Investigations and Repairs of Boston Manor Viaduct

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For Bridge Owner’s Forum and Bridges Board

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Topics

• Background
• Investigations
• Interim measures
• Repair and future management
• What worked well
• Issues for consideration/lessons learnt
Background

• Boston Manor Viaduct
• M4, J2-3
• Opened in 1965
• 21 Spans, Steel Girders with Concrete Slab
• Except Approach Span, three span truss section
• Structure is generally welded (including electroslag welding technique)
Electroslag welding technique

- **Electroslag welding (ESW)** highly productive, single pass welding process for thick (greater than 25 mm up to about 300 mm) materials in a vertical position
- ESW - an electric arc is initially struck by wire that is fed into the desired weld location and then flux is added
- Additional flux is added until the molten slag, reaching the tip of the electrode, extinguishes the arc
- Wire is then continually fed through a consumable guide tube into the surfaces of the metal workpieces
- Filler metal are then melted using the electrical resistance of the molten slag to cause coalescence
- Wire and tube then move up along the workpiece while a copper retaining shoe that was put into place before starting (can be water-cooled if desired) is used to keep the weld between the plates that are being welded.
- ESW is used mainly to join low carbon steel plates and/or sections that are very thick. It can also be used on structural steel if certain precautions are observed.

- Courtesy Wikipedia
Electroslag welding technique

- ESW was invented and patented in the US in about 1940
- It appears to have been very rarely used in the United Kingdom in the 1960’s, and was not used by steel fabricators
- TWI are aware of few sites, apart from Boston Manor Viaduct, and from checks undertaken they appear to have been demolished
- Federal Highway Administration (FHWA) monitored the new process and found that electroslag welding, because of the very large amounts of confined heat used, produced a coarse-grained and potentially brittle weld
- In 1977 FHWA banned the use of the process for many applications

- Courtesy Wikipedia
BMV
Contract Arrangements

- The Structure is within the area of M25 DBFO contract
- Operated by Connect Plus (CP)
- Lead Designer (Atkins and Arup)
- Previously Area 5 (Mouchel)
Investigations

- Over the years a number of investigations and repairs have been carried out on BMV
- More recently BMV was identified as the Agency’s only bridge similar to the collapsed Minneapolis bridge in 2008
- A number of issues were flagged including the need to complete a principal inspection, review previous reports
- From this emerged the need to investigate ESW
- Carried out by Mouchel/TWI - mainly to check condition of Electro Slag Butt Welds (>600 Nos)
- Mechanical Properties (fracture toughness, tensile hardness and fatigue crack growth properties)
- Metallurgical properties: Chemical analysis, microstructure
Investigations (Cont.)

- NDT: Fabrication flaws and fatigue cracks
- Stresses: Residual and cyclic under traffic
- Various insitu techniques (EC, ACPD, MPI, PA) (eddy current, alternating current potential drop, magnetic particle inspection, phased array)
- Lab Testing on samples (MT, fracture toughness, tensile and hardness) (although at later stage)
Findings

- Cracks identified at various locations
- At tension and compression zones
- Mostly in plate girders (at edges of flanges)
- Also directly under the web
- A combination of the above
- Limited number in the truss section
- Some “in board”
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Concern

• Safety to the Public
• Network Operations
• Load Carrying Capacity
• Brittle failure
• Fatigue (long term)
• Disruption to Olympic Traffic
Actions and Interim measures

- Load restrictions to 17 T then to 7.5 T (May 2012)
- Load carrying capacity calculations
- Fracture mechanics calculations
- Edge crack sizes
- Monitoring (including strain gauges)
Repairs Strategy

• Two phase repairs
• Phase one: carry out sufficient repairs to restore the LCC to 40 T
• Phase one: plan to complete before start of Olympic
• Phase two: complete repair to address medium/long term problems (e.g. fatigue)
Organisation

Figure 1

HIGHWAYS AGENCY
  BRIDGE OWNER

CONNECT PLUS (M25) LTD
  CONCESSIONNAIRE

OSBORNE
  CONTRACTOR FOR REPAIRS

ARUP
  DESIGN OF REPAIRS

ATKINS
  CATEGORY 3 CHECKER

MOUCHEL
  ASSESSMENT OF ELECTROSLAG WELDS

PROFESSOR MICHAEL BURDEKIN
  MANCHESTER UNIVERSITY ADVISOR TO ARUP

TWI
  NWT INSPECTION & ANALYSIS

Boston Manor Viaduct
Organisation Diagram for Delivery of Repairs
Repair types

Type A: Flange cracks
  Remove cracks by grinding or coring (stitch drilling for samples)
Type B: Web cracks (or combined A and B)
  Bolt splice plates above and below the weld
  (Approx 30 locations)
Type C: Truss crack
  Remove cracks by grinding (problems encountered)
Type D: In board cracks
  Grinding
Figure 1
Full Splice Repair

Structure: NTB, Instructive only

Weld

Crack

Splice plates professed to allow for crack removal

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Current Status

• Structure remains open during Olympics/Paralympics
• 7.5 T load restrictions plus spaced Olympic coaches
• Repairs completed with the exception of 2 locations in truss
• Restoration of 40T capacity planned for October 2012
Future Structures Management

- Monitoring
- PI in 2013 Approx
What worked well

• Swift response from NetServ, TA in less than 24 hours including weekends – stretched resources, intensive meeting schedule
• Robust handover between staff
• Specialist knowledge within the Agency was an advantage
• Involvement and swift decisions from HA managers/senior managers
• Good recognition of NetServ role (within HA and externally)
• Good communications/reporting
Lessons learnt

• Perception of NetServ TAA role (need to be very pro-active)
• Heavy demands on resources
• Challenge contractors proposals if you can
• Consider getting an independent external experts (via or in consultation with policy)
• However, produce a specific brief for external experts and stay vigilant
• Continuous commitments to critical investigations
BMV

Questions!