A Cost Effective Replacement for Short and Medium Span Bridges

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Contents

• Company Introduction
• Basic Concept
• Background
• Origin of Concept
• Development of ‘FlexiArch’
  – Experimental validation: Stability, Strength
  – Analytical validation
• Applications of ‘FlexiArch’
  – Experience to date
  – Future developments
  – Lessons Learned
• Concluding remarks
Company Introduction
Mission
To be recognised as a major provider of precast concrete technology, products, services and solutions and to serve our customers regionally, nationally and internationally.
Diverse Markets

- Network Rail
- Water Companies
- Highways Agencies
- Sea Defence
- Marine
- Agriculture
Cycle Path Tunnel, Cumbria
FlexiArch Concept
Origin of Concept – “FlexiArch”

• Historic Methods

• EEC directive 85/3 dated 1999
  – The introduction of 40T commercial vehicle

• BD 57/01 and BA 57/01; Design for Durability (UK Highway Agency)
  – No steel / High durability
Historical Method

Traditional masonry arch bridges are aesthetic, durable and strong.

However they require centring and extensive formwork, which is expensive and time consuming.
**FlexiArch** is a modular, unreinforced, precast, concrete arch bridge system, which is based on the same principles as traditional stone masonry built arch bridges dating from Roman times – but without the stone mason.
Method of Construction

- Top layer cast over voussoirs
- Polymeric reinforcement
- Precast concrete blocks
- Construction bed

Casting Voussoirs

Precast Voussoirs

Polymeric Reinforcement
Screed with Crack Inducers
Lifting of Prototype
Lifting of Prototype
Setting in Place
Development of FlexiArch

• Is there a market?
  – Over 90,000 arch bridges in UK
  – Many need repair, strengthening or replacement

• Solution may be simple but required:
  – 12 years of laboratory research leading to a patent
  – 5 years of R&D within Macrete Ireland Limited
  – Attention to detail/quality but cost competitive
FlexiArch Testing
Experimental Validation

• Model tests at QUB
  – Third scale: 5 x 2, 10 x 2, 15 x 3. (metres)
  – Conventional backfill vs Concrete
  – Loading to ultimate

• Full scale tests at Macrete Ltd
  – Stability: 5 x 2, 10 x 2, 15 x 3. (metres)
  – Strength: 5 x 2, 10 x 2, 15 x 3. Max 74t (concrete)

• Full scale tests at actual bridge site
  – (Tievenameena Bridge, NI)
3rd Scale Single FlexiArch Unit Test at QUB
Full Scale Single FlexiArch Unit Test at Macrete
Instrumentation of Full Scale Single FlexiArch Unit Test at Macrete
Full Scale FlexiArch Bridge Test at Macrete
Full Scale Cantilever Test to Verify Paragrid Creep During Lifting
Real World Test Site
Tievenameena Bridge
Load Test at Site
A range of methods utilised including:

- Reynolds / Mexe
- ARCHIE
- RING
- Spreadsheet methods
- Variable depth beam
- Equivalent grillage for Skew
- Non-linear Finite Element Analysis
Analysis using ‘ARCHIE’ software

Arch unit
Thrust line
Loading
Arch unit
Passive pressure
Backing material
Findings

- Arch ring has acceptable strain levels during lifting
- Arch ring is stable under concrete or granular backfill
- The strength of the arch ring is enhanced with backfill in place
- Good correlation between test results and the design software’s output.
Flexi*Archer* Case Study
Case Study - Devon
Hanging free
Placed
Continuing
Spandrels
Spandrel Walls Placed
Ready for concrete fill
Concrete Fill Completed
Brick Cladding
Completed Bridge
Advantages of FlexiArch

• Flat pack transportation
• Factory controlled production providing high quality finish to all elements
• All structural elements are unreinforced concrete, meaning reduced future maintenance costs (projected 120 years design life)
• Reduced number of on site operatives
• Watercourse / track not disturbed during construction
• Modular construction on site reducing construction time
• Can be cladded to suit client’s requirements
• Cost competitive with RC alternatives
FlexiArch Projects
Access Bridge, FP McCann
Celbridge – Co. Kildare
Footbridge, Newtonabbey
Gloucestershire
Tievenameena Bridge
Merthyr Tydfil
Bentely, Yorkshire
In Production

Shropshire, Sheinton Bridge - 13.7m Span
Longest commercial FlexiArch to date
Jacobs - Clough Brook Culvert
62 FlexiArch units

Option 4
Area of in situ concrete = 2.13 m²
Volume of in situ concrete = 132.06 m³ (62 m length)

In-situ concrete abutments to be designed by contractor

Minimum Requirement of Infill

Proposed line of infill
Preliminary Design

Sligo – N17
Widening MultiSpan Masonry Arch Bridge
Anticipated FlexiArch Developments and Lessons Learned
Road Widening

Flexi Arch
Increase range of spans

• Initially 3m to 10m
• Successfully constructed 15m x 3m
• Consider 20m plus achievable if:
  – Adequate crane capacity
  – Suitable transport
Skew Model
Setting Out Template for Full Scale
Trial Assembly
Trial Assembly
Spandrel Attached
Double Radius Arches being developed to fit Network Rail Profiles
Double Radius FlexiArch

NEW CILL BEAM

PROPOSED ROAD PROFILE

EXISTING ROAD PROFILE

83
1. Modification of footing blocks
   - No dowel
   - Upstand provided in insitu abutment instead, full height or to height of footing unit
Recent Technological Advances

2. Modification of fixing of spandrel wall
   – No longer use tie bars
   – Stainless steel brackets provided for fixing
3. Revised Concrete Infill - Lower strength infill is being used with good concrete slab on top
4. Provision for Stone Cladding

Original Concrete Finish

Brick Cladding

Rib slots cast-in
5. Corbels to be colour matched to stone where desired for aesthetics
Concluding Remarks

Capital vs Life Cycle vs Whole Life Costs

Time

40 years  80 years  120 years

Cost

Traditional Masonry Arch

Repair

Beam Alternative

Stone Clad FlexiArch

Concrete Finish FlexiArch

Concluding Remarks
Concluding Remarks

- Precise arch geometry without centring
- Assembly of precast bridge units << 1 day
- Minimal disruption to river / track
- Comparable initial capital cost
- Very durable, no corrodible reinforcement
- Minimum total life cycle cost
- ‘FlexiArch’ can greatly enhance use of short / medium span arch bridges
- Ideal for retrofit and strengthening
“The installation process was straightforward, went to plan, and was quick.”

Andrew Broad, General Works Manager, Dean & Dyball Civil Engineering
(Escot Estate FlexiArch Installation – two bridges)
“The FlexiArch was chosen for the Newtownabbey cycle path project because of its aesthetic suitability, economic deployment, sustainable construction and consideration for environmental issues such as avoidance of disturbance to the river bed.”

Neil Luney, Rural Project Officer, Newtownabbey Borough Council
(National Cycle Path development on rural land – three bridges)
“The FlexiArch system and installation process completely suited this location for replacement of an old arch bridge. There are definitely other locations within the county where this will be seriously considered as an appropriate solution for bridge replacement.”

Mladen Dragojlovic, Gloucestershire County Council
(County lane river crossing – bridge replacement)
“The procurement, delivery and erection of the precast units was extremely efficient. Merthyr Tydfil CBC and the general public have expressed extreme satisfaction with the completed structure.”

Mark Robinson, Merthyr Tydfil County Borough Council
(River Taff Corridor Improvements – one bridge)
Any Questions?

Thank You

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