Timber and stone bridges: will ancient materials become the Future of Design?

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In the pre-industrial era, bridge builders were largely restricted to a choice for material between timber and stone. Timber was readily available but restricted in achievable spans, limited by the size of trees available, and prone to rotting. Masonry bridges – perhaps supported on timber piles – could span great distances and would not rot away, but only where the site could accommodate an arch. The industrial age saw steel and concrete displace the more traditional materials, but bridge designers today must engineer with the carbon cost of their choice in mind. Crucially –unlike cement and metals – neither timber nor stone rely on large inputs of energy (generally from fossil fuels) to convert the raw material into a useful bridge building product. Could these low carbon ancient materials become mainstream bridge construction technology again?

In Europe, led by firms including IB-Miebach, a new generation of timber bridges is developing which use glued laminated timber (glulam) beams and a stone or concrete deck to make attractive, durable, and low carbon structures. The second-generation timber bridge Eurocode (EN 1995-2:2026) will contain detailing rules for a 100-year design life; these rules originated in recent decades and have already been applied to many European foot and vehicle bridges. National Highway's recent low carbon footbridge competition saw timber entries well-represented in the shortlist – as well as use of stone for foundations or post-tensioned into primary structural elements. The characteristics of a modern timber beam-and-slab bridge can be summed up as:

- Main members formed of glulam, an engineered product which can be manufactured into large elements with consistent properties, and easily shaped into efficient and aesthetic forms.
- The main members being protected from moisture by a deck acting as a roof and with natural ventilation.
- Decking formed from stone or concrete slabs, acting compositely or non-compositely. Exposed granite slab decking results in an exceptionally high quality and low maintenance surface for pedestrian users.
- Capable of spans up to around 30m (vehicles) or significantly longer for pedestrian bridges.

Mott MacDonald recently completed an optioneering and outline design study for a family of four bridges – two foot and two vehicle – for a proposed water supply facility. Our design was guided by a client ambition for low carbon structures and an aspiration to create an enjoyable environment for leisure users. We collaborated with Stephen James Architects to maximise the aesthetic appeal and user experience of the bridge family. Usual bridge requirements for long service lives, minimal maintenance, and safe and affordable construction were also considerations.

Our options appraisal included conventional solutions like steel truss footbridges, and vehicle bridge solutions including steel composite and pretensioned concrete beams. After a detailed quantitative study, we concluded that glulam beams, with stone decking for footbridges and a composite concrete slab for vehicle bridges, would be the most effective way of achieving low carbon structures with a high-quality user experience and a distinctive unifying aesthetic. Unlike carbon steel, the durability of timber does not rely on paintwork or other protective coatings, even if exposed to chlorides.

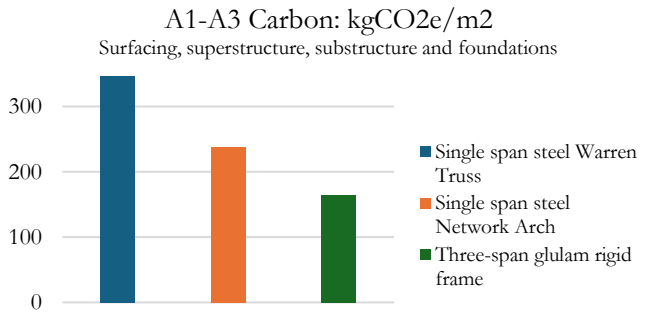

Figure 1: preliminary carbon assessment for footbridge A, A1-A3 kgCO2e/m²

Although our design work has yet to progress past outline definition, the adoption of this bridge typology in other parts of the world should give our client – and others – confidence that our proposals are not only viable, but an optimum solution. While timber and stone are not business as usual materials, nor are they revolutionary, and business as usual solutions will not be adequate to tackle the climate crisis.

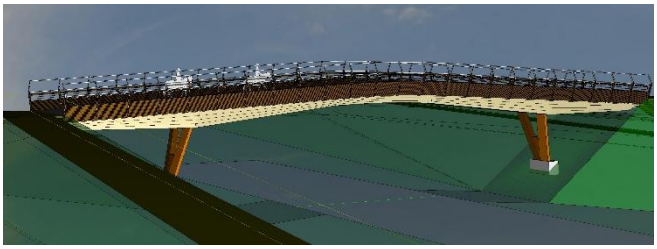

Figure 2: preliminary visualisation of footbridge A, Stephen James Architects

Timber is simultaneously a very familiar everyday material and a very unfamiliar bridge-building material, but the advantages of modern timber bridges – in sustainability, in aesthetics, and in low maintenance – should encourage all bridge designers to learn more and consider choosing timber and stone for future projects.