Resin Infused FRP Bridges

Bridging The Gap

Lifespan Structures Ltd

Bridging The Gap

- Introduction to Lifespan Structures
- UK Footbridge – Market Overview
- Introduction to Composites
- History of Composite Use in Bridges
- Lifespan Bridge Deck – Case Studies
- Footbridge Solutions – Cost Comparisons
- Composite Footbridge Benefit Summary

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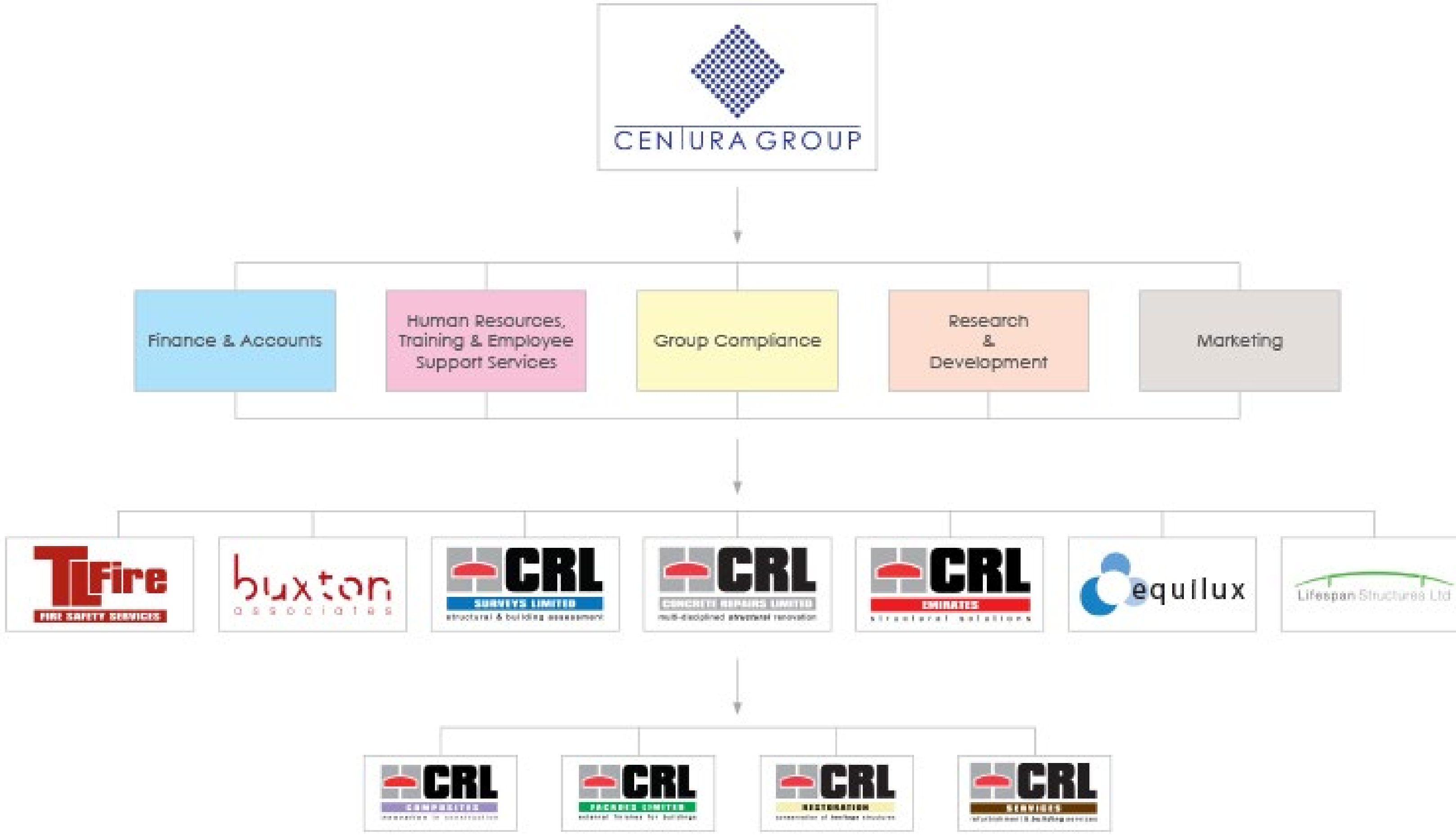
Lifespan Structures - Introduction



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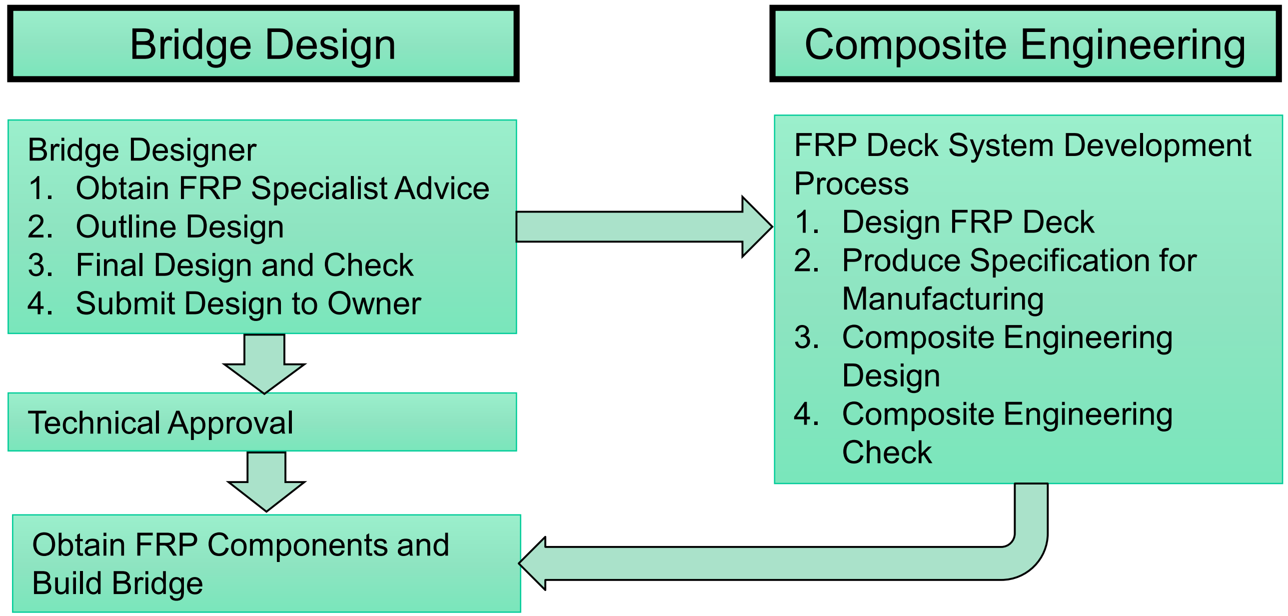
Lifespan Structures - Introduction

- Established to provide FRP solutions to bridge owners and contractors
- Lifespan Structures have developed a bridge specifically designed to provide
  - Cost effective
  - Low maintenance
  - Durable
  - Solution for simply supported elements
  - Up to a 20m span
  - In a variety of widths suitable for footbridges
- Linking up expertise in Bridge and Composite Design and Composite Manufacturing
- Work with other partners to provide a longer span footbridge solutions

Lifespan Structures - Introduction

- Involvement at Conceptual Stage allows
  - Structural Bridge Design
  - Development of Composite Engineering
  - Efficient manufacturing processes to be utilised
  - Production of a viable composite structure for even simple but elegant structures
  - Capital costs of a composite footbridge to be much more in line with those of traditional steel and timber type structures
  - The owner to take full advantage of the whole life cost benefits

Simplified Procurement Process



BD90/05 Summary of FRP Bridge Deck Procurement Process

Single Point of Contact Service

What are FRP Composites ?

- Comprise resin matrix and fibres
  - Resin transfers stress between and protects fibres
  - Fibres provide strength and stiffness
- Developed in 1940's
  - High specific strength and stiffness
  - Lightweight
  - Durable

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FRP Strengthening since 1990's

project: bridge strengthening

Strengthening a bridge using carbon fibre reinforced plates

Neil Dodds (M) of Scott–White and Hookins describes the practical use of carbon fibre reinforced polymer plates to strengthen a live bridge in North London which carries both underground and main-line trains. As a designer he highlights the challenge of using this relatively new material

Fig 1. Bridge MR46A prior to strengthening

Bridge MR46A is on the Amersham Branch of London Underground's Metropolitan Line and carries twin rail tracks over Station Road, Harrow, adjacent to North Harrow Station. It was constructed in 1960, and is of all-welded steel half-through construction, with a clear square single span of 26.06m and a clear width of 8.31m. Minimum head-room over Station Road is about 4.9m (Fig 1).

The structural arrangement of the bridge is as follows. There are two main fabricated steel edge girders, about 2.45m deep, which are simply supported at either abutment. These girders are

shows the cross-section prior to strengthening works.

A loading capacity assessment was carried out by London Underground Ltd in December 1997 as part of an ongoing programme. The assessment was carried out in accordance with London Underground Ltd Standard E3314[1]. Full RU loading, as defined in Department of Transport Standard BD37/01[2], was applied, because the bridge carries main-line trains as well as the lighter London Underground stock.

The assessment found the bridge to be understrength to resist RU loading, with capacity/assessment load ratios of 0.84

Statement (corresponding to an Approval in Principle for Highway projects and Form A for Railtrack projects).

Initially, conventional means of strengthening were proposed, which involved welding on steel cover plates. However, at London Underground's request, carbon fibre reinforced polymer (CFRP) was investigated and pursued as the preferred scheme. This followed the successful trial use of CFRP on a bridge at London Underground's Acton depot[4].

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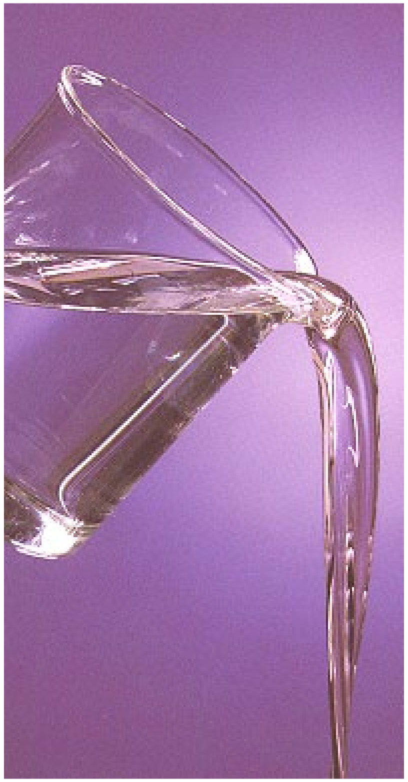
Types of Resin

- Phenolics
  - good fire resistance
  - poor mechanicals
- Polyurethanes
  - good abrasion resistance
  - poor temperature performance
  - toxicity problems
- Polyesters
  - workhorse of the trade
  - inexpensive - good general properties
  - VOC and odour problems
- Vinylesters
  - good fatigue, moderate price, good chemical resistance, VOC and odour problems
- Epoxies
  - best resistance- adhesion/ fatigue
  - more expensive, low odour and VOC



Types of Fibres

- Aramid - The TOUGHEST fibre, good in impact situations, expensive, absorbs water, good in vibration damping, relatively high creep, very light
- Carbon - The STIFFEST fibre, expensive, virtually inert, very low creep, limited availability, extreme temperature resistance, most brittle of the three
- Glass - the ECONOMIC choice, low creep, good temperature resistance, susceptible to strong acids and bases, very inexpensive. Subject to stress corrosion, readily available
- Renewable organic fibres – the ENVIRONMENTAL choice? Still in development, more research

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UK Composite Bridges – Aberfeldy Footbridge

- Aberfeldy Footbridge Scotland
- Installed in 1992
- Major step forward in large-scale application of FRP composites for bridges
- Is believed to still be the longest span FRP bridge in the world with a main span of 64m

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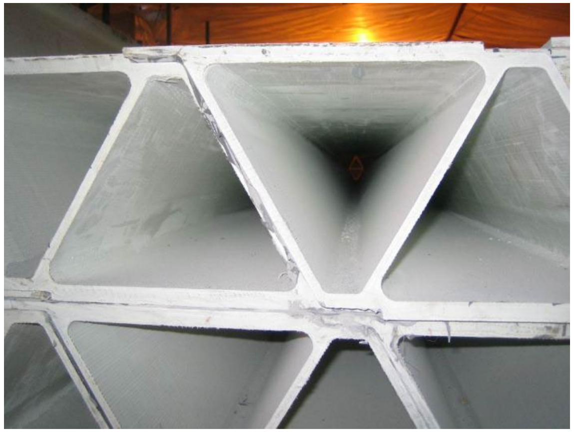
UK Composite Bridges – West Mill Bridge

- West Mill Bridge Oxfordshire
- First FRP public highway bridge in the UK
- Installed in 2002
- 10m span bridge across a river
- Pultruded FRP deck supported on FRP beams manufactured by a combination of pultrusion and resin infusion



UK Composite Bridges- Bradkirk Footbridge

- Bradkirk footbridge Lancashire
- Installed over the railway in 2010
- Two spans each of 12m
- Staircase also in FRP

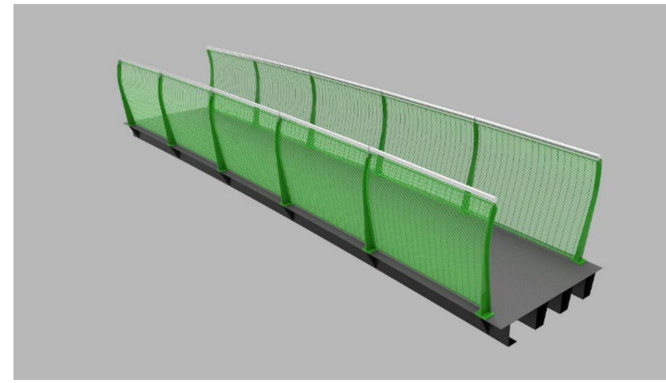
Lifespan Bridge, Case Study - Sedlescombe

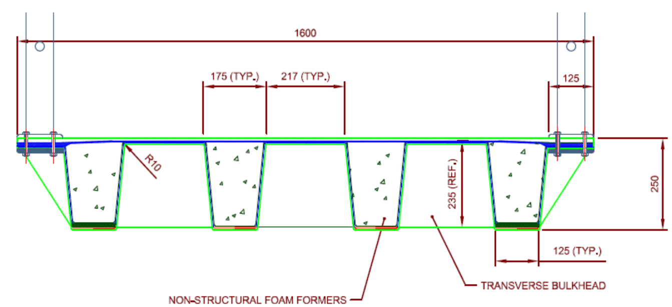
- Existing Structure

Lifespan Bridge, Case Study - Sedlescombe

Design

- Clear Span of 8m and Clear Width 1.35m
- Designed to the requirements of Eurocodes and BD90/05
- The maximum deflection under a characteristic live load of 5kN/m2 was 24.4mm, less than span/300.
- The minimum natural frequency was 9.71 Hz, Greater or equal to 5Hz
- The maximum deformation under a 10kN local load was 4.5mm
- All strains were kept below allowable limits under ULS load cases
- Bolted connections shall accommodate an allowance of at least +/-5mm for thermal expansion





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Lifespan Bridge, Case Study - Sedlescombe

- Installation

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Lifespan Bridge, Case Study - Sedlescombe

- Completed

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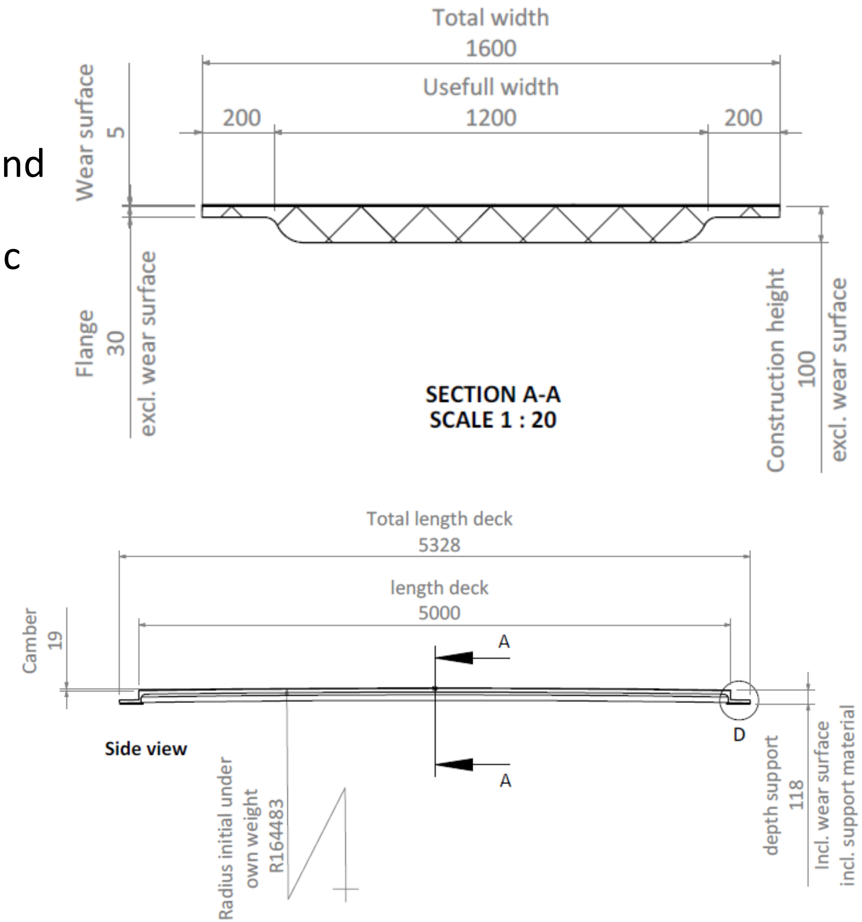
Lifespan Bridge, Case Study – Covert Way

Design

- Deck Length of 5.0m and Clear Width 1.2m
- Designed to the requirements of Eurocodes, and CUR Recommendation 96
- The maximum deflection under a characteristic live load of 5kN/m2 was 30mm, less than span/100
- The minimum natural frequency was 7.0 Hz, Greater or equal to 2.3Hz
- All strains were kept below allowable limits under ULS load cases
- Bolted connections shall accommodate an allowance of at least +/-2.5mm for thermal expansion



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Lifespan Bridge, Case Study – Covert Way

- Manufacturing

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Lifespan Bridge, Case Study – Covert Way

- Completed

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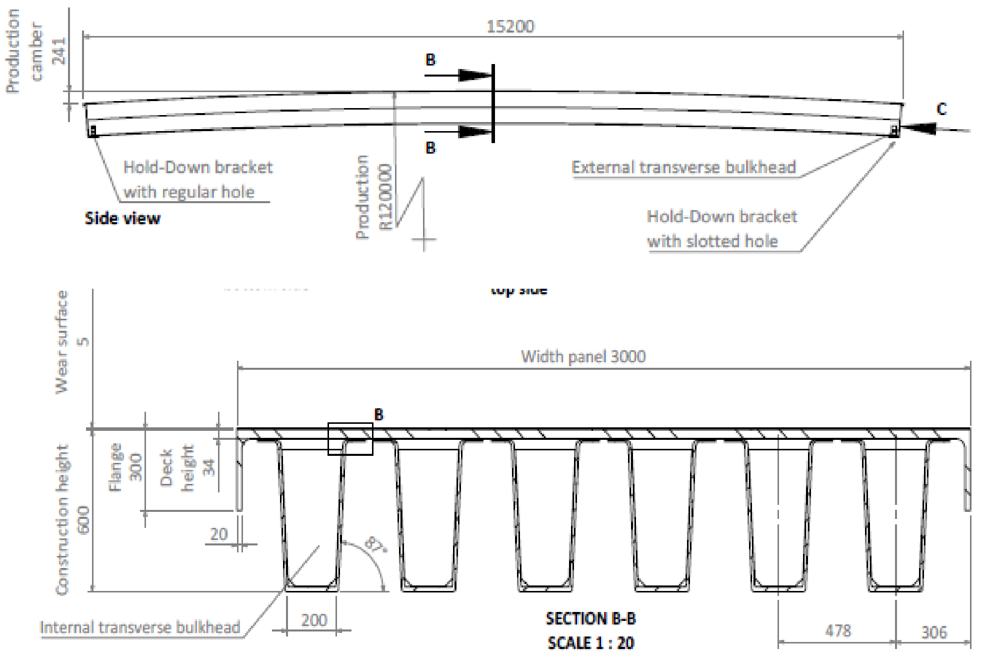
Lifespan Bridge, Case Study – Eastbourne Cycleway

Lifespan Bridge, Case Study – Eastbourne Cycleway

Design

- Deck Lengths 11.0m and 15.2m and Cl Width 3.0m
- Designed to the requirements of Eurocodes, and BD90/05
- The maximum deflection under a characteristic live load of 5kN/m2 was 28mm and 42mm, less than span/300

- The minimum natural frequency was 12.93Hz and 9.9Hz, Greater or equal to 5.0Hz
- All strains were kept below allowable limits under ULS load cases



Lifespan Bridge, Case Study – Eastbourne Cycleway

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Footbridge Solution Cost Comparison

- Bridge Details
  - Simply Supported Single Span
  - Span – 8m
  - Width – 1m
  - Standard Anti Climb Pedestrian Parapet
- Capital Costs have been obtained from real project tender information for bridges with similar details.
- Maintenance Costs and Intervention Intervals have been developed from client feed back

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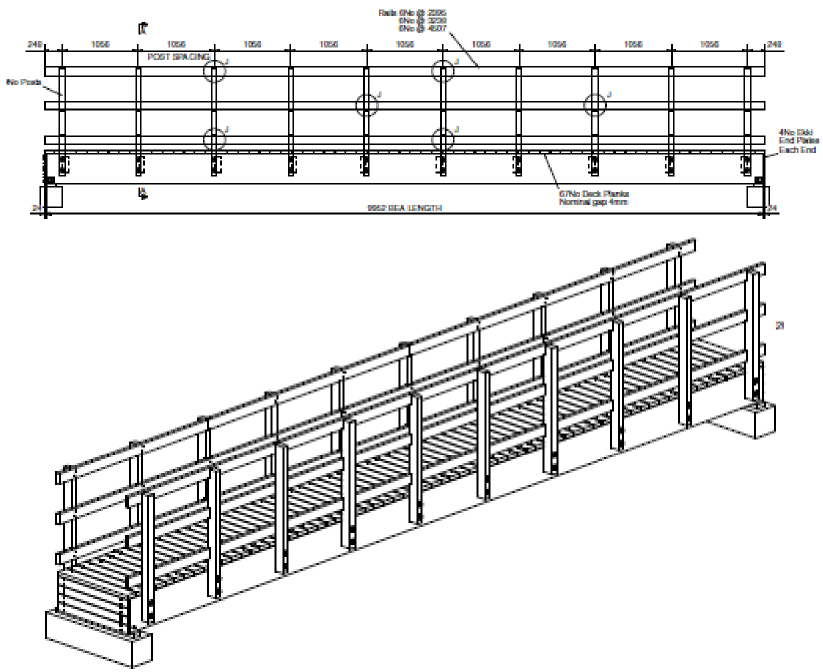
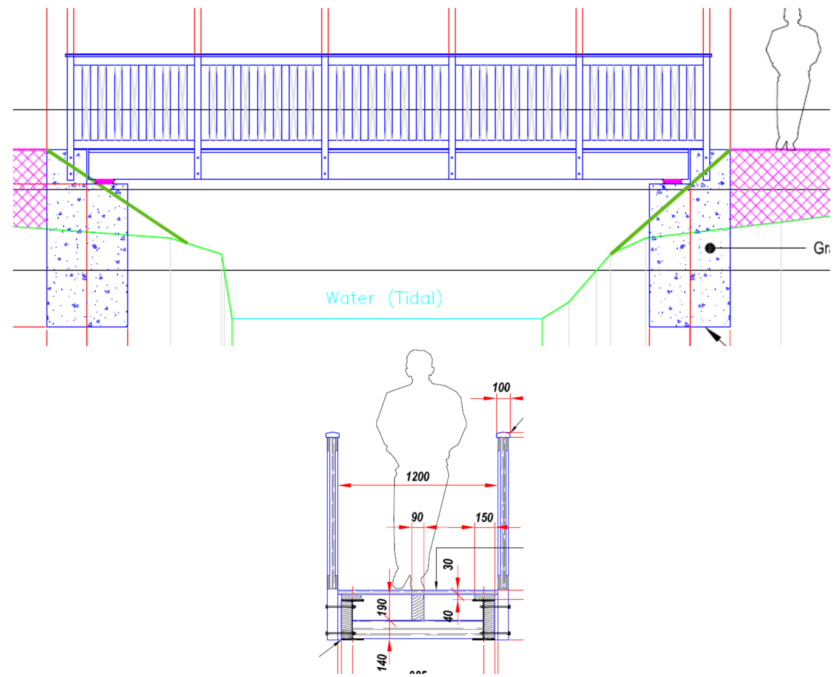
Footbridge Solution Cost Comparison

Timber



Approx 3000kg

Steel Timber Hybrid



Approx 2500kg

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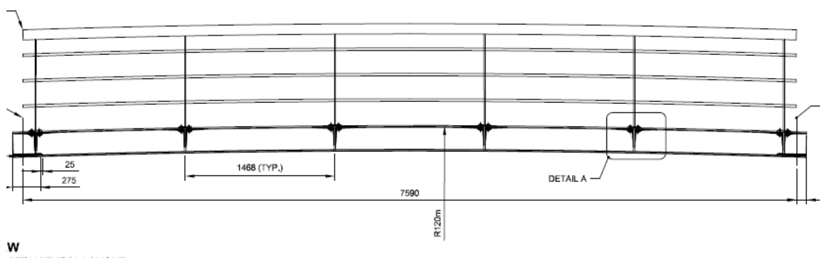
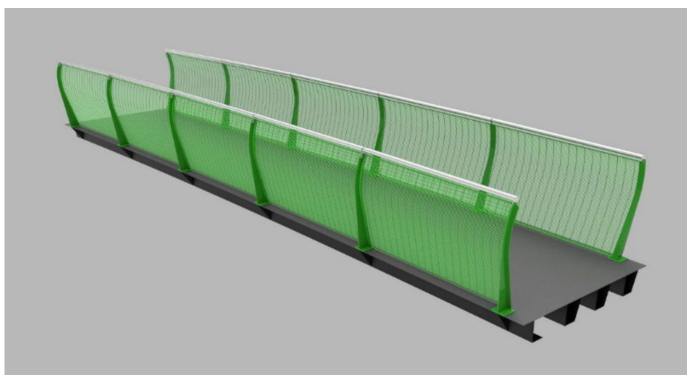
Footbridge Solution Cost Comparison

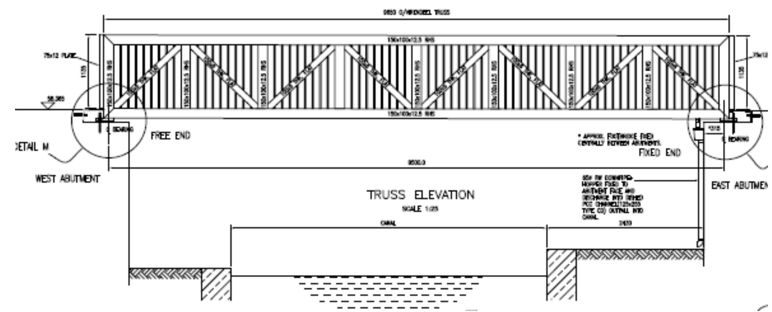
Lifespan Bridge - Composite

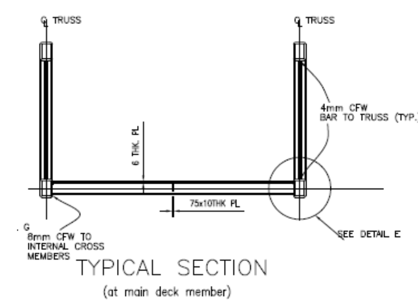




Approx 1000kg

Steel with Corrosion Protection





Approx 3000kg

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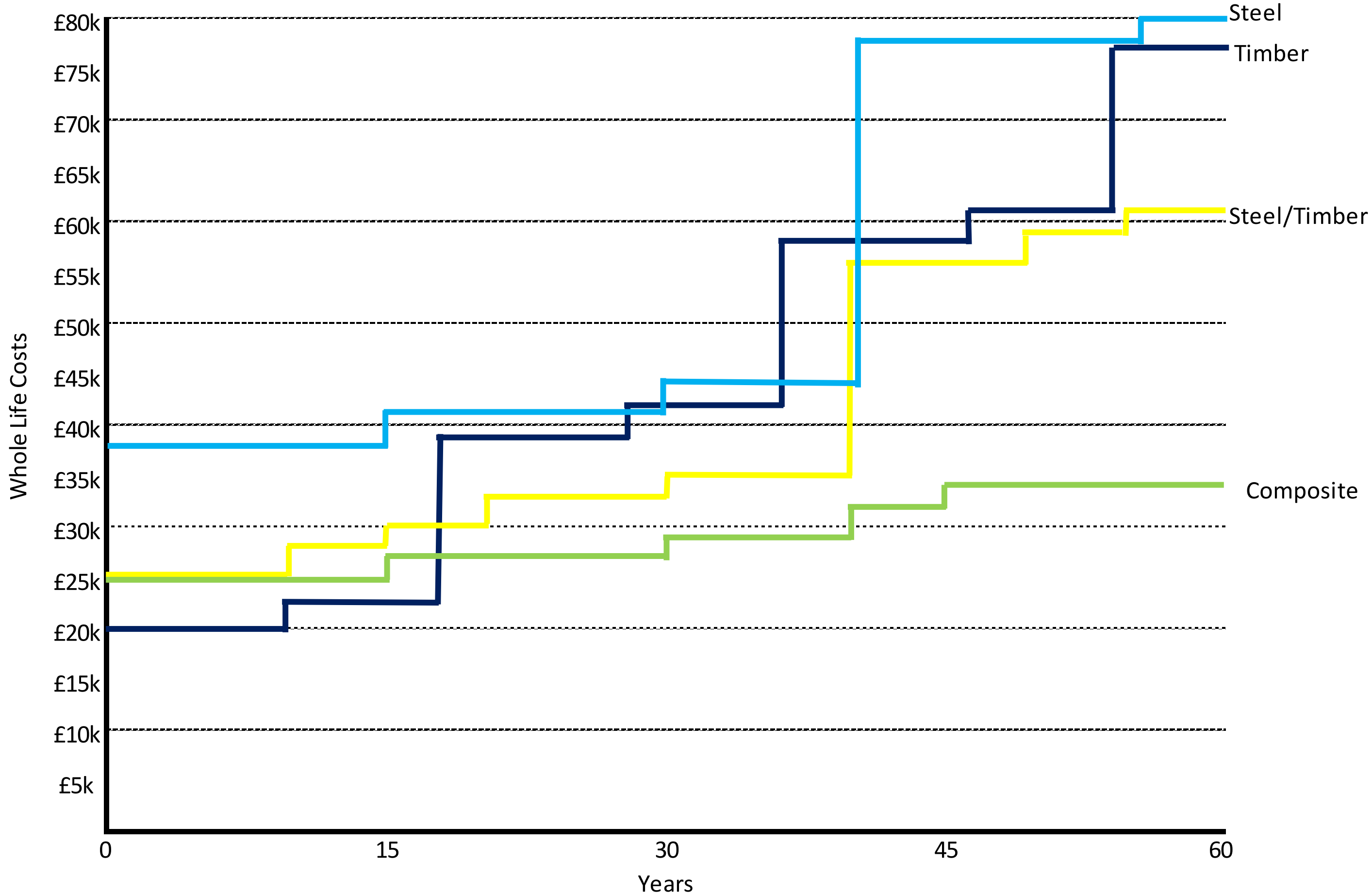
Footbridge Solution Cost Comparison

- Whole Life Cost Assessment



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Footbridge Solution Cost Comparison

- Timber Structures are lowest Capital Cost Option
- Maintenance Intervals are shortest for Timber Elements
- Replacement costs of steel elements are significant
- Lifespan Bridge Composite solution is Capital Cost Competitive against all but timber option
- Lifespan Bridge Composite Solution has a significantly lower whole life cost compared to all other solutions over a 60 year period

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Embodied Energy and Carbon Comparison
Toll Gate Bridge Eastbourne Cycleway

Footbridge Type	Material weights (Kg)	Embodied Energy Coefficients (MJ/Kg)	Embodied Energy (MJ)	Embodied Carbon Coefficients (CO2/Kg)	Embodied Carbon (Kg)
Steel section	15200	28.1	427,120	2.12	32,224
FRP Composite deck and steel handrails	Carbon 170 Glass 964 Resin 1013 Steel 1220	Carbon 235 Glass 23 Resin 71 Steel 28.1 Manufacturing 10.2	190,226	FRP 8.10 Steel 2.12	19,977

- 62% reduction in weight
- 38% reduction in carbon embodiment
- 55% reduction in energy embodiment

1. Toll Gate Bridge 15.2m Deck Length and 3.0m wide with 1.4m high parapet
2. This Embodied Energy data is derived from the a paper published in 2009 – "Life Cycle Energy Analysis for Fibre Reinforced Composites" , MIT Univ
3. The coefficients for steel are for steel section using 35.5% recycled. Source ICE Version 2.0

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National Highways -

amey consulting

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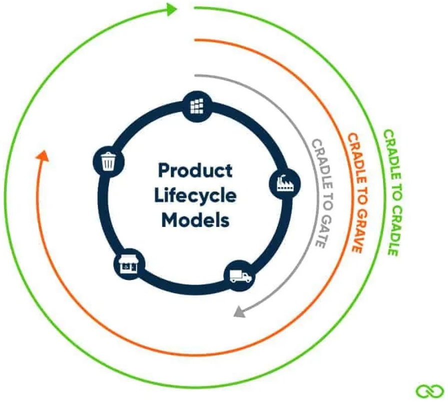
National Highways – A5036 Park Lane

amey consulting

- FRP Feasability
- Replacement of existing footbridge in Area 10
- Reduce whole life cycle carbon emissions of scheme

Recycling



- Early days due to technology
- FRP chopped up
    - Resin used to create energy in cement production
    - Fibres used in concrete
    - CF in car body production
- Traditional boat hulls
    - Metal inclusions make it difficult to retrieve fibres cost effectively
- Wind turbine blades
    - 25 year durability
    - New ‘dissolvable’ binder resins in development

Resources

- Technical Team
  - UK
  - Design
  - Budget proposal development
- Website
- Technical Open Days in 2022
  - NCC Q3
  - North Yorkshire Q3
- Technical Newsletter

Conclusion

- A Lifespan footbridge ‘bridges the gap’ for a client between choosing a low capital cost and low whole life cost options

Thank You

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