally

- Climate changes - unpredictability / increases in corrosion rates
- Other factors & new technologies
    - Trends demonstrate increasing de-icer use

- Need to reduce chloride use – opposing pressures of need to clear road vs. possible damage to the structure
    - Alternative de-icers
    - Salt is most cost effective / most damaging
    - De-icer often required earlier and more frequently

5. Innovative methods of managing risk operationally cont.

- Drive for innovation and research into de-icers & delivery in UK
  - TRL for Highways Agency, Transport Scotland & National Winter Service Research Group (NWSRG) – new guidance
    - Far lower salt rates in UK at “marginal temperatures”
- Alternative de-icers (below -5 to -7^{o} C) research
  - Alternative or salt mixes – more effective & less salt required
  - Benefits between -7 to 0^{o} C leading to less salt
    - more economy
    - less structural & environmental damage
    - reduced exposure to salt

5. Innovative methods of managing risk operationally cont.

- Other factors to consider:
    - Min spread rates are achieved if optimum time for prevailing conditions is met
    - Forecast temperature, road surface wetness, volume of traffic - wetter the road surface the more de-icer required
        - Traffic helps to effect the salt to dissolve
        - High volume may disperse too quickly ……and onto bridge structure
    - Traffic also disperses water - so delay spreading
- Delay to avoid general loss of de-icer , and to allow surface water dispersal – helpful for bridges

6. Reducing rates of corrosion in reinforced concrete bridges

- Need to consider winter service provision at bridge design stage:
  - Ensure components are protected or resistant
  - Detailing to prevent brine seepage
  - Specialised winter provision elements

- Electrochemical means of polarizing the steel reinforcement (-ve)
- Cathodic protection (CP) - suppress / reverse the internally generated corrosion current
- Extensively assessed in UK and elsewhere
- Extensive UK use e.g. Midland Links structures – 100000m^2 of concrete protected

6. Reducing rates of corrosion in reinforced concrete bridges cont.

- CP can lead to remedial work cost reductions of 20 to 80%
- Sustainable option as is extending the current structure's life – less waste to landfill
- CP performance of 10 – 40 years before maintenance – embedded items with theoretical life of 120 years
- Two main types
    - Impressed Current Cathodic Protection (ICCP) – Long term / large scale / higher budget
    - Sacrificial Anode Cathodic Protection (SACP) – Shorter term / targeted / lower budget

7. CONCLUSIONS – A joined up & targeted approach

- Significant revenue financial pressures in the maintenance of highways infrastructure, including road bridges
- Maximise life of the existing (& new) asset, ensuring whole life cost effectiveness
- Predicted climate changes in the UK – high chance of corrosion rates increasing
- De-icing agents applied in more targeted, optimised ways (from -7^{o}C to 0^{o}C)
- Limit exposure to chlorides – more sustainable
- At design stage new structures include details appropriate to winter service – maybe including active systems

7. CONCLUSIONS – A joined up & targeted approach cont.

- Use of established, effective and sustainable remediation methods such as CP – condition, accessibility, maintenance and available budget
- Systematic risk-based approach to the inspection regimes of bridges - targeted asset management according to need and available budgets
- Manage risk further and reduce costly human intervention by using 2D (maybe 3D) imaging as investigated by TRL
- Use (in UK) of Government / DfT initiatives / resources - Highways Maintenance Efficiency Programme (HMEP) to manage the asset

7. CONCLUSIONS – A joined up & targeted approach cont.

Thank you

Merci

Gracias

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