Bridge of the Month No72, December 2016
Moco Farm accommodation bridge 3

I have a number of bookings to talk about Moco already. The first in Cardiff on 17th Jan. It will be advertised here but perhaps not till the new year starts. The the Bridges conference in Coventry on 16th March and Engineers Ireland in Dublin on 22nd March.

Also talking about Viaduct behaviour (some new understanding) at IStructE History Group on 7th Feb.

Many of the photographs here and all of the 3D modelling were contributed by Hamish. If you are into arch bridges you should read his piece on hidden details.

This marks the end of year 6 of BoM. I think I still have plenty left to say, though I might, at some point, have to call a temporary halt and switch to producing a book. I think I need to do two, one general interest and one more specifically about engineering. Funding the work needed for the latter will be difficult and there is still so much to learn.

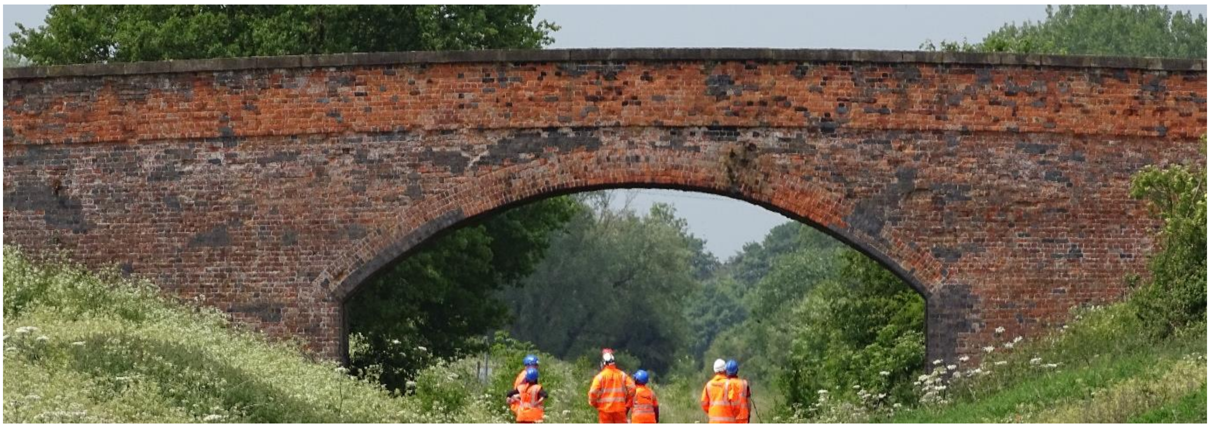
I will probably break off with Moco here because I have some photos from Christchurch in New Zealand that I want to write up. I hope, though, that there might be a mid-month edition from Hamish on the monitoring work he did at Moco, which is worth a wider audience. There is still stuff for me to cover too.

So, what are we looking at this month. Well essentially at some of the side issues and lessons learned from the bridge lift.

Bridge details

Let's start with that vexed issue of hidden details. Some, of course, are only hidden if you don't look properly or if you don't allow your brain to accept what you see.

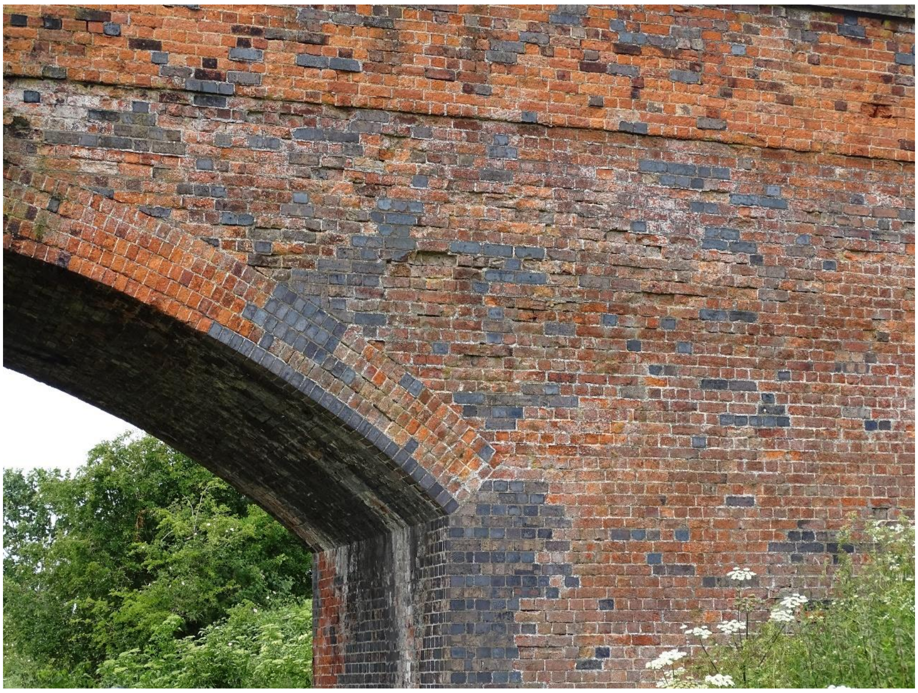
The first thing I would like to call attention to is the general condition of the bricks exposed on the surface.



Lets begin with a general picture from our initial inspection. There are a lot of blue bricks scattered through there and it is reasonable to assume they represent the position of the worst deterioration to develop before the railway was closed. There are noticeably more in the paler band below that shadow line at the bottom of the parapet. It is unlikely that the bricks there are of generally worse quality so it seems likely we are seeing the effect of water penetration, meaning that the wall must be thicker above that line, or at least following that line and slightly higher, since we can assume that water will run downhill as it penetrates from inside.

A closer look confirms that general impression. There is that stripe of paler appearance then a band that is generally darker but still severely damaged and finally the wall face looks essentially sound.

We know from the drawings that the thicker (i.e. structural) part of the wall was intended to top out at a line parallel to the base of the parapet. What isn't shown on the drawings was how that might be done.

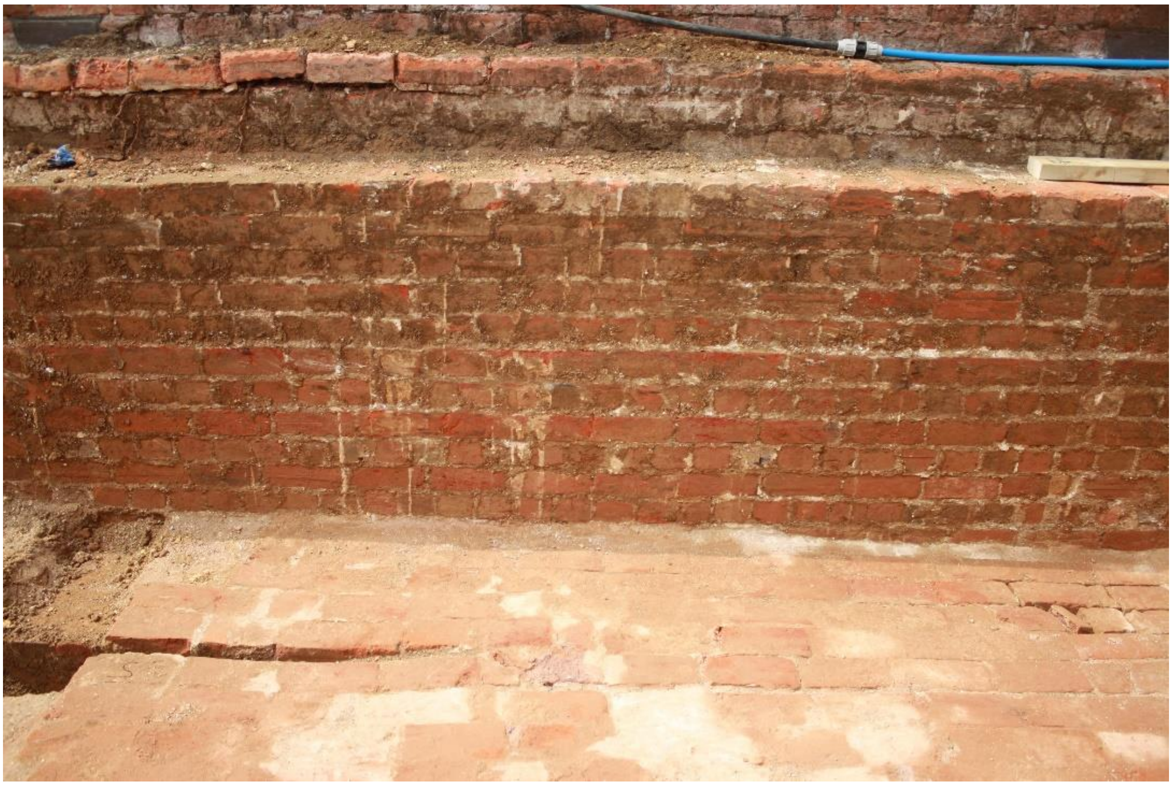


After the excavation behind the abutments (Note to self, we need to find a way to avoid doing that in future) we could see much of the detail of construction. Of course, it didn't match the drawings.

The stuff we can see here is almost worth a BoM in itself:

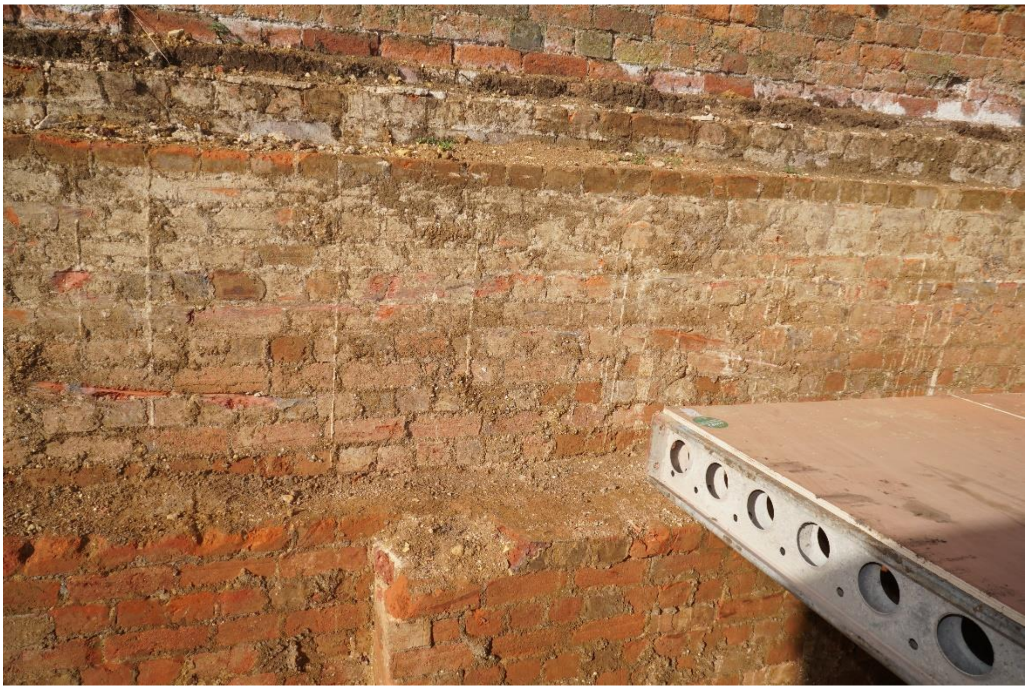
- The parapets sit on a slightly thicker plinth
- The spandrel walls then step out to a greater thickness with a top face and the coursing still parallel
- The backing is level topped and laid in such a way that there is no bond in the main direction of force flow. Actually they are pretty much stack bonded too so no bond in any direction.
- The wing walls step out in thickness again at backing level.
- The sloping beds of the wing wall meets the level beds of the backing at a clean but joint that suggests no bond.
- There is a much bigger crack at the backing/wing wall interface reflecting that in the arch

The wing walls are about 1.2m thick at this point. The higher level reduces to about 600mm.

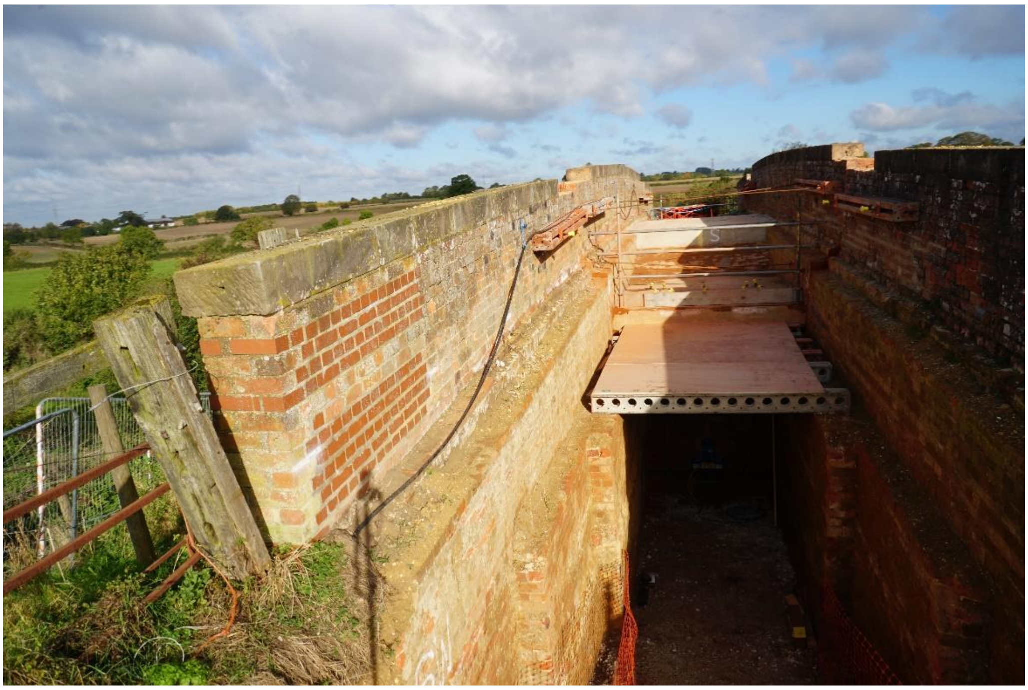


Looking to the side we can see that the courses in the upper wing wall are inclined (which means they match through thickness) whereas those of the backing are horizontal. This raises obvious questions about the bond between these two parts. Is it hit and miss, with a through brick wherever the courses lined up or is it just a butt joint?

Further back, the pattern seems to continue so that the thickening part of the wing wall is bedded on the slope while the inner part is horizontal.



Looking in from the back end, note that the wing wall thickness steps in as shown on the original drawings.

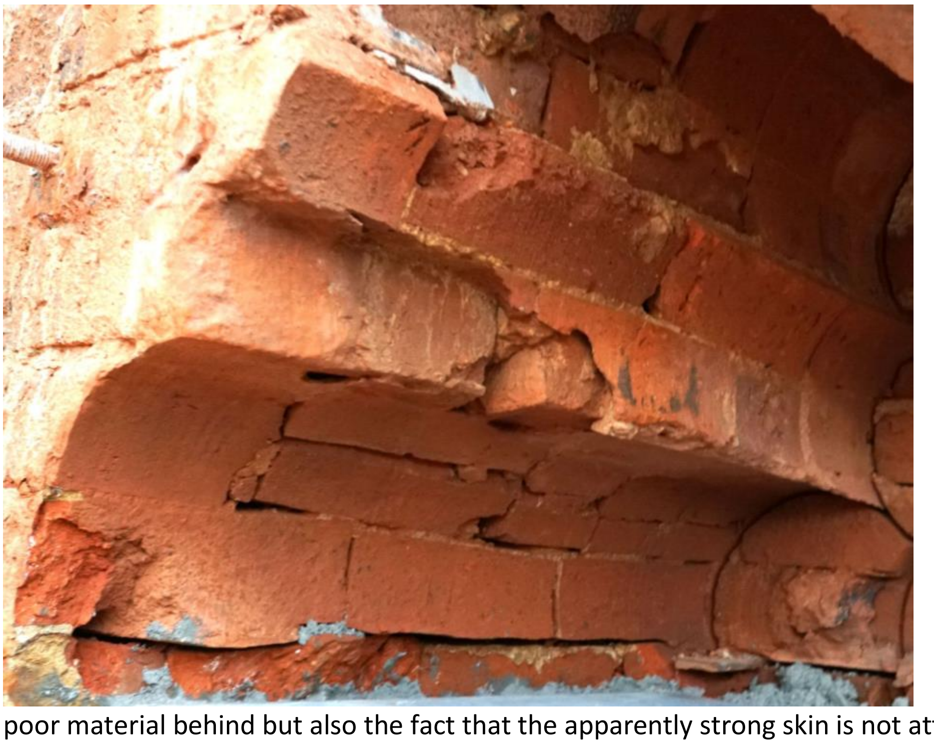


If you look back to the second picture you will see that the outer courses are horizontal at arch springing level and then progressively tilt backwards on very slightly tapered mortar beds. On the inside face, things are done more coarsely using bricks tipped up on edge to make steps. How and where the two meet remains unclear.

Cuts are very difficult to interpret as you will see from this where the South east corner jack was cut in.

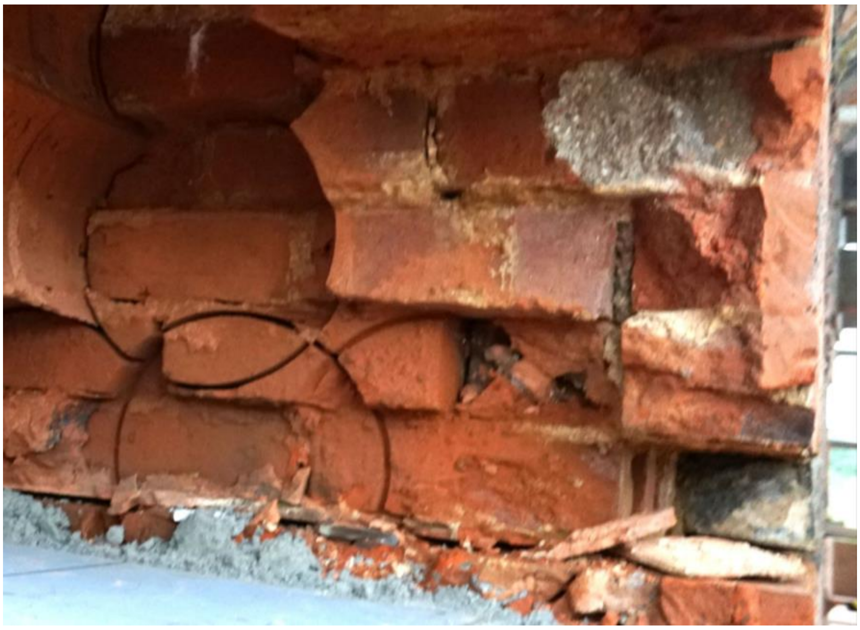
At the right hand side here is the front face of the abutment. 5 cores were taken out to provide a seating for the jack (3 across) and space above for the ram. The bricks to the right were then deemed too exposed and were also removed. The jacks are not in place. The horizontal cut line is though and the arch is sitting on strips of steel. At the rear edge of the cut (left of picture) are three stretchers (so headers in the outer face. Next comes a stretcher in the outer face followed by bricks bonding with those below. Behind the skin, both horizontal and vertical joints are visible and aligned. The joint in the headers on the face and the one visible in the layer above within suggest that the bricks are stack bonded in the other direction. As the layers work upwards, the bond looks less complete and there is certainly a snap header in that top course.

Turning to the front face, there is no apparent bond at all between the front half brick skin and the core material. This is simply confirmation of what we already knew. The abutment has been reskinned. The process of re-skinning is purely cosmetic in the worst way. It disguises not only the



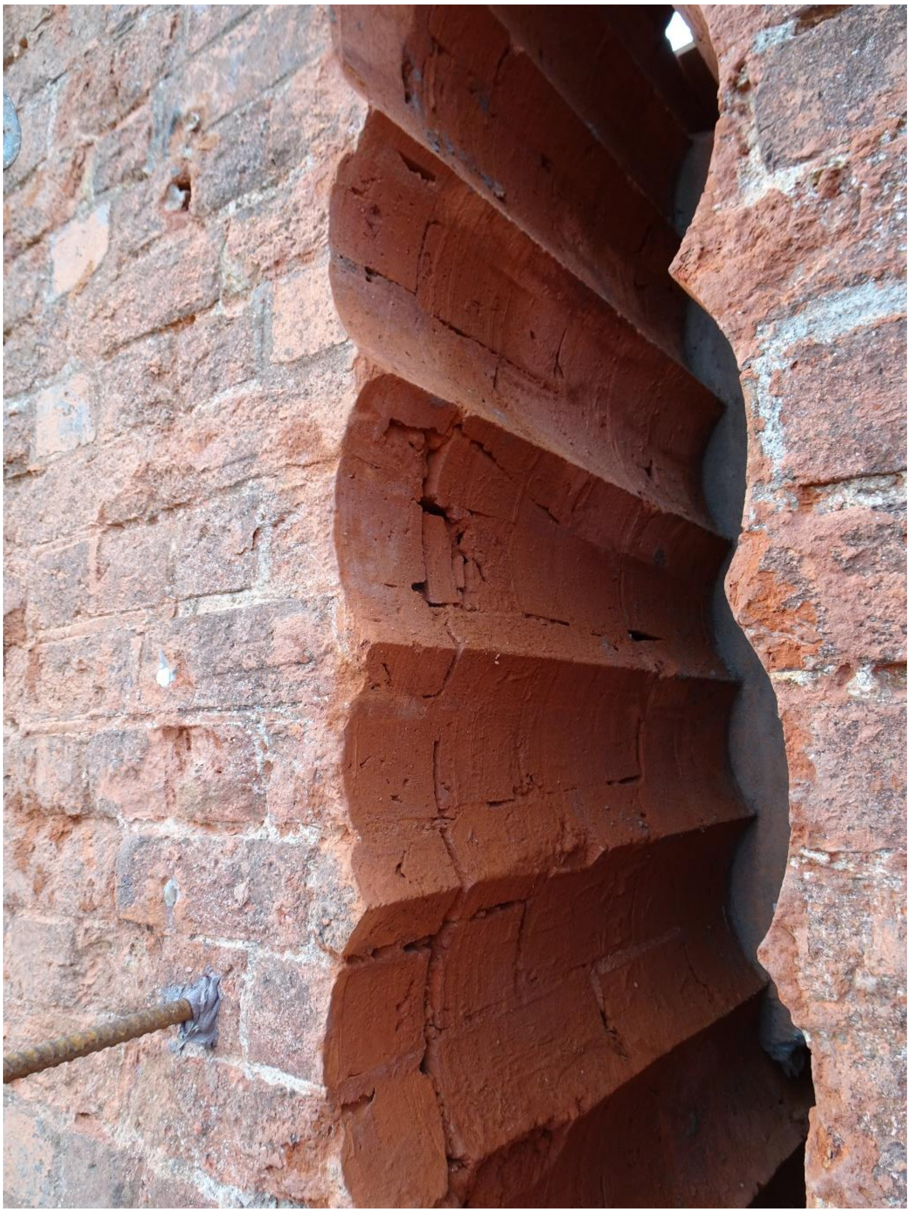
poor material behind but also the fact that the apparently strong skin is not attached. It contributes nothing to structural performance. It is easy to forget that modern photographs are very high resolution. Below are two patches extracted from the photo above. They allow a much more detailed examination.

Here, the pattern of bricks one course up from the cut is much clearer, though it still looks, at first glance, as though there are two thin layers. The core actually cuts the bottom corner off one brick and then leaves just the very top corner of the next. The completely empty joint is actually vertical. What was lost in shadow at the smaller scale is the pair of headers behind which is, after all, providing bond 2 bricks back. The lack of mortar, though is quite evident and that despite attempts to grout the abutment before cutting. The mortar is obviously sufficient to cause dams.



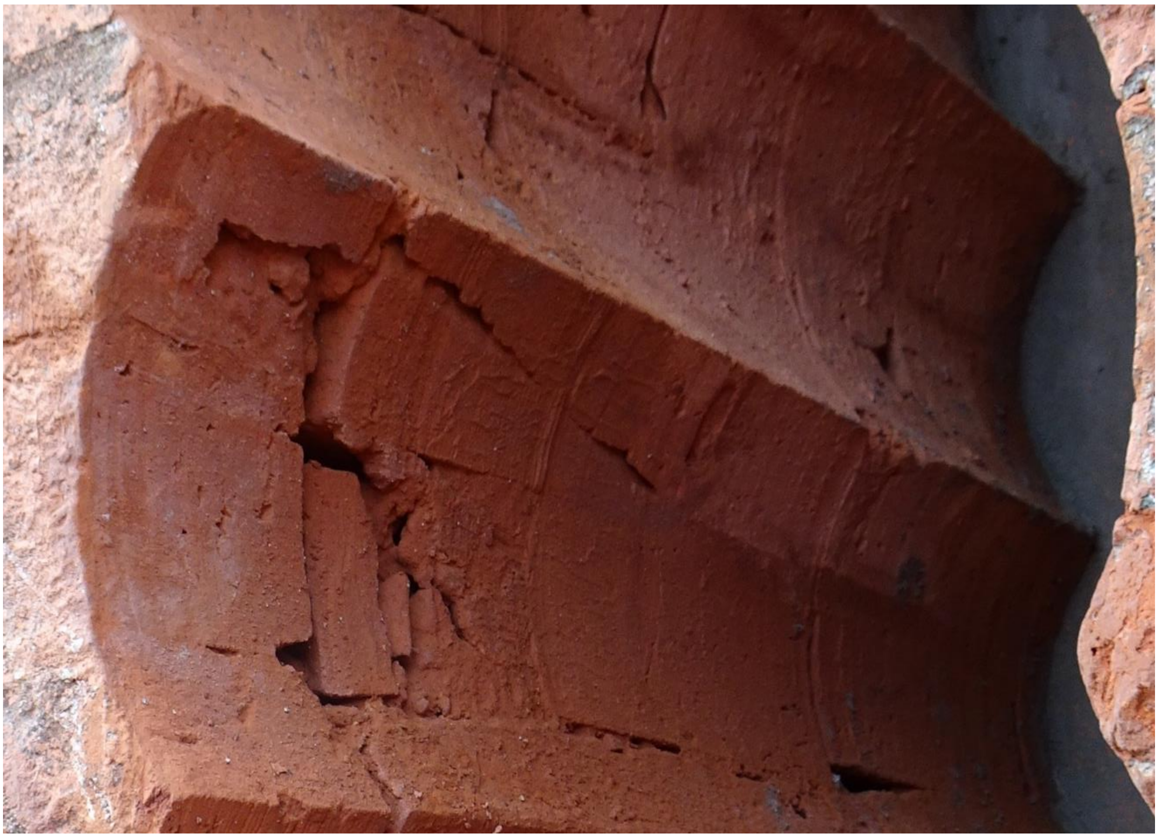
Here, the rubble packed into the header root is evident and the mortar in there very different from the original.

With the bridge lifted 900mm we were able to take enough photographs of the cut face in the north abutment to create a model and render a plan image. Unfortunately the surface (this is the top face) was not clean enough to show the bond near the edges. The windows are where the jacks were in position. The build of the bottom face was incomplete at the first attempt but we are working on that.



The coring for the bearing also provides a nice, visible vertical section through the wing wall. Once again, just here, we have snap headers and a loose skin so structurally the wall is 115mm thinner than the designer intended and not terribly well built behind that. There also seems to be very limited bond two bricks (450mm) further back. I presume this is where the sloping and horizontal courses meet. I wonder whether that was what the designer intended, really negligible shear strength down the neutral axis of the wall.

The closer look below shows another interesting feature. A vertical joint between two bricks that is obviously substantially inclined to the normal line of the core. I would say that those bricks are about 25mm out of line in the 225mm length.



And that hasn't really covered much of what I intended but it is surely enough for this month. But there is a point I would like to make about it all.

The anatomy of arches

Assessing existing structures is notoriously difficult. Part of the problem with masonry bridges is that even when we have drawings, they tell us nothing about the detail or the workmanship. Over many years, I have built up a picture of how construction worked but the vast majority of engineers working on these bridges are new to the job and receive no worthwhile training.

Much of what I have recorded here (and there is much, much more to come) is only available because we took thousands of photographs whenever we were on site. Despite that, the record is far from complete. When bridges are demolished, for whatever reason, similar records should be kept and that means having someone on site whose only responsibility is recording. These bridges were built by the dozen and there is every reason to suppose that the workmanship and detail is similar through a complete contract. Sound records therefore have real value even when a bridge is gone, because they tell us about the one next door which hasn't been demolished.

Creating and keeping such records would be very good training for young engineers new to the business of masonry bridges. There is certainly nothing here that is beyond the compass of a graduate with open eyes and an open mind.

Ahh, but just before I go. I was asked for a better picture of the bearings to show how they relate to the structure as a whole. I think that this the the best I can offer. Its from a 3D model created by Hamish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