Effective Bridge Management

Area Engineers March 2014

Liam Duffy - National Roads Authority

Overview

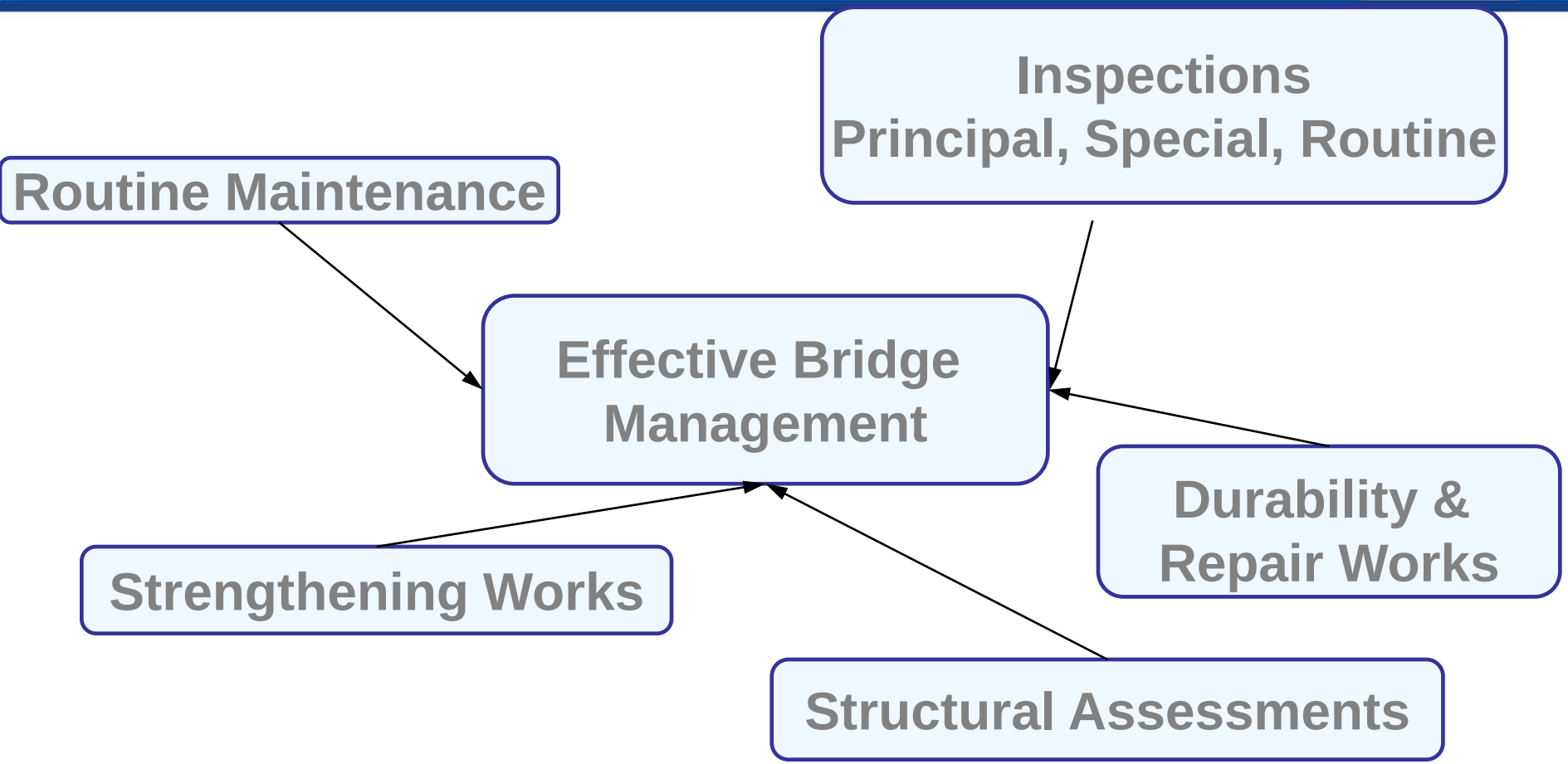
- Introduction
- Inspection types
- Factors affecting bridge durability
- Bridge Defects
- Structural Capacity Assessments
- Repairs and Strengthening

Long Life Bridges: Adare Bridge Co. Limerick

Irish Stone Bridges (O'Keeffe and Simington): "*...there is no reason to dispute the date range 1390-1410...*"

Irish Stone Bridges (O'Keefffe and Simington): "*...Richly mantled with ivy, this ancient Bridge is very picturesque, blending as it were with the ivy-clad walls of the castle...*"

Effective Bridge Management



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ADVISOR NAMED
QS gets top government post
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WIND POWER DOUBTS
Over-reliance could threaten targets
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Water industry spend finalised

26.11.09

CUMBRIA FLOODS

ENGINEERS IN THE FRONT LINE AS VITAL INFRASTRUCTURE IS KNOCKED OUT

News

Minneapolis bridge collapse exposes inspection failures

INADEQUATE INSPECTION regimes failed to expose fundamental and catastrophic structural weaknesses in Minneapolis' devastated I-35W bridge, structural specialists said this week.

The I-35W bridge across the Mississippi river at Minneapolis in Minnesota collapsed without warning at 18.05 local time last Wednesday, killing five and leaving a further eight unaccounted for.

Fatigue in the structure's members is now thought to be the main focus of the investigation by the federal National Transportation Safety Board (NTSB), now in full swing.

It is currently carrying out a detailed finite element analysis of the bridge to help assess possible scenarios.

Minnesota's State Department of Transport (MNDOT) this week confirmed that annual inspections of the bridge relied on "visual inspections with load tests and strain gauges".

A spokesman said no intrusive tests were carried out.

But according to Mouchel Parkman's structural technical director, Donald Pearson-Kirk visual inspections, such as those carried out on I-35W, would have missed crucial details. He recently led inspection regimes in the United States while with Parsons Brinckerhoff.

"As well as looking, you have to do some testing with some intrusive work, to get a much better picture," said Pearson-Kirk.

"If something looks good, it might not always be so. Similarly, there are times when they look bad but are OK."

He said that with steel bridges, small inclusions could be made and strain gauges installed to give engineers a better picture of precisely what was happening inside the structure.

The bridge was a three span steel truss built in 1967. It had longitudinally split a concrete slab deck and was known to have no structural redundancy.

According to a recent report by consultant URS, written in 2005 it had 52 "fracture critical" truss members along its 186 6m span and two 81.6m side spans (see page 6). The report also criticised the inspection regime for the structure.

MNDOT this week confirmed that it would now review its inspection procedure and had engaged consultant Parsons Brinckerhoff to provide advice. It said it would speed up inspections on five similar bridges.

Senior vice president of Chicago-based structural engineering firm CTL Group, Gene Corley, also pointed out that vital evidence must have been missed during inspections.

"Something was not being done," he said, adding that if steel fatigue turned out to be the cause of the collapse "a visual inspection might not have picked this up."

But MNDOT was keen stress that it conducted inspections annually, while federal law required biennial inspections.

The bridge was also undergoing non-structural resurfacing and joint replacement work at the time of the collapse.

Although it was known to have been suffering severe fatigue cracks it is understood this work may have also contributed to the collapse.

Resurfacing work closed two of the four lanes in each direction, but asymmetrically across the bridge while concrete deck sections were replaced.

Bridge expert Mark Whitby said this "would give some interesting stresses in the two trusses – one going one way, the other the other way, and some strain in the cross-members."

Another UK based structural engineer who wished to remain anonymous added: "The deck replacement work may have damaged a critical member of the truss. If there was a fatigue crack, who knows, they may have taken a piece of deck out above a fatigue crack, put a jack hammer on it and set it off."

He added: "It only needs one member in one truss to go for the whole thing to come down – truss bridges will not generally have any redundancy."

Benaim chairman Mark Raias, said that the collapse is consistent with fatigue in the steel members.

"Fatigue always starts slowly, but you would expect cracks before anything began falling down," he said. "Most fatigue failures are preceded by visible cracks, but it is possible the crack length is small or invisible to the naked eye."

Ed Owen in Minneapolis

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News

● Network Rail was praised by the Office of Rail Regulation last week for reducing train delays on the national network. But it was warned that it must do more at regional and local levels. The rail regulator's third annual report on the rail operator also reveals that Network Rail has failed to meet all of its health and safety targets.

Poor maintenance blamed for Montreal collapse

SALT CORROSION of steel reinforcement in the deck of a road bridge in Montreal is the likely cause of a collapse which killed five people on Saturday, engineers said this week.

Heavy road salting, required during Canadian winters, was thought to have created a corrosive cocktail that easily penetrated the movement joint where the road deck slab met the cantilever supports – an acknowledged weak spot (see diagram).

Motorists contacted emergency services at around 11am last Saturday, as chunks of concrete fell onto the highway from the overpass.

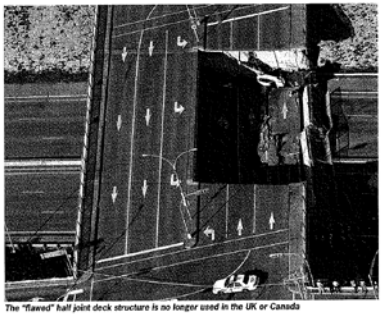
A spokesperson for highway authority Transport Québec, confirmed that a highway patroller arrived at the scene before midday, made a visual inspection, but did not conduct a full survey of the structure.

The patroller assumed that the falling concrete was not a structural threat and declared that the bridge did not need to close.

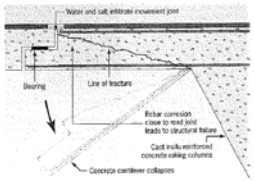
But debris continued to fall and at around 12.00pm the structure collapsed. Witnesses said that light traffic prevented further loss of life.

"The inspection was not adequate. We need to know what sort of inspection was carried out, what sort of inspection would have been adequate, and how prevalent is this fault," said Dr Ghani Razaqpur, chair of civil engineering at Canada's McMaster University.

The bridge was a half joint deck structure comprising two short cantilever spans supporting the bridge's central span on either side. The central span is simply supported between bearings on the side cantilevers.



The "flawed" half joint deck structure is no longer used in the UK or Canada



Engineers explained that the most likely cause of failure was salt corrosion over time. This would have led to reinforcement deterioration which would then have caused a shear failure of the concrete from the joint to the point of contact with the support.

"Chloride from salt is causing havoc on both concrete and steel. On this bridge there would have been the release of oxygen from the steel. In addition there would have been accidental chemical spills, seeping into the con-

Bridges on the NRA Network

- Almost 3,000 structures on NP & NS network > 2.0m span
- 60% Concrete, 27% Masonry, 8% Steel
- Not responsible for managing PPP bridges although we monitor the Concessionaire's management of bridges
- MMaRC Contractors responsible for RM for bridges on their networks & NRA manage structural work

Eirspan Database

- New desktop version of database for Regional Road bridges will issue to LAs next month from NRA IT
- Existing data requires converting by NRA IT
- Booklet with screenshots from database explaining data transfer etc.
- New web-based version for NRA bridges

Inspection Types

- Routine Inspection
  - Previously an annual inspection by LAs
  - Engage consultants now
- Principal Inspection
  - Structural inspection by experienced bridge engineers
  - Interval 1-6 years
- Special Inspection
  - Defect investigation, underwater inspection, assessment

Routine inspection and maintenance

Vegetation clearance prevents stonework deterioration, debris clearance from watercourses prevents scour damage

Scour Damage & Scour Susceptibili

Scour:

•Debris build-up must be cleared when found

•BD97/12 Assessment of scour at highway bridges

•CIRIA C551 Manual on scour at bridges and other hydraulic structures

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PI – Inspect difficult access components

Special Inspection - Youghal Bridge
PTSI Phase 3 Inspection

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Factors affecting durability

Leaking expansion joint or failed waterproofing. Modern construction of integral bridges where possible.

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Waterproofing Application & Testing

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Bridge Inspector Decisions – RC Defects

- BA 35/90 Inspection and repair of concrete highway structures
- CBDG Technical Guide 2: Testing & monitoring the durability of concrete structures

Leenane Bridge collapse

Build-up of debris at bridge following rainfall which exceeded 1/100yr return

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Bridge Inspector Decisions – Parapet Damage

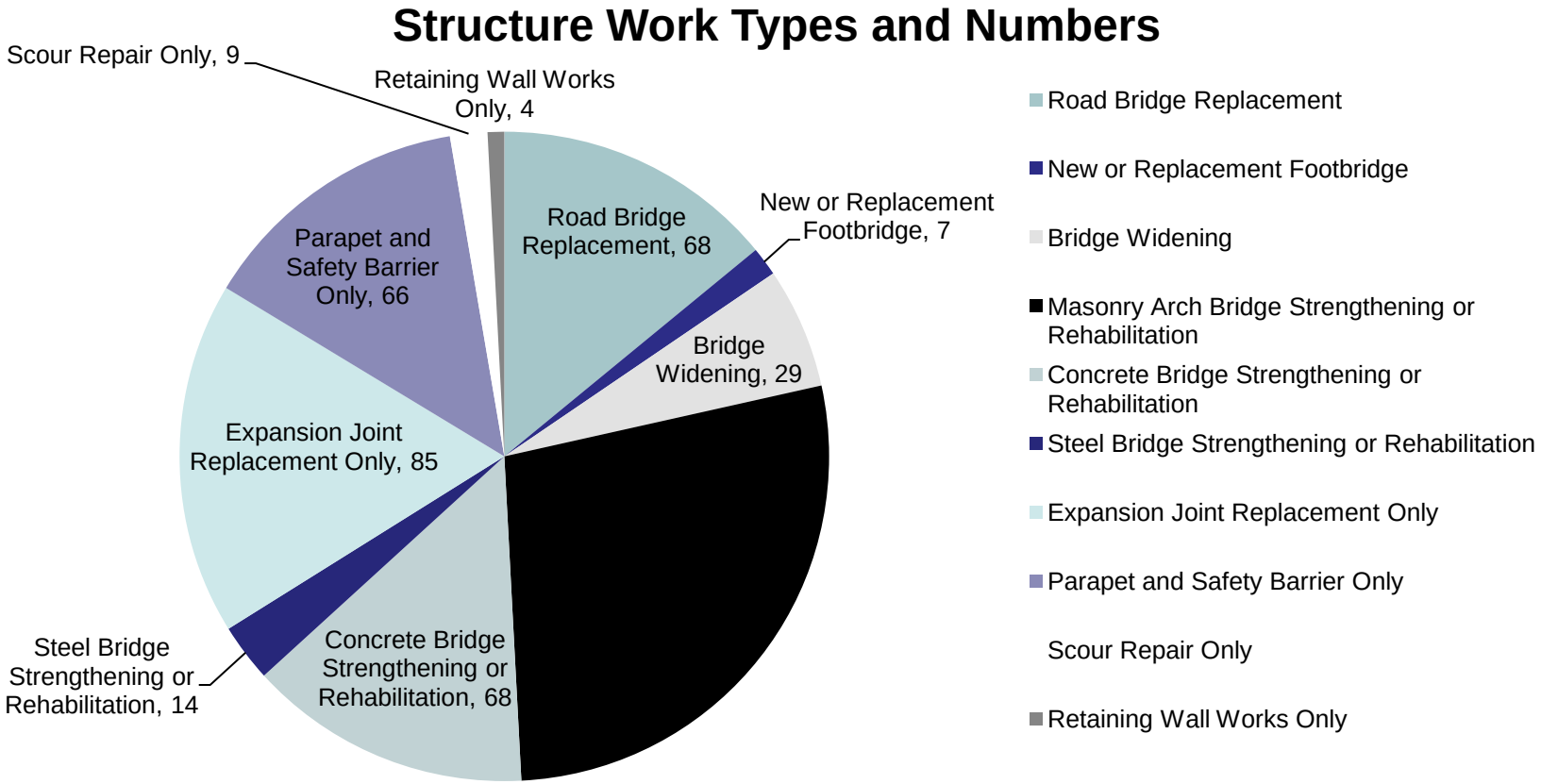
Is the failure mode of these parapets correct? Inspector to check for cracked posts

Bridge Inspector Decisions –Steel Defects

BD12 includes for concrete invert to prevent such corrosion.

Plate Girder corrosion

Structure Work Types and Numbers



Issues to Consider Before Repair

- Condition rating & likely rate of deterioration
- Durability
- Structural capacity – assessment should be considered before significant repairs. Assess using BD21/01, BA16/97, etc for structures designed pre-BS5400.
- If bridge fails assessment, strengthening may be required
- No link between condition rating & assessed capacity
- Whole life cost – is it better to undertake cyclical concrete repairs to a slab soffit or replace the deck?

Assessments

Coring to determine arch barrel depth

Rare example of failure under load

Repair historic structures sympathetically

New NRA Specification Series 2400. Lime mortar 1part NHL5 to 2.5 parts well-graded sand, full joints, stonework to match existing

Bridge Management Issue - Services

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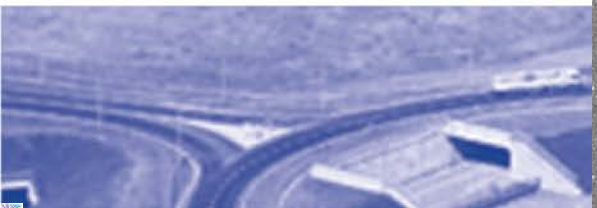
Poor Aesthetics, Durability Issues

Expansion Joint Awareness



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Masonry arch construction