

Viewpoint



As London's proposed Garden Bridge is granted planning permission, **Simon Bourne** offers a topical perspective on the question of 'good value' in bridge design, arguing that engineers are best placed both to lead such landmark projects and to educate clients and the public in what constitutes good value.

Landmark bridges – *utilitas* versus *venustas*

There is often surprisingly little debate about how government agencies or local authorities spend their money on landmark bridges, which can lead to both excessively expensive schemes and ones upon which not enough money has been spent. Cost is certainly not the most important measure in this issue, but it is the area that can be most easily seen and appreciated by the vast majority of observers – it is a very

objective point. However, 'good value' is the obvious best measure. As well as cost, value considers the needs of the client, the quality, aesthetics and integrity of the design over the life of the bridge, the environmental impact and the needs of society – all quite subjective points.

Bridge costs

The overall cost of a bridge per m² of deck

area is relatively easy to extract for almost any scheme around the world. These overall costs/m² vary reasonably linearly with typical span, although they are very dependent on bridge types and local conditions. Very roughly, the total bridge cost in £/m² is currently about 1000 + 15L, where L is the typical span (in m). These figures apply to spans of up to 100–150m; above these spans, the cost becomes closer to 2000 + 7L. Taking account of inflation over the years, the costs of nearly all major bridges fall within a reasonable zone around these two defining lines, within a margin of about ±25% (Figure 1). Even the most stunning selection of bridges fall within these cost boundaries, including schemes like the Millau Viaduct or the Forth Replacement Crossing. It is therefore quite simple to identify the typical cost range within which a suitable solution should fall. Any scheme that clearly falls outside this range should be seriously questioned – is it too utilitarian or too sculptural for a major piece of infrastructure?

The proposal for the rather controversial River Wear Crossing at Sunderland in 2013 had an equivalent span of about 300m, although in reality it needed spans of no more than about 50m, or perhaps an elegant 100m cable-stayed span. According to Fig 1, it should therefore have cost about £4000/

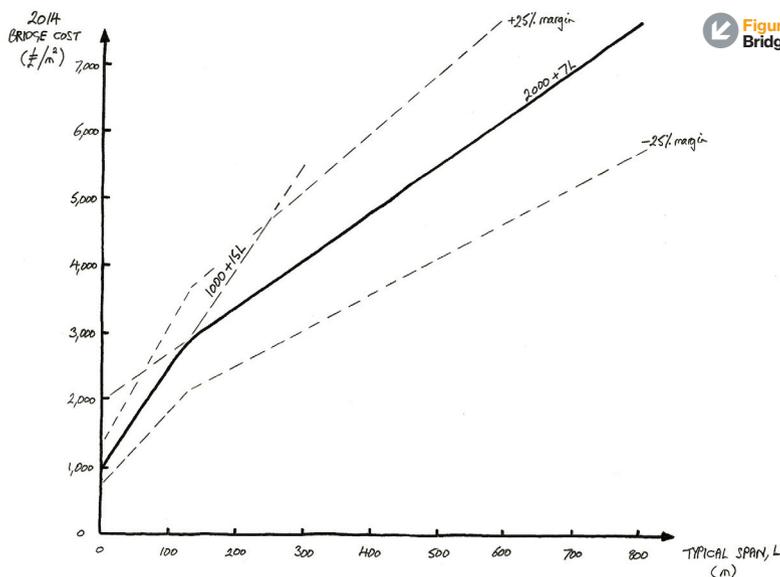


Figure 1
Bridge costs vs span



Figure 2
Brunel's wonderful
Saltash Bridge

Figure 3
Maillart's stunning
Salginatobel Bridge



m² for the spans shown – although an equally stunning design with 100m spans, say, could have cost around £2500/m². However, the proposed scheme had an expected bridge cost of nearly £7000/m² and the returned tender figures (which were deemed by the client to be unaffordable) must therefore have been even higher. I would suggest that a premium of this size is wholly unacceptable, at any site. One would only find costs of this magnitude among the largest and most complex bridges in the world. Any publicly-funded scheme that clearly struggles to progress or has a budget that escalates to such an extent should certainly be held open to considerable public scrutiny.

Equally, the current proposals for the Garden Bridge across the Thames in London show a scheme with a 165m main span,

which should therefore also have a cost of £2500–4000/m². However, the exhibited cost is a staggering £25 000/m², probably making it the most expensive footbridge in the world. In these circumstances, it should almost certainly be viewed as a piece of artwork, rather than a piece of infrastructure. Nevertheless, the use of public funds, if there were any to be used, should be examined very carefully to ensure that 'good value' is still being created. The assessment of 'good value' in London is somewhat different to that in Sunderland though, as London can attract many thousands of tourists to such pieces of artwork.

Quality of bridge design

A bridge designer has twin obligations – to use their client's money wisely and to produce a structure for society that will

enhance the built environment'. These two elements are the classic balance between function and form. It was Vitruvius *circa* 50BC who noted in his *De Architectura* the three principles of *firmitas*, *utilitas* and *venustas*. *Firmitas* is the attribute of durability and robustness – a given for any structure. *Utilitas* is the utility, or function of the structure, i.e. the wise use of your client's money. *Venustas* is the beauty, or form – the elegant structure that delights society.

Every bridge or piece of infrastructure should be a fine piece of engineering of the highest quality. But that notion does not necessarily have an additional cost attached to it, and every bridge cannot have a premium anyway. However, there will be a selected number of major or landmark bridges that do deserve a premium. Society has to decide what premium is acceptable

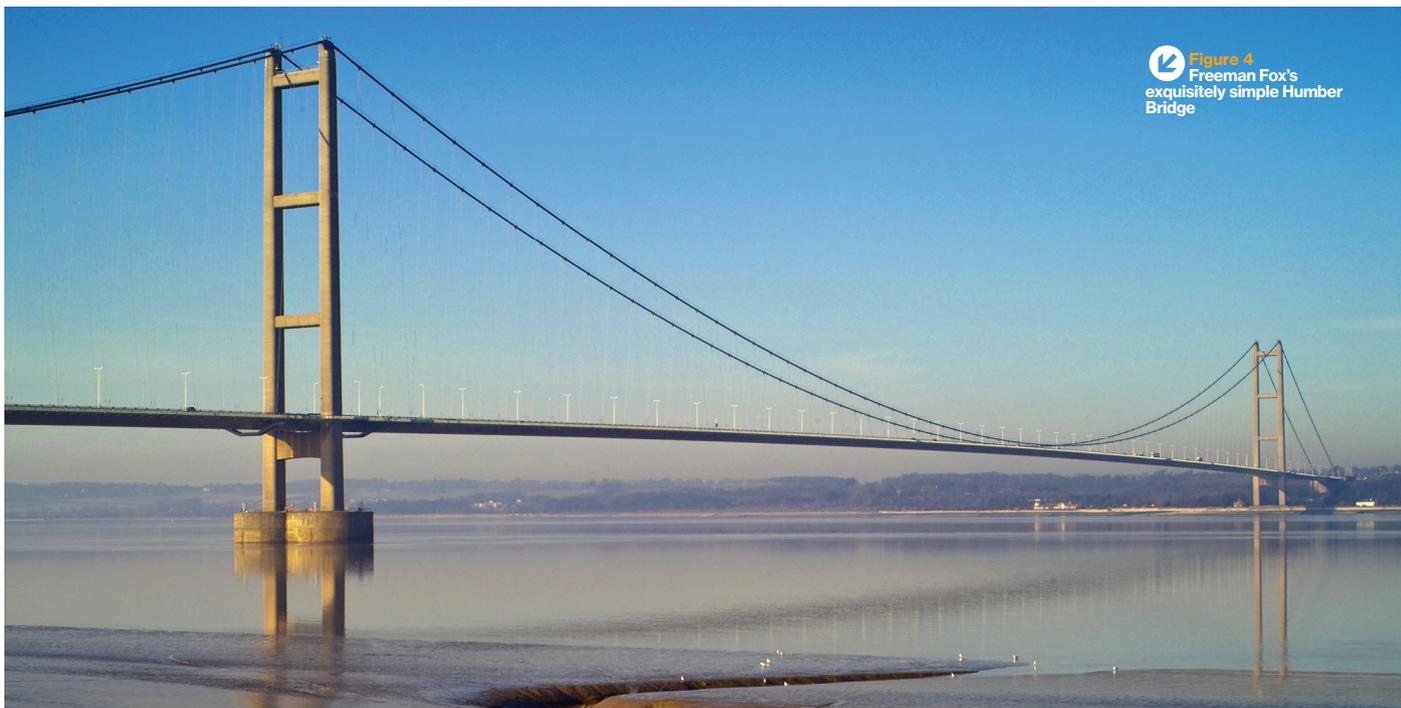


Figure 4
Freeman Fox's
exquisitely simple Humber
Bridge

and where or when it is applied, although engineers and architects, as representatives of society, should formulate those figures. As one can get well-designed bridges at little or no premium, these should be the norm. At certain key sites (major estuaries, major cities, bridges of national interest, or certain bridges with considerable traffic) or at certain key times (e.g. for the Olympic Games), one could suggest premiums of 10–25%, say. Most major bridges are dominated by their engineering and environmental challenges, and it is nearly always the resolution of these issues that defines the beauty and success of the bridge. The huge majority of the world's most fabulous bridges had no premium applied to them and indeed had no architectural input – consider my favourites such as Brunel's Saltash Bridge (Royal Albert Bridge) across the River Tamar, or Maillart's Salginatobel Bridge in Switzerland or Freeman Fox's Humber Bridge (Figures 2–4). Aesthetics are a central feature of any design development but solutions such as these, which are designed to suit the flow of forces in the bridge, will tend to have a natural elegance. More recently, architects have indeed become involved in bridges, which can be a very welcome addition as long as the architect is skilled in bridge design and respects the considerable forces at work within the bridge. Architects also bring a wider appreciation of social and environmental issues, which can be fundamentally important too.

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So, I can see the need for every bridge to be well engineered and carefully designed, with architectural input as the engineer needs it, and the need for a certain number of landmark bridges to have a premium attached to them, but I cannot see the need for a premium of two or more to be applied, at any major site. It might be possible to play some architectural or sculptural games, or some structural gymnastics, with a £2–10M footbridge, where a significant premium might thus be applied, but it is certainly never acceptable to do the same for a £10–500M piece of infrastructure. A footbridge is often more akin to a building, with a shorter lifespan and fewer concerns over its long-term integrity, and is often privately funded. A major bridge though has to last well over 100 years, be virtually maintenance-free for the same period and justify its existence using public funds.

Clients also often quote the economic advantages of a landmark bridge. However, the vast majority of the economic benefit of such schemes lies in the building of a

road and a bridge, any bridge in fact. The rather nebulous benefits regarding the further advantages of a landmark scheme are desperately difficult to define and hard to validate, and it is equally hard to find any supporting evidence of such benefits. One has to question the desire of the client to seek a landmark scheme so strongly. Any publicly-funded client should be seeking to procure a high-quality scheme that fulfils its purpose – the premium to be spent on anything further, such as a landmark solution, should be proportionate to the needs of the area or the value/benefit of the scheme.

Quality of bridge designers

Bridge designers have to use their client's money wisely as well as leaving an elegant legacy for society. I welcome the involvement of skilful architects in this process and, indeed, the majority of my major bridge designs (many of which have won awards for their elegance, economy and innovation) were developed with specialist bridge architects – architects who understand the engineering and construction principles, and who work with the engineer to develop forms and details that improve the scheme for everyone² (Figures 5a and 5b).

In the last 20 years, architects with good bridge expertise have joined the engineering teams that design both major and minor bridges, mainly because engineers often do not have this level of aesthetic training or knowledge of the social impacts. This liaison

with skilled architects is certainly to be encouraged as it will raise the overall quality of the scheme, generally at little or no cost. My favourite bridge of the last 20 years, Virlogeux's Normandy Bridge, rightly had good architectural input too, and the current crop of major bridges (such as the Millau Viaduct in France, the Stonecutters Bridge in Hong Kong or the Forth Replacement Crossing) have also had architects involved as part of the design team, although clearly the engineering still dominates with all these schemes.

The key is for the architect to be experienced in bridge design and for their role to be proportionate. On a building, the structural content might only account for 20% of the total cost, and as such the architect leads the design and the engineer supports as part of the team. However, for a bridge, where the structural content might account for 90% of the total cost, the engineer must lead and the architect should provide support. On all of the major bridges where experienced bridge architects have been involved, they have worked with the engineering to develop overall forms and particular details that work well. On a few occasions though (often with footbridges and rarely with major infrastructure), architects, artists or designers have ignored the engineering and developed their own forms, which is a dangerous precedent that generally leads to a considerable lack of structural integrity within the chosen scheme. This sort of solution is defined by its high costs and can rarely be viewed as 'good value' for the client or society. One has to query the reasoning behind some clients appointing teams that seem to have had little major bridge experience. A client commissioning a new hospital or airport would clearly seek an architect, and an

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engineer, with substantial experience in the design of such buildings. A well-informed client for a major new bridge should only seek an engineer (and an architect if needed) who also has substantial experience of major bridges. Michel Virlogeux noted recently that the demise of a central client authority in France will lessen the likelihood of further spectacular bridges in that country³. Although I do not entirely support that view (on the basis that design-and-construct schemes can indeed deliver excellence in all areas – elegance, economy and innovation), it is a good point that the procurement of major schemes can often be best managed when that client is a national body, with extensive experience and knowledge, the ability to best judge when and where a premium should be applied, and who has control over, and a vision for, the design direction. This would avoid the one-off procurement by a less experienced client, who might be blinkered by their own desires to create an unnecessary and expensive landmark.

Conclusions

Our industry should lead the way in taking the debate about the value of landmark bridges to a wider audience. Engineers and architects are best placed to assess all the key criteria for this discussion. However, we cannot always control the purse strings and therefore we need to

explain the elements of 'good value' to both our clients and to society in general. We should help them to define what premiums might be acceptable for certain landmark bridges. The architect's role in bridge design is also definitely to be encouraged, but that role must be proportionate to the dominance of the engineering forces at work, and that architect must have valid major bridge experience. All infrastructure and bridges must be well designed and of high quality, with a number of key national projects being worthy of suitable premiums. A central national authority to manage the procurement and design direction of these landmark projects would make good sense – in the UK, the Department for Transport would seem the obvious candidate for this role given that it is often the prime source of public funding in this area.

Author biography

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Simon is a bridge consultant and former owner of Benaim.

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