

Bridge of the Month No14 Feb 2012 Approach viaduct at St Pancras Station

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Railway Viaduct, St Pancras (<http://g.co/maps/8h74h>). Large parts of this structure were demolished during the construction of the Channel Tunnel Rail Link or HS1 as it is now known.



This is by way of being a holiday effort. I am in New Zealand till 12th March for my daughter's 40th birthday and my 65th. And no I am not thinking of retiring any day soon.

It isn't often you get to see a bridge sectioned in this direction. I spotted this one a few years ago when St Pancras was being upgraded for the CTRL. The section shows a lot of the detail of construction of bridges in the high railway era. I don't have any dimensions but it looks like about 30ft spa. and is certainly 4:1 span to rise. A brick count says about 125bricks round the ring which would be close to 28ftx7ftx17.5ft radius, giving an arc of 32.45ft or 129.8 bricks. Brick dimensions varied somewhat in those days anyway so this calculation cannot be exact.



Here I have fitted a 4:1 circular curve. Perhaps it would be useful to present the calculation.

When two chords intersect in a circle, the products of the divided parts of the chord are the same. The span of the bridge represents one chord and is cut in half by a vertical line through the centre. So the product mentioned above is the square of half the span. One part of the other chord is the rise and the other full chord is the diameter so:

$$(\text{span}/2)^2/\text{rise}+\text{rise}=\text{diameter}$$

19th century railway engineers were pretty good at picking dimensions that went together comfortably. So, in this case we can expect span rise and radius all to be “good” numbers. Good means whole feet, quarters or thirds. Having 12 inches in a foot means that $1/4=3''$ and $1/3=4''$. Nice easy round numbers.

When surveying an arch bridge, it always pays to convert the dimensions to feet and see whether they fit. All too often, when people send me bridge details to consider, the dimensions given do not make sense. I even have on case on record of an 11 span railway viaduct where the spans varied from 39ft to 41ft6in. That just would not happen. The survey can only be described as incompetent.



This enlarged view is a bit pixilated because this is an early digital photo. It does, though, show the arch construction clearly. The five rings are bonded in two pairs and a single. Fully bonding the ring right through is not viable. In this case, the mortar beds would vary by more than 10% over the ring thickness which would create a tendency for the arch to deflect by creep. The alternative approaches used over the years were the other extreme of completely independent rings and the intermediate scheme of a course of headers every time the consecutive layers lined up. Over time, it became clear that the latter scheme did not work. The headers were stiffer than the mortar and attracted all the load from shear creep between the rings. That caused them to snap and transfer the load back to the mortar. So why bother with the more complex arrangement.

Over the years there has been a lot of concern expressed about ring separation. Most of this is based on the known fact that at ultimate load, arch rings fail by ring separation. However, this does not occur until long after the arch has cracked transversely. Indeed, I know of many bridges which have been forced to articulate and have generated transverse cracks without any apparent detriment to load carrying capacity.

The greater flexibility of the mortar layer contributes considerably to this behaviour. Notionally, there should be a big concentration of stress in the beds adjacent to the crack. In practice, the stress transfers gradually over a considerable length and stress levels are very low. A typical 9m span bridge might have a working thrust of 450kN/m width but if that thrust transfers between layers over even 1m the shear stress is only 0.45MPa. More typically, the transfer would take place over 2 or 3m.



Looking at the left hand half of the arch we see a section through the hollow spandrels. I have always thought of these as having been built to stiffen the arch without adding too much weight, but a look at the picture below suggests an alternative. In railway construction it is important that the track bed stiffness doesn't vary sharply as it would if the arch were filled only with soil. The crown of the arch would be stiff while the deep fill over the piers would allow settlement creating a wave in the track. Here, the construction has been brought up to a stiff level platform.

The picture below also shows the layer of (somewhat dry) puddle clay below the ballast.





This final segment of the picture shows where the pier was pierced with a cross vault. Looking at the construction here the vault almost certainly didn't rise as far as the main arch but it did divide the arch considerably and induce a substantial additional stress in the pier.

News

Archie-M The latest version of can be downloaded from: <http://www.obvis.com>. This is labelled as a Demo version but it can be activated to become a full version.

Seminars and courses. Courses are run as a profit making concern by Bill Harvey Associates and need take £3000 to cover the costs so say 10 people at £300 each. The standard charge for Seminars, run as part of the support for Archie-M is £100 which is intended to cover costs only.

Take up for seminars has been very low in the past year. I believe that councils are cutting back on training budgets. We will float some more dates soon but only go ahead with a meeting if we confidently expect 10 people. Personal commitments suggest a Scottish visit in June. Probably to tie in with an inspection of the plastic bridge in Aberfeldy. We may try to raise an event in the north again in late April. If you wish to declare an interest in either of these please email philip@obvis.com.

Bill will be in Dublin for an evening lecture on 1st May and may run a seminar in association with that. If you are interested please contact Philip@obvis.com. He is also in Scotland in late June and in Mid July so that might provide an opportunity there. If any users would like to host meetings we would be pleased to discuss arrangements.

If you would like us to run a course (a full day intensive training) or a seminar (intended as an update on arch studies and Archie plus discussion between users) near you, please let Philip@obvis.com know.

Continuing thoughts about arches and Archie at <http://billharvey.typepad.com>