

## ARCH OF ART A LA CARTE OR BENDING OVER BACKWARDS

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### SUMMARY

Taking the author's projects involving arch bridge type as examples, the paper sets out to argue that in some cases joy and exuberance can be brought to arch bridge design in a practical and rational way, without structural frivolity. The paper also argues that the new proposed Nine Elms bridge in London should be an arch and presents the rationale behind the author's proposal for this crossing, and criticism of the winning cable stayed design against socio-political reality and in the context of its location.

**Keywords:** *Structure, arch, art, joy, exuberance, design, adequacy, purpose, efficiency, competitions, perceptions, socio-political context.*

### 1. INTRODUCTION

Besides a simply supported beam, an arch is arguably the second most archetypal bridge form, and one that is instinctively 'understood' by humans as 'natural'. Ironically, while it is logical, utilitarian even, most people probably do not really understand how it works. In the writings of Leonardo da Vinci ( born in 1452 ) we find this sentence : "an arch is nothing else than a strength caused by two weaknesses". Opposing action of two sides of an arch is what makes it work as a structure. In 1660 Robert Hooke discovered the law of elasticity, which states that stretching of solids is proportional to the forces applied to them. Hooke uncovered the secret of the arch. All this is likely to be difficult to understand for an uninitiated person.

It seems that being so utilitarian the arch suffered from being relegated to the 'practical/uninspired' drawer. Indeed most of arch form bridges being built these days are basic, many devoid of grace. At best, or worse, they are 'graced' by colour, frequently garish. However, an arch bridge does not have to be just utilitarian. With little effort, and drawing from its context, an arch form can be exuberant and full of surprise and joy, and enrich its urban context.

### 2. DUBAI, ARABIAN CANAL, INLAND DEVELOPMENT PHASE 1 – LOCK ISLAND BRIDGES

#### 2.1. Background

A Dubai development company Limitless LLC invited Studio Bednarski to join a pool of world-wide architects selected to design bridges crossing a new 75km long Arabian Canal planned for Dubai. The client brief asked us among others, "to address the

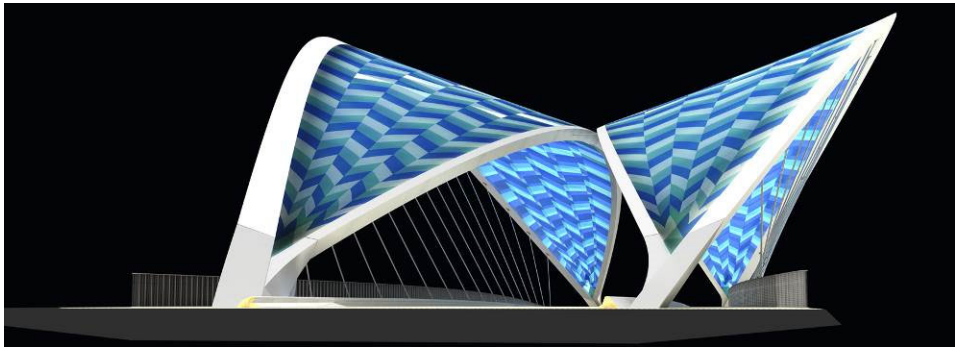
*symbolic quality of the design and respond to the Canal and urban environment, (...) the bridge is to be modern, safe, economical and beautiful*". Our concept design for two bridges for Phase 1 was developed with Prof Jiri Strasky, Halcrow, DPA Lighting and the Islamic artist Dr Ahmend Moustafa. Soon after we delivered our concept Dubai got into economic difficulties and the project did not progress.

### 2.2. The thought

It is difficult to refer to Dubai as a 'city', by which we normally mean not just a depository of a large number of buildings and functions but also, and critically, a network of public spaces with rich mix of uses at ground level, which are best navigated on foot, cycle or indeed using public transport. We were pleased that the agenda set for the Dubai extension took into account the then severe shortcomings of Dubai. The client stated among others : *"Limitless is focused on creating balanced urban environments where people can live, work and play."* *"The development is committed to the principles of new urbanism formulating a life style that is pedestrian"*. *"The Locks and the Sluice Gates will be one of the main attractions along the Arabian Canal and the Lock Island itself will be a high value residential development area"*

### 2.3. The concept

Our ideas for the twin bridges were the result of search for local contextual and cultural inspirations. In case of this design we tried to respond to the broader aspirations of the client and to the climate of Dubai offering a shaded retreat from the hot sun. and indeed also from rain ( for example the 2016 Dubai Duty Free Tennis Championship matches were postponed after a downpour ), hail and even occasional snow.

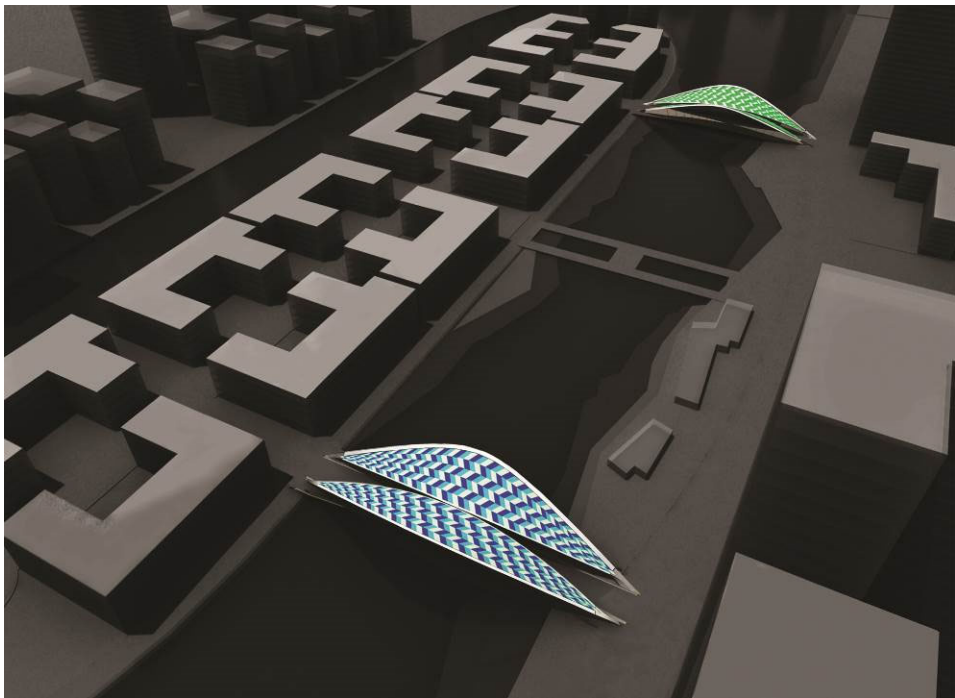


*Fig. 1. General view.*

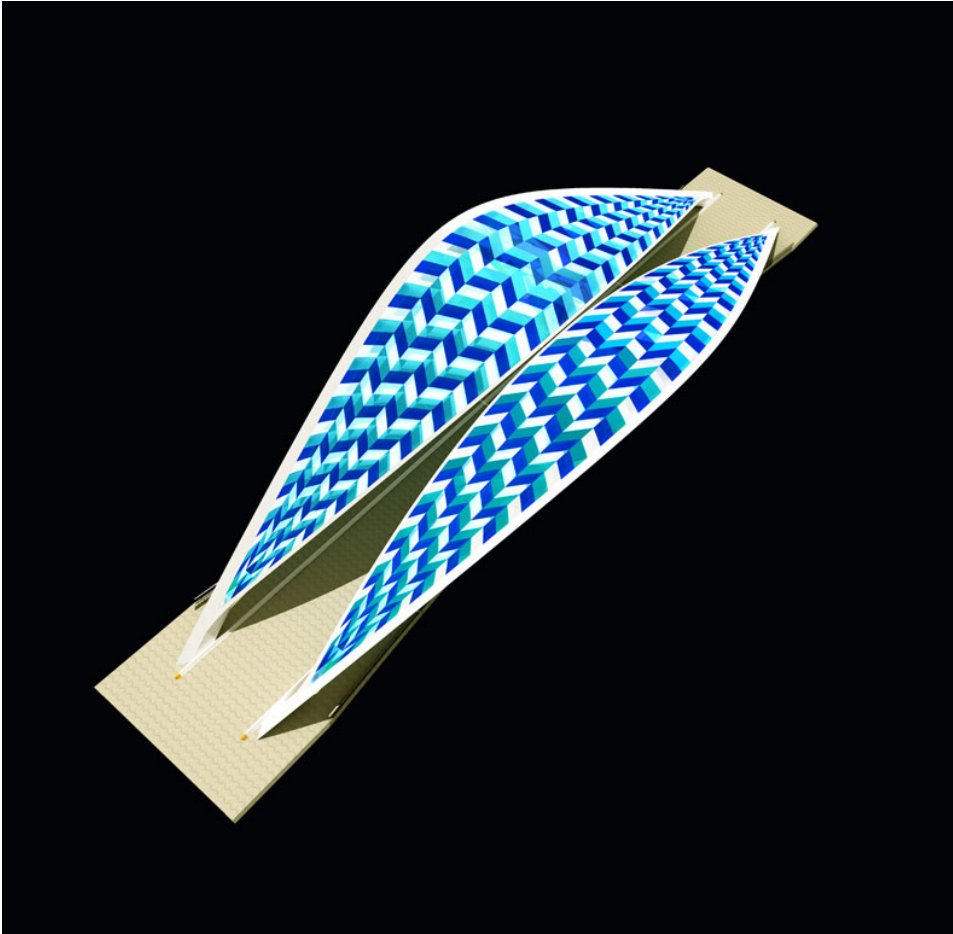
We have analysed a number of options in the end choosing what we believed was the most logical solution in the circumstances, and which in our opinion was:

1. beautiful as an object of urban art
2. timeless in its form ( in contrast to 'structural gymnastics' aimed exclusively at strangeness that have plagued smaller bridge design in recent years )
3. unique at daytime and at night

4. responsive to the climate of Dubai offering a shaded retreat from the hot sun, and shelter from rain
5. responsive to the intense high-rise urban environment around it and through its form 'stand up' to it visually
6. based on a well-known, proven and economic structural principle, that of a tied arch
7. eminently suitable for urban context where land value was high ( it took up minimal land space at the abutments with no, for example, cables or back stays to anchor )
8. spanning the whole width of the canal with no intermediate supports in the water that would obstruct the water flow
9. enhanced with a '5<sup>th</sup> elevation' to be viewed top-down from tall buildings nearby
10. economic to build and easy to maintain ( for example it had no major bearings to maintain )



*Fig. 2. Bird's eye views of the proposed bridges.*



*Fig. 3. Bird's eye views of the proposed bridges.*

#### **2.4. Bridge as art**

We saw the two bridges as an opportunity to create a major twinned piece of functional public art in Dubai. The bridge design consciously avoided imagery and detailing normally associated with bridges. Its sculptural form was of equal importance to its function as a bridge. Although it was essentially an abstract contemporary form, a careful observer could see references to the fronds of a palm, of gently rolling sea waves, of the dhow's sail, undulation of the ray's wings, the playful jumps of dolphins or gliding of a sea bird. The bridges were a light, almost ephemeral, poetic insertion, and an insertion that unequivocally belonged to our times.

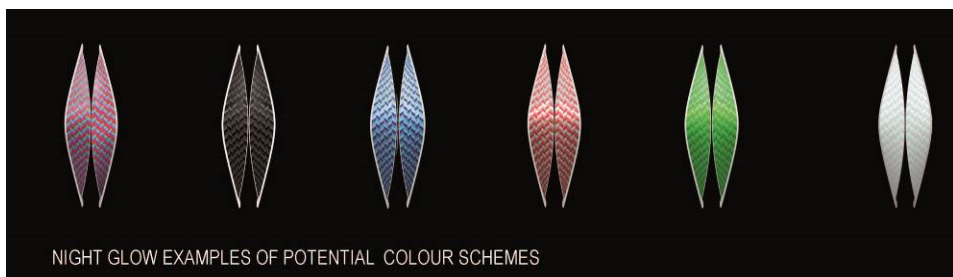
The rainbow-like iridescence of a butterfly, or a dragonfly wing was the inspiration for these urban glass sculptures. By day sunlight would filter through their coloured glass as through stained glass windows. By night they would glow with a myriad of changing colours. The glass arches would be lit from within with colour changing light utilising computerised lighting technology to vary the appearance with ambient conditions and to

emphasize the movement along it. Visible from near and far, from water, cars and the sky, with changing colour and transparency, the multi-coloured 'glass leaves' bent over the Arabian Canal would also provide a degree of weather protection for the weary pedestrian. Our mission was not only to create a twinned landmark, but also living bridges with a purpose to improve the quality of life in a place designed for people. Colourful glass wings supported on steel arches shelter the suspended footway, cycleway and driveway. It is a new idiom of a covered urban bridge, an object of art endowed with functional purposefulness. Playful, defiant and art-in-your-face they tried to move bridge design onto new grounds, ephemeral yet of significant materiality sophisticated presence in the Dubai townscape. The colour changing glass arch would catch the eye from many perspectives in the city while providing a crucial link to the Lock Island for its residents and visitors. This was a site-specific urban bridge but also a look-out point onto the canal and the lock. It defended its presence amongst many high- and low-rise buildings, which a less 'volumetric' bridge, say a structure based on cables and masts, would not achieve.

## 2.5. Amazing glazing

The pattern of glazing to the canopies was loosely inspired by Arabic script and ornaments as well as the omnipresent textile artefact of the Arab culture - the kuffiveh, also known by other names. It is worn by men as protection against sun, wind and dust, and is typically a checked scarf. While originally an item of protective clothing, it evolved into a deeper meaning - black and white kuffivehs are associated with Palestine and used as a symbol of solidarity with Palestinians in the context of the Israel-Palestine conflict. The word itself simply means "from the city of Kufa," an Iraqi town on the Euphrates River.

The bridges' presence is assertive and masculine but with a gentle side to it, like a 21<sup>st</sup> Century continuation of the work of René Jules Lalique or stained glass artists. Glass art was the key means of expression. Glass panels based on triangular module facilitated economic use of flat glass on surfaces that are not developable. The glass panels were fixed onto cable truss grids, fully protected from the elements, and held in place by means of stainless steel clamps. Considering that several thousands of these would be needed, it would be possible to custom design a unique clamp especially for this project, maybe encoding it with an appropriate shape, form or text. Casting such a large number of clamps would be the most economical way of producing them. Thus, as is the case, for example, with cast iron manhole covers, there would be no extra cost were the clamps to be designed as objects of art in their own right and, carried a Dubai crest.

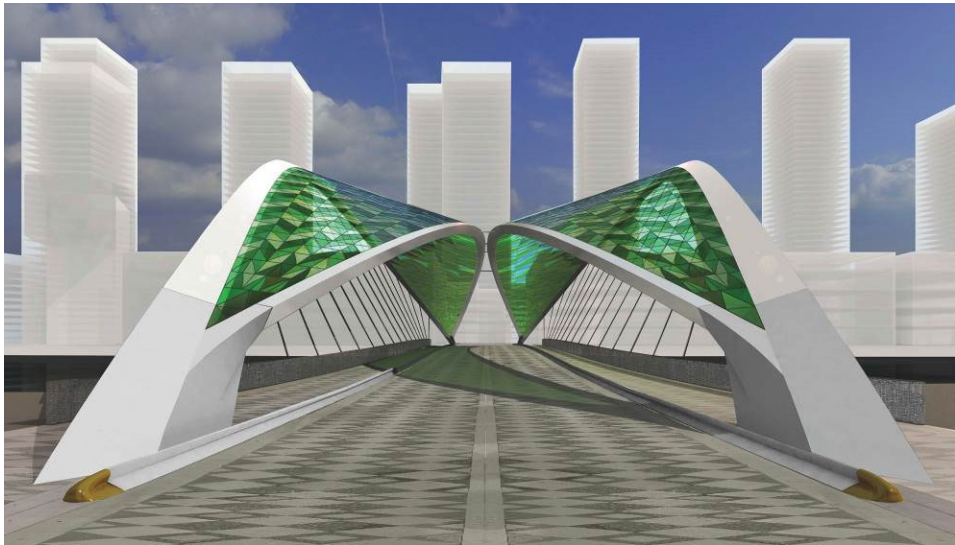


*Fig. 4. Examples of potential glass colouring.*





*Fig. 5. Street level view.*

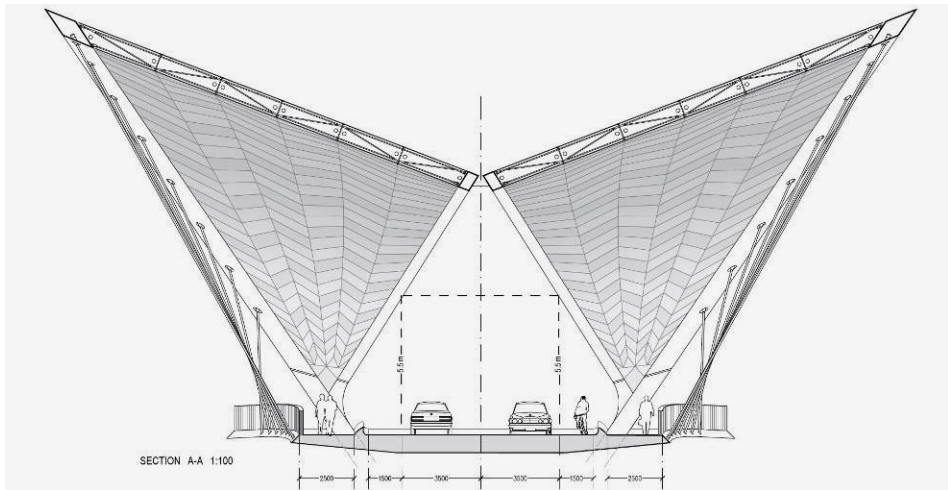


*Fig. 6. Street level view.*

## **2.6. Bridge structure and materials**

The basic structural diagram is that of a tied arch. The structure of each of the bridges consists of a pair of paraboloid arches supporting hangers from which the deck is suspended. The main outward inclined arches spring from points set back from the Canal. Secondary circular arches provide counterbalance for the main arches and support to the inner edges of the double skinned glass canopies. The composite deck serves as a tie -

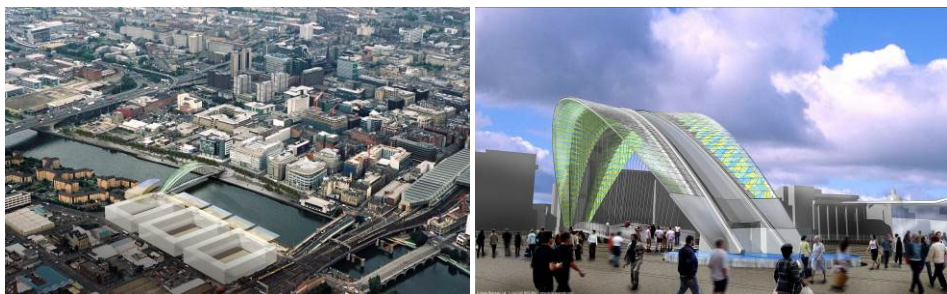
horizontal forces from the arches are resisted by the post-tensioned deck. The deck is designed to have stiffness and mass sufficient to eliminate problems related to vibrations from wind effects, from traffic, and dynamic pedestrian loads.



*Fig. 7. Cross section at bridge centre.*

### 3. GLASGOW

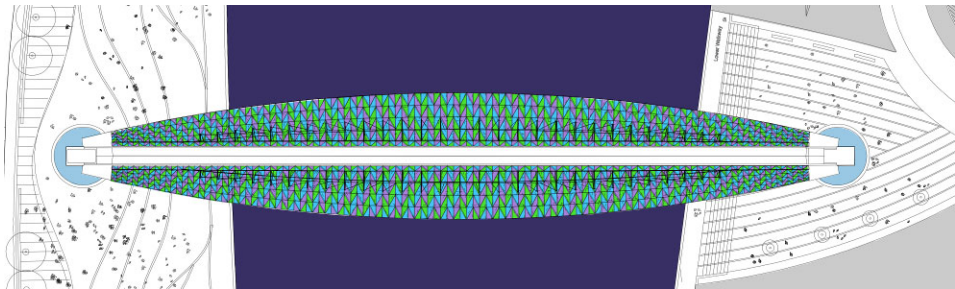
In 2003 the Glasgow city council held an invited competition for a new bridge linking two neighbourhoods, those of Tradeston and Broomielaw. We were among six teams, which were invited to propose ideas for a bridge and urban environment on the banks of the Clyde. On the shortlist of this £40 million limited competition were also Richard Rogers, Norman Foster, Future Systems, Lifschutz Davidson and a Scottish team. The first prize and the job were awarded to Richard Rogers's team who proposed a long deck arched in plan carried by a cable suspended system. RR gained planning permission for their bridge design in December 2004 but owing to spiralling costs the design was abandoned in the spring of 2006.



*Fig. 8. Bird's eye view (left) and street level view of the bridge (right).*

### 3.1. Bridge as art

Despite being on the same latitude as Moscow and northern parts of Canada, Glasgow has a significantly more moderate climate, however as any Glaswegian will tell you, Glasgow is wet throughout the entire year. Like in Dubai also here we were guided by the prevailing weather conditions, in addition to our ambition to create a colourful optimistic and symbolic brooch spanning the two contrasting neighbourhoods over the river Clyde. Our entry was developed with Faber Maunsell and involved a single arch solution. While based on the time-honoured arch principle this structure was not an engineering statement. In contrast to the winning design our idea was to create the shortest possible route across the river and one that, to at least some degree, and depending on the wind direction, was protected from the elements. Like in Dubai also here rainbow-like iridescence of a dragonfly's wings was an inspiration. With changing colour and transparency, the multi-coloured glass leaf bent over the Clyde would have provided some weather protection. Taking into account times of severe weather conditions we proposed also a funicular cabin that travelled on top of the arch. It would have offered safe passage in bad weather and views of Glasgow and of the glass pattern on the bridge while being also a tourist attraction and a source of revenue. It was thus a living bridge, a landmark for Glasgow and a means of animating the Clyde. Its deck, like an elongated piazza, 10 meters wide in the middle, provided ample space to mingle and to interact, space for a market with removable stalls and for installation art.



*Fig.10. Bridge plan with glass canopy.*

### 3.2. The structure

The loadbearing structure here was a large single steel arch. Outrigger brackets on both sides of the arch carried hanger cables as well as glass panelling. The steel deck was lozenge shaped.

## 4. NINE ELMS BRIDGE, LONDON

A new pedestrian / cycle bridge is being promoted by the Nine Elms Vauxhall Partnership, whose members include Transport for London (TfL), the Greater London Authority (GLA) and the Leaders of Wandsworth and Lambeth Councils. It is to improve the connectivity of the Vauxhall Nine Elms Battersea area, where a significant amount of major infrastructure and building works are underway and planned. In 2014 a two stage competition was held involving a major new cycle and pedestrian bridge for London linking Pimlico with Nine Elms, an area of intense development south of the river, which includes also a new 'fortress', also known as the new US Embassy. 87



teams were admitted to participate in the first stage, and Studio Bednarski were invited to participate with a team of which the other key members were Arup as bridge engineers, IPV Delft as bicycle movement experts and the urban artist Peter Fink.

#### 4.1. Socio-political context

The competition was organised against the background of strong resistance to a bridge in this location, mainly from the Pimlico side of the river. As reported by a variety of London media *“Fewer than two per cent of the residents of Pimlico are in favour of the much-opposed Nine Elms Bridge, which could turn the quiet area into a cycling track for more than 60,000 riders every week.”* Peter York, chairman of the anti-bridge campaign, said that the crossing *“has nothing to do with Londoners, but clearly is a development for foreign investors and global elites, who are using Nine Elms as investments”*. And Westminster Council Cabinet Member for Sustainability and Parking stated: *“Westminster City Council does not support the proposal and our officers have, and continue to express strongly the Council’s opposition to the proposed bridge, on the grounds of its visual and environmental impact including the impact that a new bridge would have at a landing site in Westminster; on traffic flows, pedestrian movement and on residential amenity.”* It is thus clear that in addition to technical parameters there were also issues of perception that had to be addressed by the design teams.

#### 4.2. The concept

Having gone in great depth into the contextual issues and perceptions it was clear to us that while we could not address the perception of the impact of the feared sixty thousand rides spoiling the peace of Pimlico, we could address worries such as visual impact and not intruding upon the Pimlico river park and its relationship to the Thames.

The competition organisers stated among others: *“This competition is calling for architects from across the globe to come forward with exceptional, inspiring designs for a new bridge at the centre of the world’s greatest city. The successful entry will have to win the hearts of Londoners who are tremendously proud of their river and its rich architectural heritage”*. While it should be noted that the competition was billed as being about selecting a team rather than an actual design or location, both of which could potentially still change, in my view the organisers chose a bridge, which will not win the hearts of Londoners, and it definitely did not win my support on design grounds.

Addressing the site specifics our design – a single tied arch entirely founded on solid ground on both sides of the Thames, scored on four counts with one design decision:

1. A large arch (274m, 41m above the ground level) formed a highly visible landmark, and there is not a single arch-above-deck arch bridge in London. Despite its large scale it came right down to the ground level and so didn’t have adverse impact on the adjacent urban context and did not obstruct the views of the Thames from the Pimlico river park with extensive ramps etc. The winning design with its ramps above the Thames will create visual obstruction to views from the river banks.
2. Its clear span dramatically simplified and speeded up the construction process reducing the need for river traffic restrictions during construction
3. It did not pose any restrictions or danger to navigation where safe manoeuvring of large barges for Cringle Dock Waste Transfer Station was of concern to the Port of London Authority. The winning design has a significant

impact on clear navigation widths on the river as all water areas below the ramps will have to be fenced off to prevent water based collisions.

4. It avoided a significant cost, and environmental impact, of river piers in this area (and the split deck reduced shading to river bed). The winning design has its structure set in the water.



*Fig. 11. High level view of the bridge.*

### 4.3. Specific functional and design issues

#### 4.3.1. Ramps versus Autowalks

Having considered the available land and the urban context we concluded that ramps were not the answer at this location but also that as cyclists we would be very frustrated if forced to wait for a lift to cross the bridge. We thus drew from the Dutch cycling innovation and proposed three separate Autowalks for cyclists. These are used in Holland even in large underground cycling hubs. The movement direction of the Autowalks and number of them that are made available to cyclists and to pedestrians, can be programmed to suit the intensity of use at any given time. Entry onto the bridge is weather protected by light-weight glass canopies covering the Autowalks, shallow steps for pedestrians and access to the top-of-the-arch-walk. The winning design relies on spiral ramps which may lead to collisions, particularly on the downward trip at time of heavy cycle use.

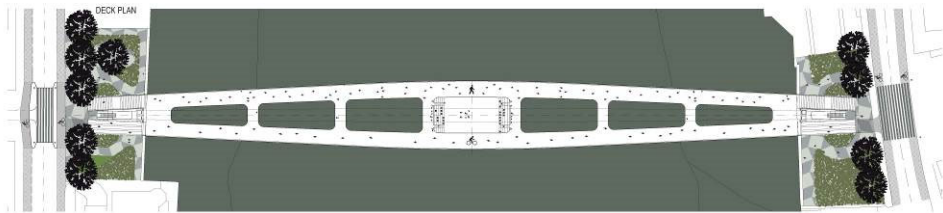
#### 4.3.2. Disabled access

Disabled access onto the bridge is by way of two through-lifts with the lower landing partially weather protected by the deck and the arch above. The winning design uses the

long ramps for all access onto the deck of the bridge which in my view is unacceptable and poses a risk to all bridge users at times of intense cycle traffic.

#### 4.3.3. Public domain

For structural reasons of lateral stability the bridge deck is relatively wide at mid-span. This facilitates a sunken piazza, a new public space suspended above the river. At both abutments formal public spaces come with bushes and trees and decorative paving pattern.



*Fig. 12. Deck plan with public piazza at mid-span.*

#### 4.3.4. Cyclists / pedestrians

While cyclists and pedestrians use separate decks, the use of the bridge can be as flexible as needed, with both user types at times using the whole deck surface.

#### 4.3.5. Additional attractions

It is more difficult to book a walk atop the Sydney Harbour Bridge than to get tickets to the Sydney Opera. A walk over the O2 in London is popular. We suggested a top-of-the-arch-walk on our bridge, with controlled access. The views would have been spectacular.

#### 4.3.6. Trees

There was no need for any tree cutting at the north and only limited tree removal and replacement on the south.

### 4.4. Conclusion

While our arch was maybe a bit on the heavy side and needed more work, it would be relatively easy to argue that an arched system was by far more appropriate for this bridge taking into account opposition to the bridge and the technical parameters that needed to be addressed. This is not to say that the selected design did not have its visual merits.

## 5. CLOSING REMARKS

Among all bridge systems it is the arch that is not only the most evocative but it also offers most scope for pushing boundaries of artistic expression and bringing in secondary functions and uses.

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