AGEING GRACEFULLY WITH COMPOSITE TECHNOLOGY

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GET TO KNOW THE COMPANY
YOU THOUGHT YOU KNEW.
FURMANITE TECHNICAL SOLUTIONS KEY SERVICES

- Front-end engineering & design
- Life-cycle analysis
- Engineering
- Procurement
- Construction management
- Commissioning & start-up
- Project management
- Automation solutions
- Operations & maintenance
- Feasibility studies
- Staffing
FURMANITE INSPECTION
KEY SERVICES

- Traditional & Computed Radiography (RT/CRT)
- Magnetic Particle Testing (MT)
- Penetrant Testing (PT)
- UT Thickness and Flaw Detection
- Tube Inspection (ET/IRIS/RFT/NFT)
- Phased Array (PAUT)
- Time of Flight Diffraction (ToFD)
- Electromagnetic Acoustic Emissions Testing (EMAT)
- Alternating Current Field Measurement (ACFM)
- Long Range UT Testing (Guided Wave)
- API Inspectors (510/570/653)

Integrated Industrial Solutions. Seamless Implementation.
FURMANITE SPECIALITY MECHANICAL KEY SERVICES

- On-Line Leak Sealing
- Composite Repair
- Controlled Bolting
- On-Site Machining
- Heat Treatment
- Weld test & Isolation
- Hot Tapping & Line Stopping
- Valve Repair
- Trevitest
Ageing Gracefully

• Use of composite materials in managing ageing metal structures

• Examples
  – Bridges
  – Tunnels
  – Ships
  – Offshore
The history

• London Underground
  – Tunnel construction started in 1843 (by Marc Brunel and his son, Isambard)
  – First line (Metropolitan) started running in 1863
  – Subsequent development has led to significant changes in loading and access
    • Second photo shows Regent Street, rebuilt between 1895 and 1927
The challenge

• Tunnels built using the latest materials and techniques
  – “Cut and cover” tunnels
  – Cast Iron beams with brick jack arch infill
• Subsequent development has led to significant changes in loading and access
• Some of the structures are now over 160 years old
• This key infrastructure must continue to perform safely
Cast iron

- Cast iron known to be unreliable
  - Strong in compression
  - Weak in tension
  - Early QA - load tests on as-produced beams (up to 45 tonnes) followed collapse of Dee Rail Bridge in 1847 (built by Robert Stephenson, son of George, who is father of modern rail)

- Wrought iron even less suitable
  - Corrosion a longer term problem below ground (and higher cost)

- Blast furnace first patented in 1855 – too late for the tunnels
Performance in Service

• Several beams have fractured but none have collapsed
  – Beams in highest risk locations have been replaced
• Cast iron covered-way roofs below roadways were rebuilt or underpinned in early 1960’s
• Cast iron tunnel roof remain a risk
  – in areas below buildings
  – in areas below footways and open spaces
The challenge

• Covered way roofs below buildings
  – Only accessible from below when trains are not running
    (about 3 hours per night)
  – Need to maintain building support
  – Available space
    • Cast iron beams only just above trains
    • Only space available is in jack arch segmental void

• Can’t lower the track
  – Large sewers pass immediately under tracks
  – Trackside retaining walls undermined (kick in at base unless restrained)
Current Solution

• Steel aerofoil beams
  – Each beam has a mass of 6½ tonnes
  – Loads in cast iron are unknown
  – Concern that installation may overload the cast iron in tension during installation
  – Solution required to strengthen tensile flange of CI beam
Composite Strengthening

- UHM carbon fibre validated as a strengthening option
  - High stiffness vs cast iron (360GPa vs 110-130GPa)
  - Pick up load quickly for small deflections
  - Use tensile strength of carbon and compression strength of cast iron
  - Only thin plates required
Verification

- Extensive test programme completed
- Component and materials scale testing
- Long term properties measured
- Application techniques verified
- Structural monitoring in-situ to confirm performance
Application Development

• Interest from wider industry in reinforcement of older bridge-stock

• Methodology standardised and published (ICE, CIRIA)
  – Wide range of projects completed
  – Pre-stressing techniques developed
  – Few older bridges in Europe post-1945
Other Structural Applications

• Materials also used to manage other cast iron structures
  – Tunnel pans
  – Struts
• Extended application to steel structures
  – Included webs and compression-side of beams
Other Structural Applications

- Blast wall strengthening
- Testing completed to determine:
  - Short term mechanical properties
    - Tension and compression
    - Temperature and strain rate effects
  - Bond strength
    - Surface preparation
    - Temperature and strain rate effects
  - Representative blast tests completed to verify performance
Other Structural Applications

- Wide range of applications for repair of degraded metal structures pioneered using data, design methodology and test results developed
  - Cold work application process
  - Easy to apply and cost-effective
  - Add little extra weight to structure
- For example, Offshore Deck repair (up to 400m²/4000sqft)
Other Structural Applications

• Repair of corroded steel decks in ships
• Cold-work application process meant work could be completed without disrupting other activities
• Programme was compressed, leading to significant cost savings
Other Structural Applications

• Use of composites for crack reinforcement studied
• JIP led by DNV in Norway
• Trial applications of crack repair and deck repair completed on FPSO’s in Europe and Asia
• Performance in line with expectations
Ageing Gracefully

• Composite materials can ensure help ageing structures continue in service

• Plastic surgery that does more than make you look younger!
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