HIGHWAYS AGENCY

Safe roads, reliable journeys, informed travellers

Investigations and Repairs of Boston Manor Viaduct

Prepared by

Said El-Belbol/Neil Loudon

For Bridge Owner's Forum and Bridges Board

September 2012

HIGHWAYS AGENCY

Safe roads, reliable journeys, informed travellers

Topics

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

HIGHWAYS AGENCY

Safe roads, reliable journeys, informed travellers

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)

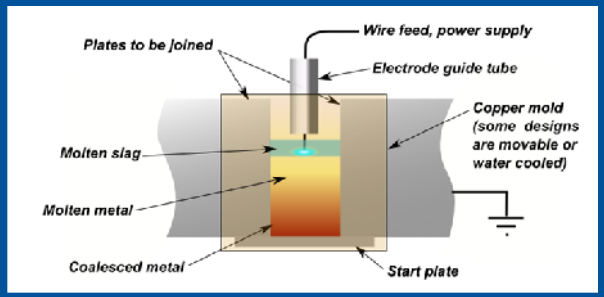
HIGHWAYS AGENCY

Safe roads, reliable journeys, informed travellers

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



HIGHWAYS AGENCY

Safe roads, reliable journeys, informed travellers

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

HIGHWAYS AGENCY

Safe roads, reliable journeys, informed travellers

BMV

HIGHWAYS AGENCY

Safe roads, reliable journeys, informed travellers

BMV

HIGHWAYS AGENCY

Safe roads, reliable journeys, informed travellers

BMV

HIGHWAYS AGENCY

Safe roads, reliable journeys, informed travellers

BMV

HIGHWAYS AGENCY

Safe roads, reliable journeys, informed travellers

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)

HIGHWAYS AGENCY

Safe roads, reliable journeys, informed travellers

Investigations

- Over the years a numbers 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

HIGHWAYS AGENCY

Safe roads, reliable journeys, informed travellers

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)

HIGHWAYS AGENCY

Safe roads, reliable journeys, informed travellers

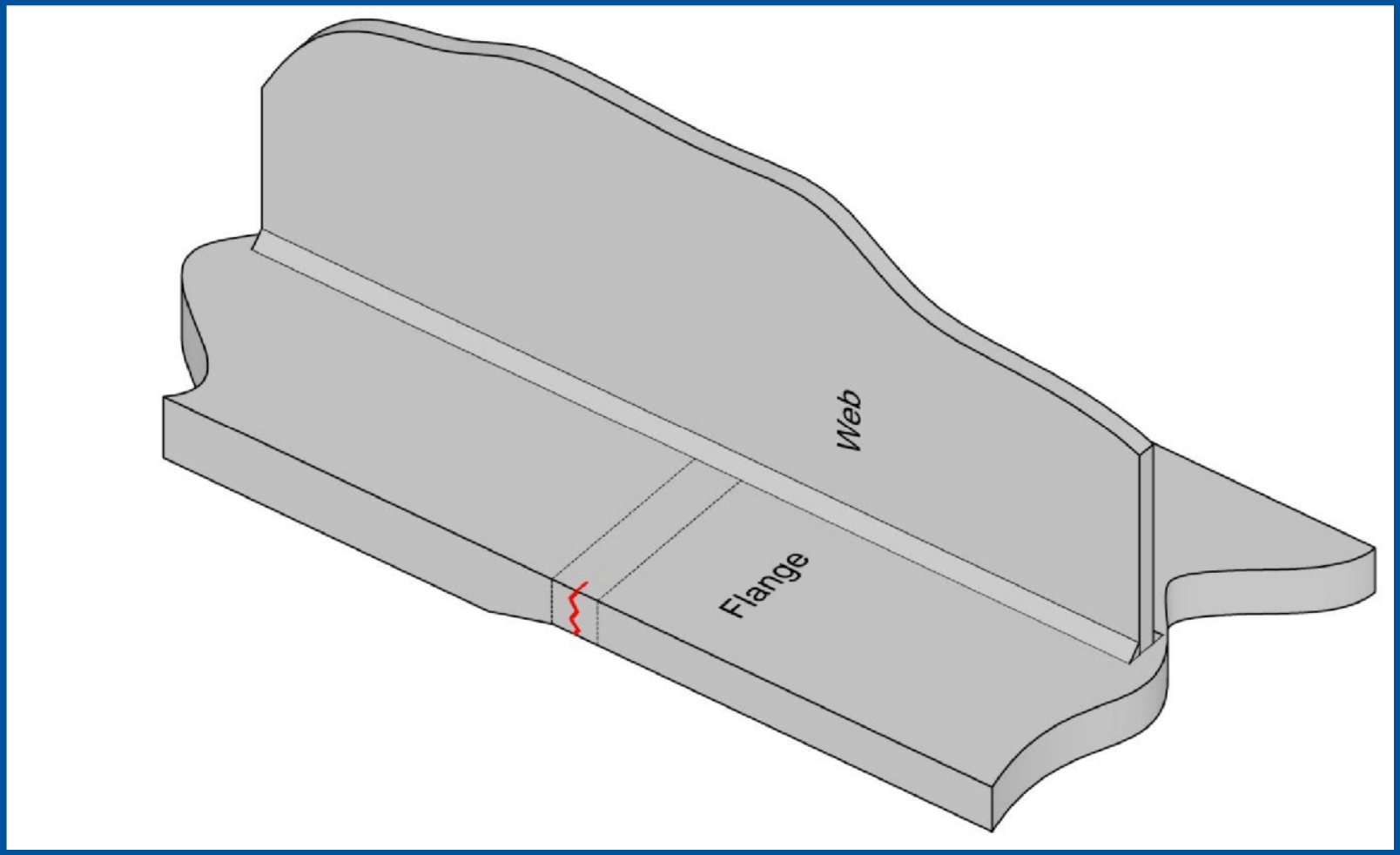
Findings

- 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”

HIGHWAYS AGENCY

Safe roads, reliable journeys, informed travellers

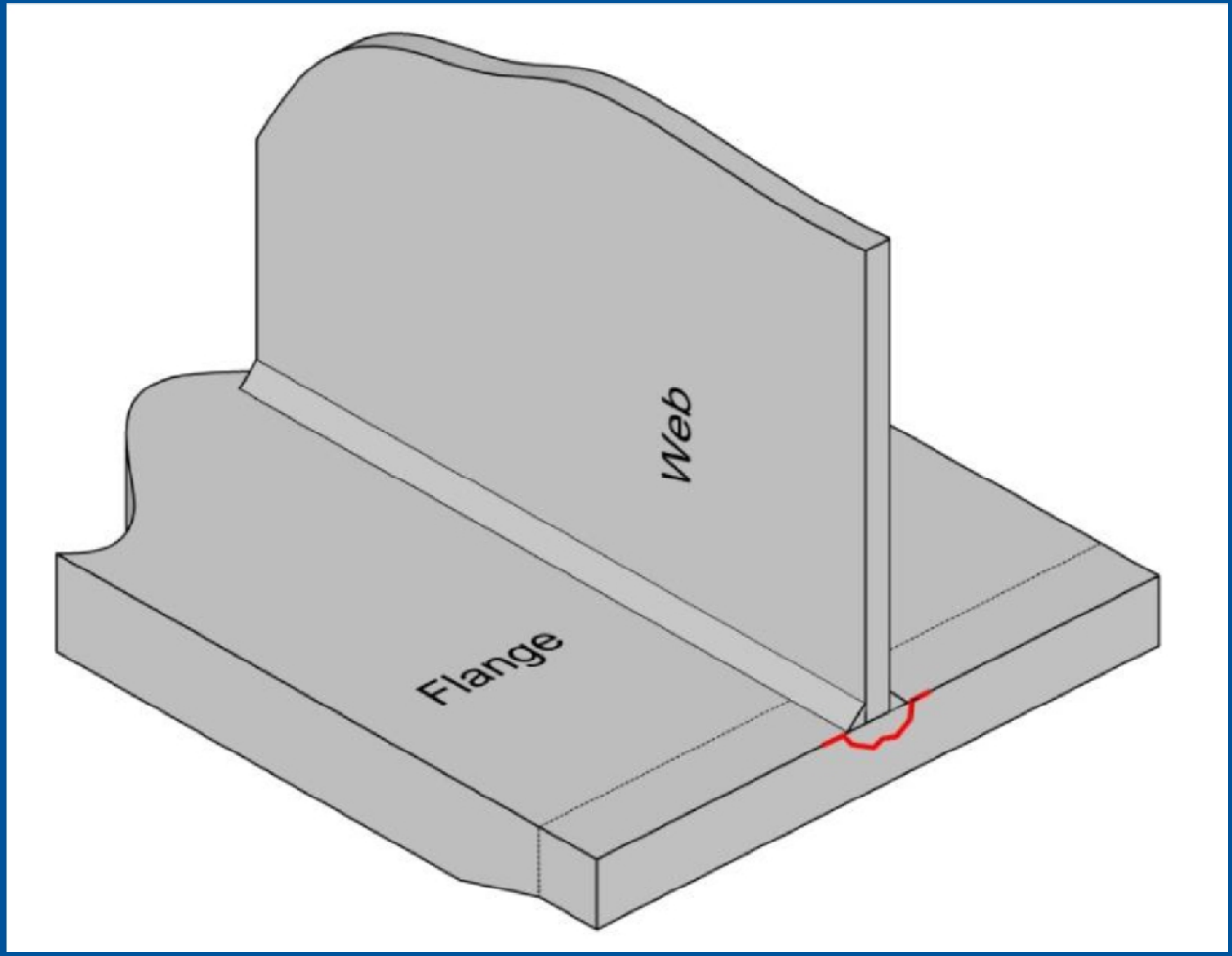
BMV



HIGHWAYS AGENCY

Safe roads, reliable journeys, informed travellers

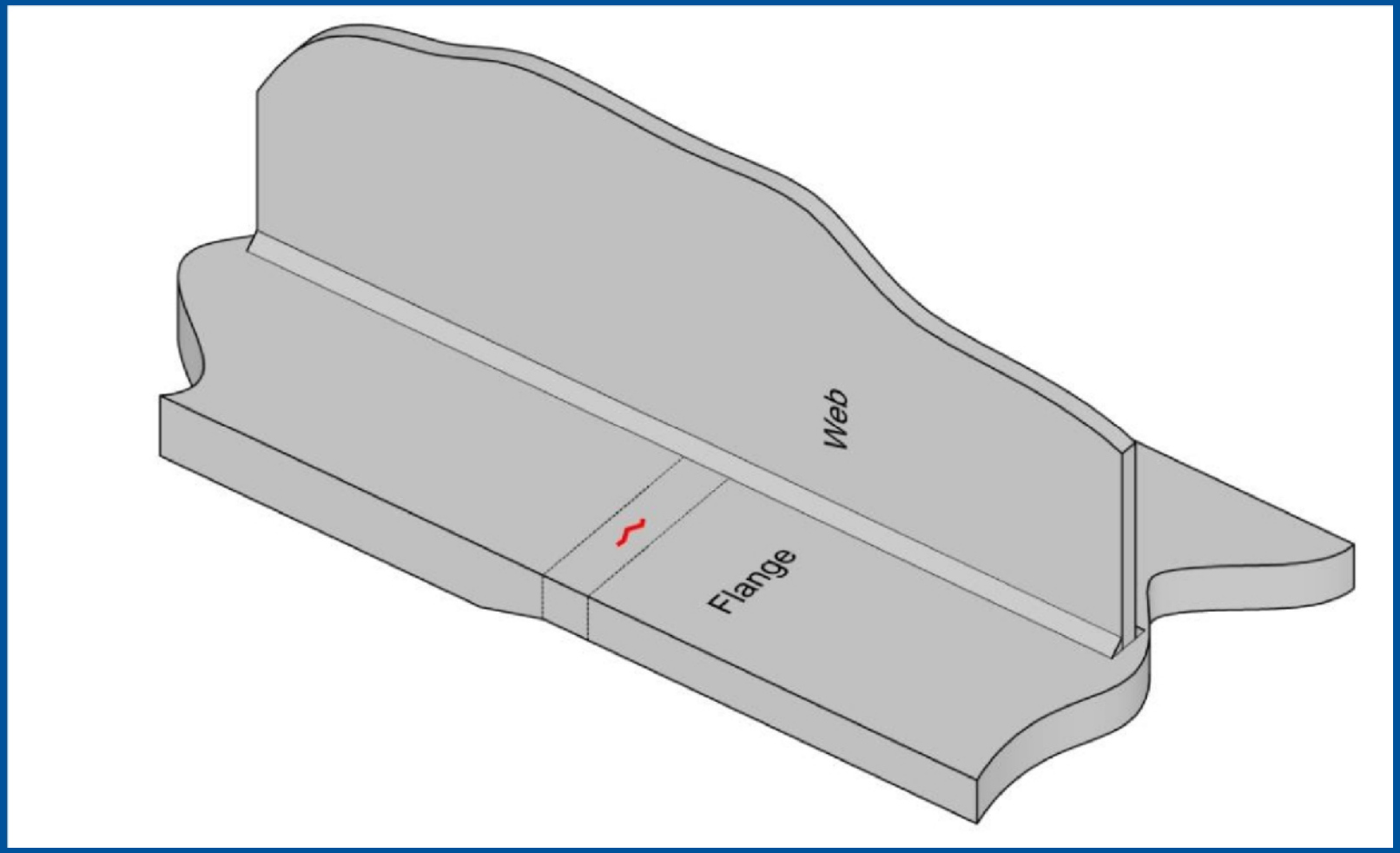
BMV



HIGHWAYS AGENCY

Safe roads, reliable journeys, informed travellers

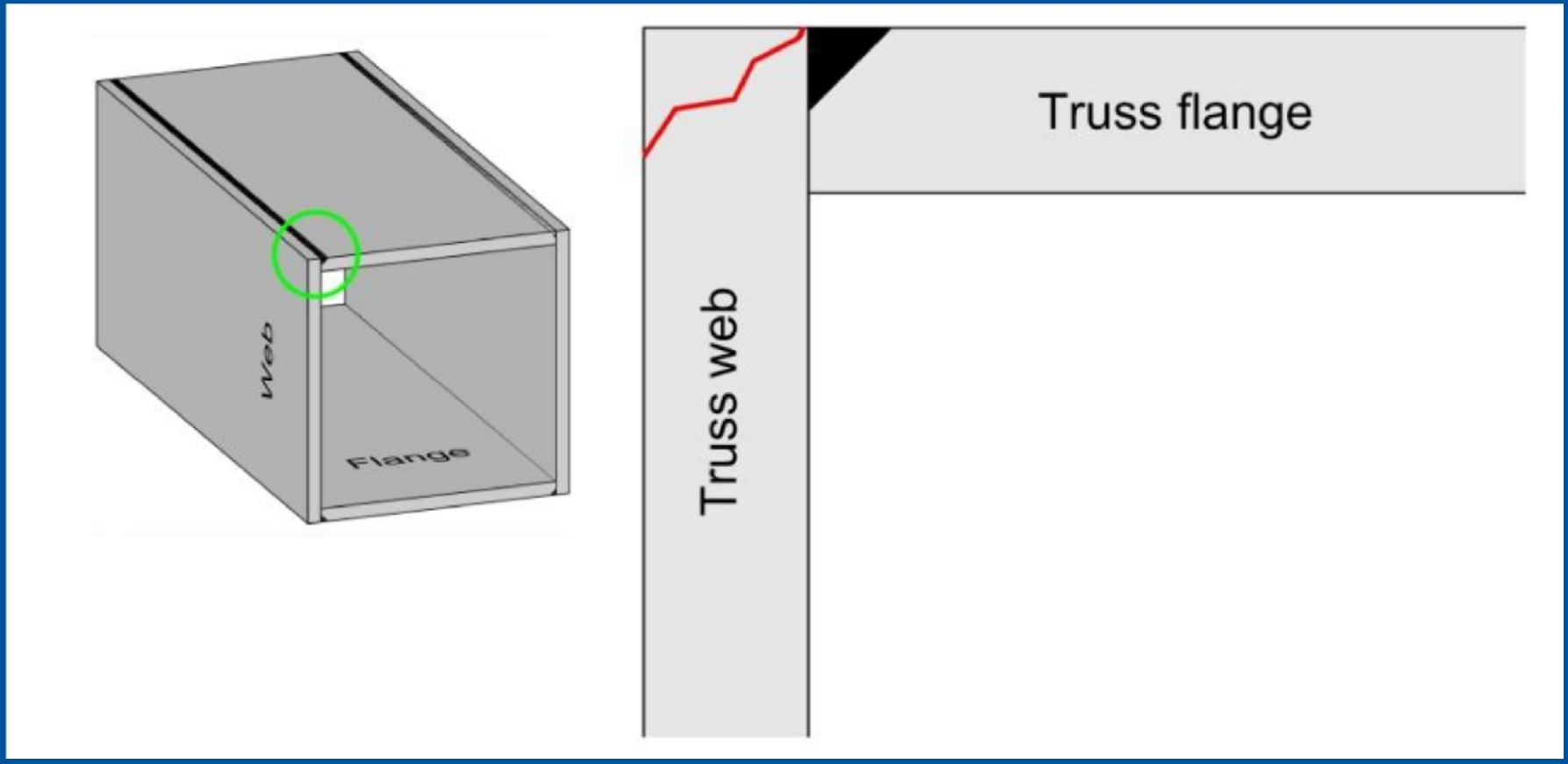
BMV



HIGHWAYS AGENCY

Safe roads, reliable journeys, informed travellers

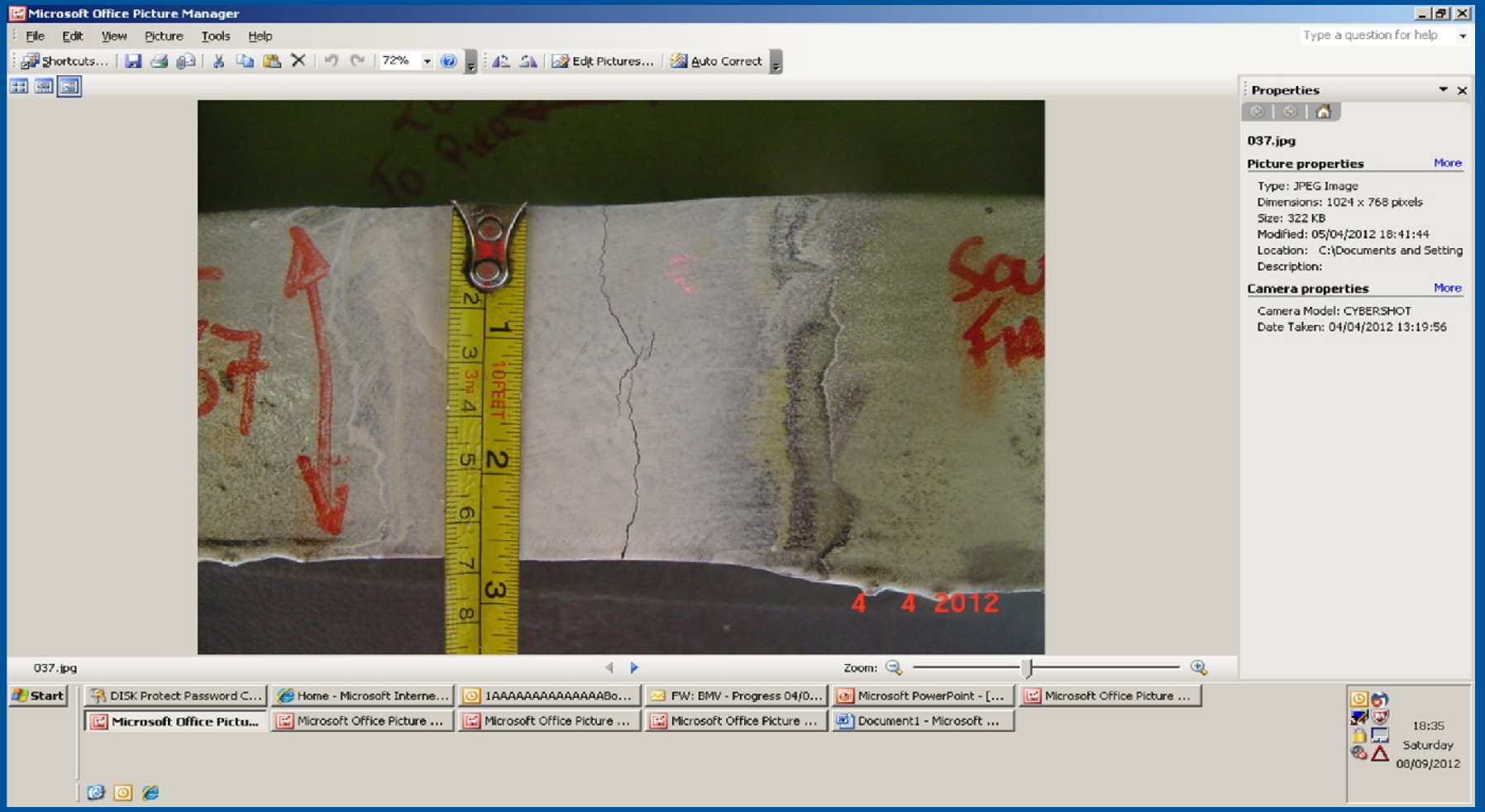
BMV



HIGHWAYS AGENCY

Safe roads, reliable journeys, informed travellers

BMV



HIGHWAYS AGENCY

Safe roads, reliable journeys, informed travellers

BMV

HIGHWAYS AGENCY

Safe roads, reliable journeys, informed travellers

Concern

- Safety to the Public
- Network Operations
- Load Carrying Capacity
- Brittle failure
- Fatigue (long term)
- Disruption to Olympic Traffic

HIGHWAYS AGENCY

Safe roads, reliable journeys, informed travellers

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)

HIGHWAYS AGENCY

Safe roads, reliable journeys, informed travellers

Repairs Strategy

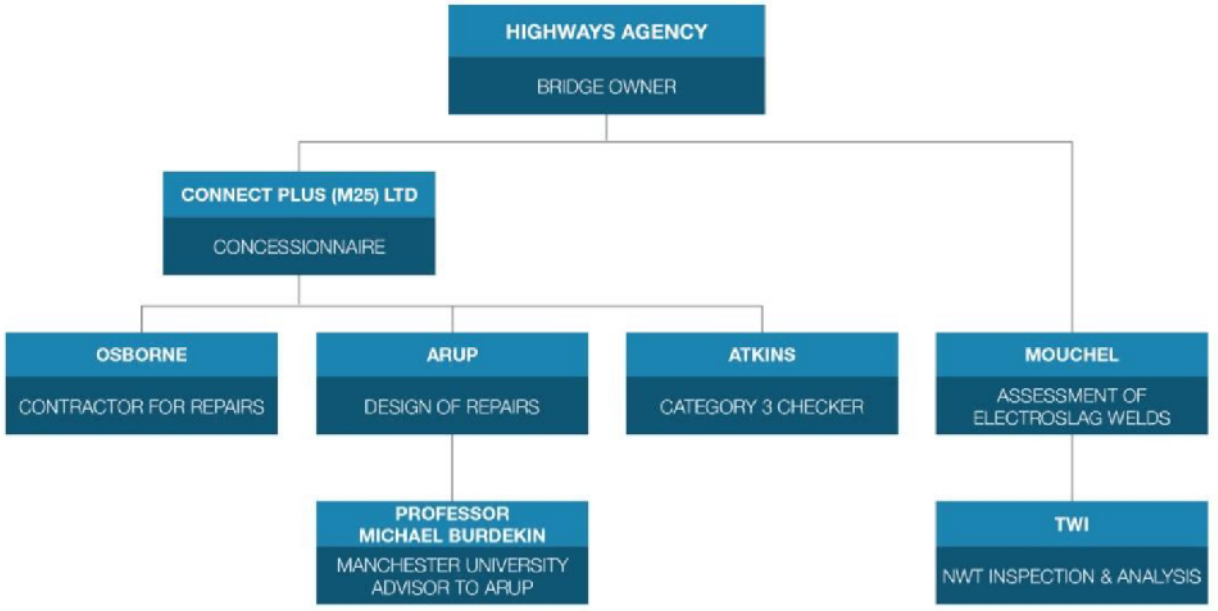
- Two phase repairs
- Phase one: carry out sufficient repairs to restore the LCC to 40 T
- Phase one: plan to complete before start of Olympic
- Phase two: complete repair to address medium/long term problems (e.g. fatigue)

HIGHWAYS AGENCY

Safe roads, reliable journeys, informed travellers

Organisation

Figure 1



Boston Manor Viaduct
Organisation Diagram for Delivery of Repairs

HIGHWAYS AGENCY

Safe roads, reliable journeys, informed travellers

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)

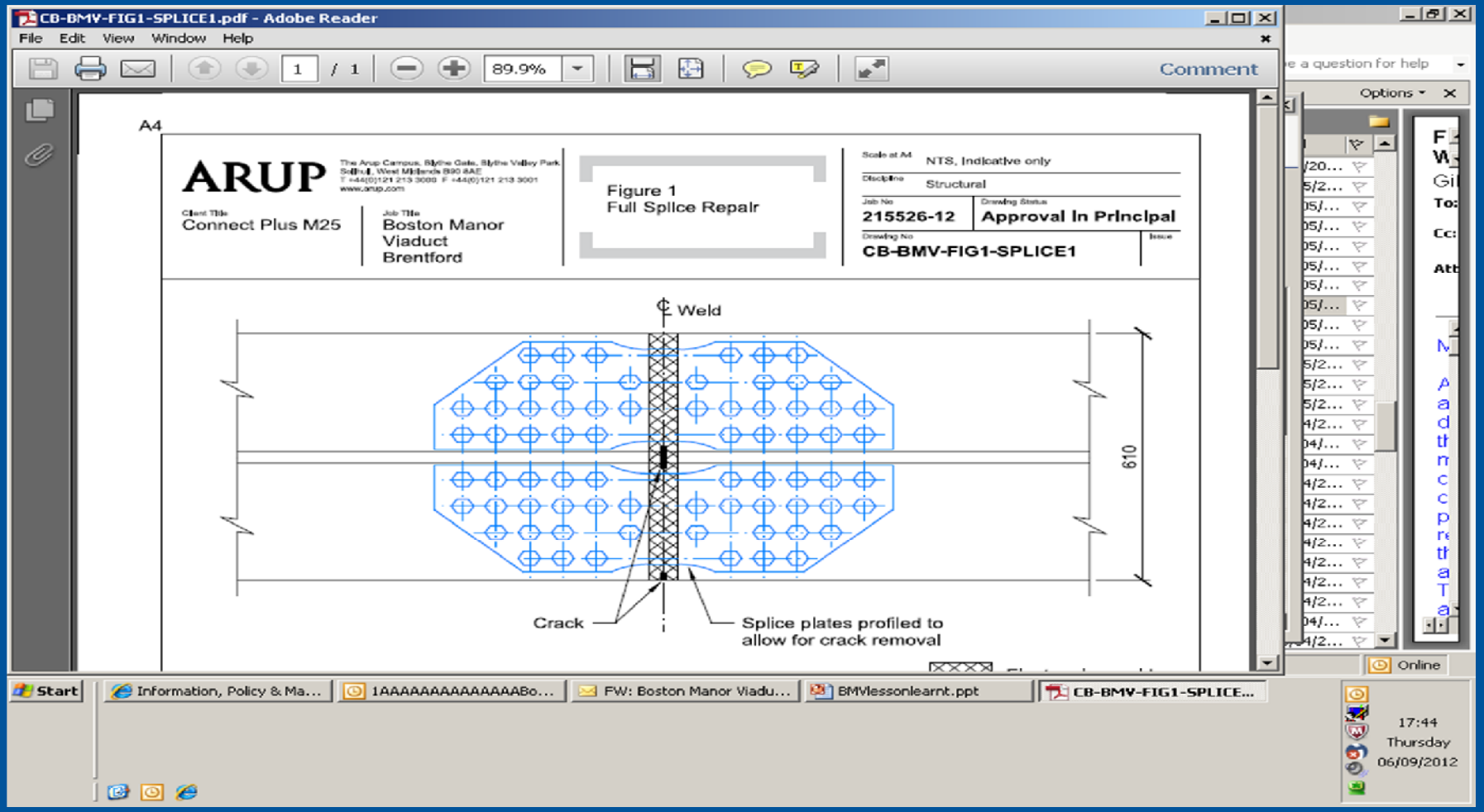
Type D: In board cracks

Grinding

HIGHWAYS AGENCY

Safe roads, reliable journeys, informed travellers

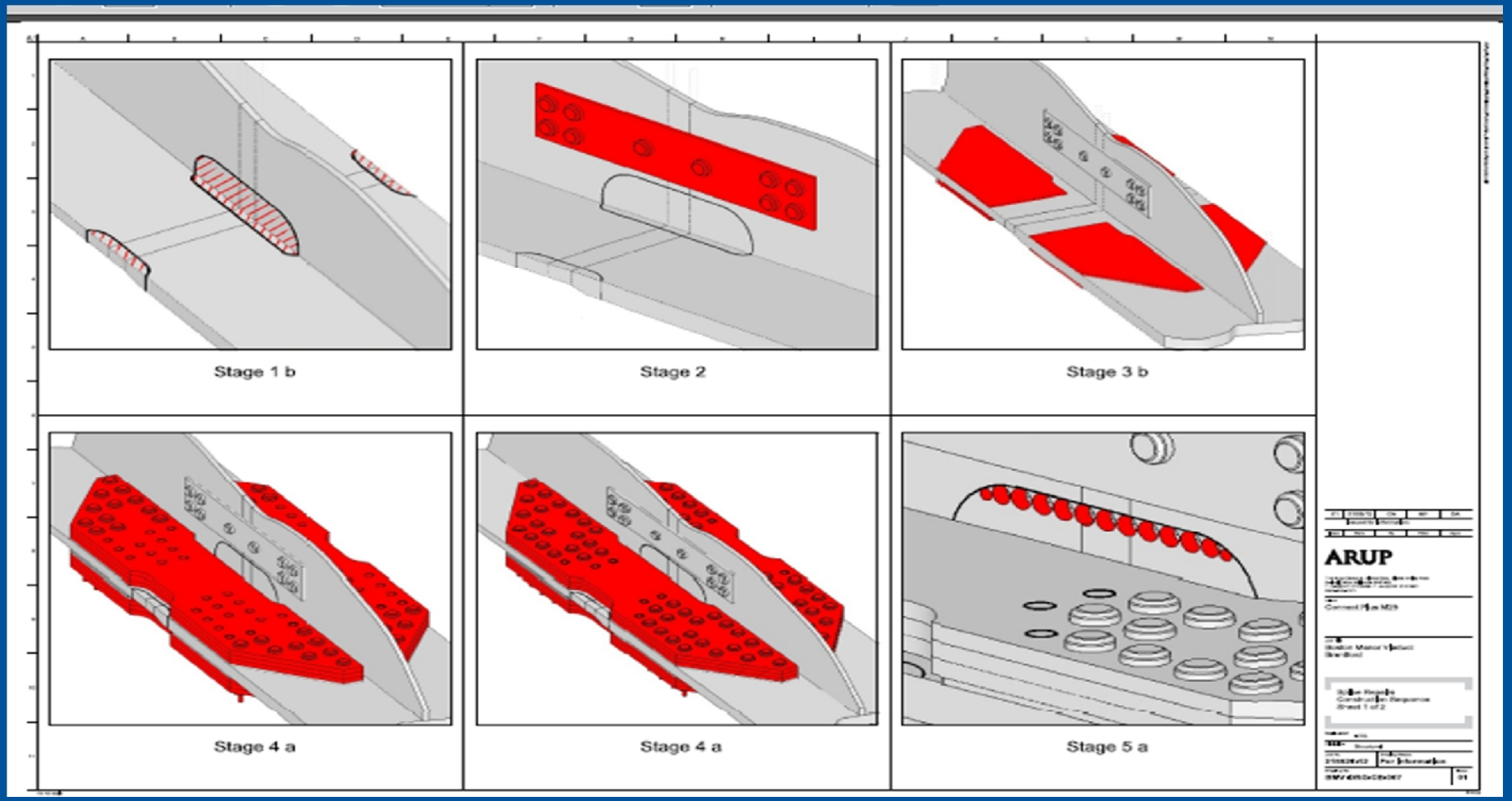
BMV



HIGHWAYS AGENCY

Safe roads, reliable journeys, informed travellers

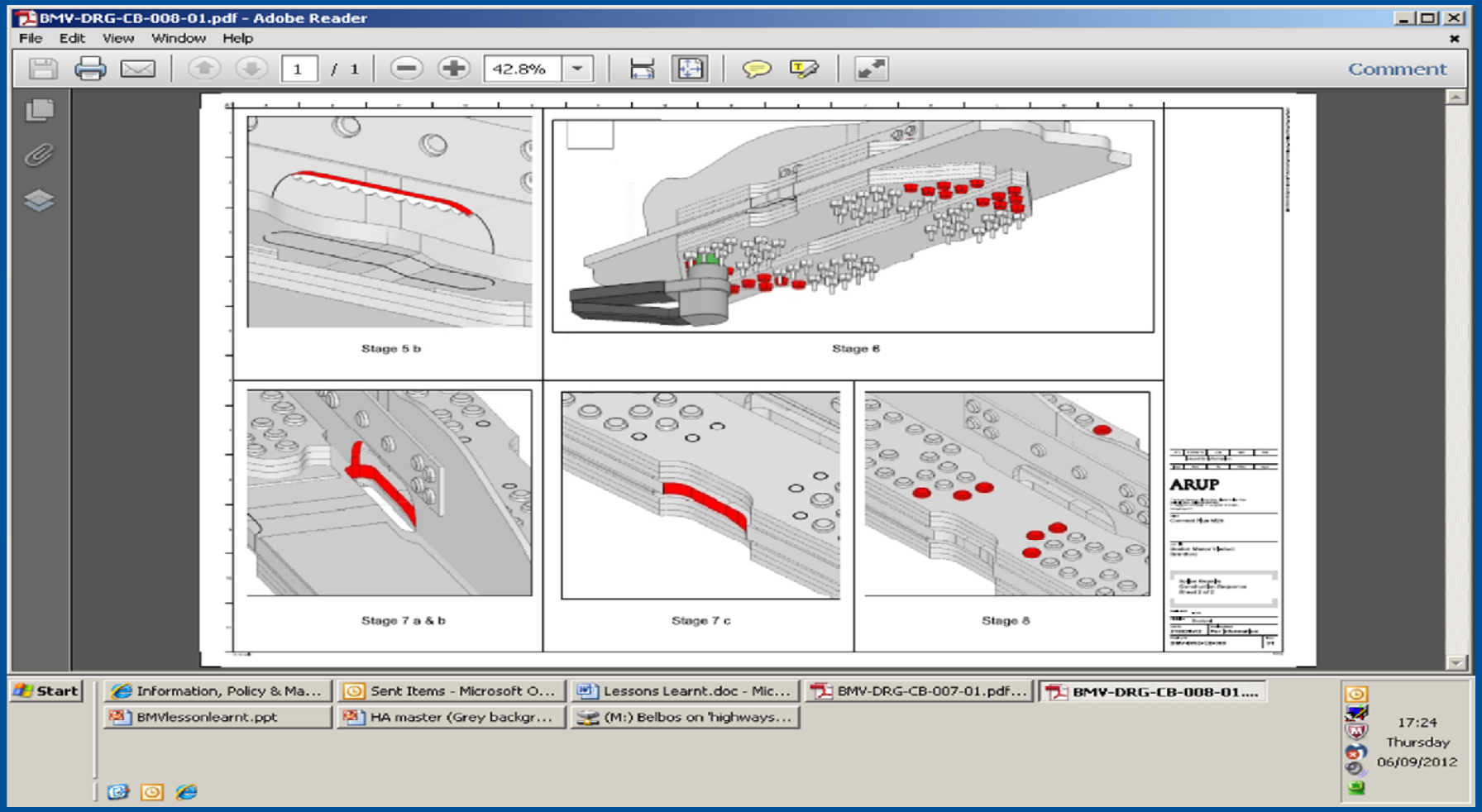
BMV



HIGHWAYS AGENCY

Safe roads, reliable journeys, informed travellers

BMV



HIGHWAYS AGENCY

Safe roads, reliable journeys, informed travellers

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

HIGHWAYS AGENCY

Safe roads, reliable journeys, informed travellers

Future Structures Management

- Monitoring
- PI in 2013 Approx

HIGHWAYS AGENCY

Safe roads, reliable journeys, informed travellers

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

HIGHWAYS AGENCY

Safe roads, reliable journeys, informed travellers

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

HIGHWAYS AGENCY

Safe roads, reliable journeys, informed travellers

BMV

Questions!