Bridge of the Month 120, Dec 2020
A Decade On

BILL HARVEY
ASSOCIATES LTD

It is hard to believe that this marks the end of 10 years of Bridge of the Month. Some months were late and some quite brief but I have managed to post every month for that time.

Figure 1 This tree made me suddenly think about the absence of hugs in my life.

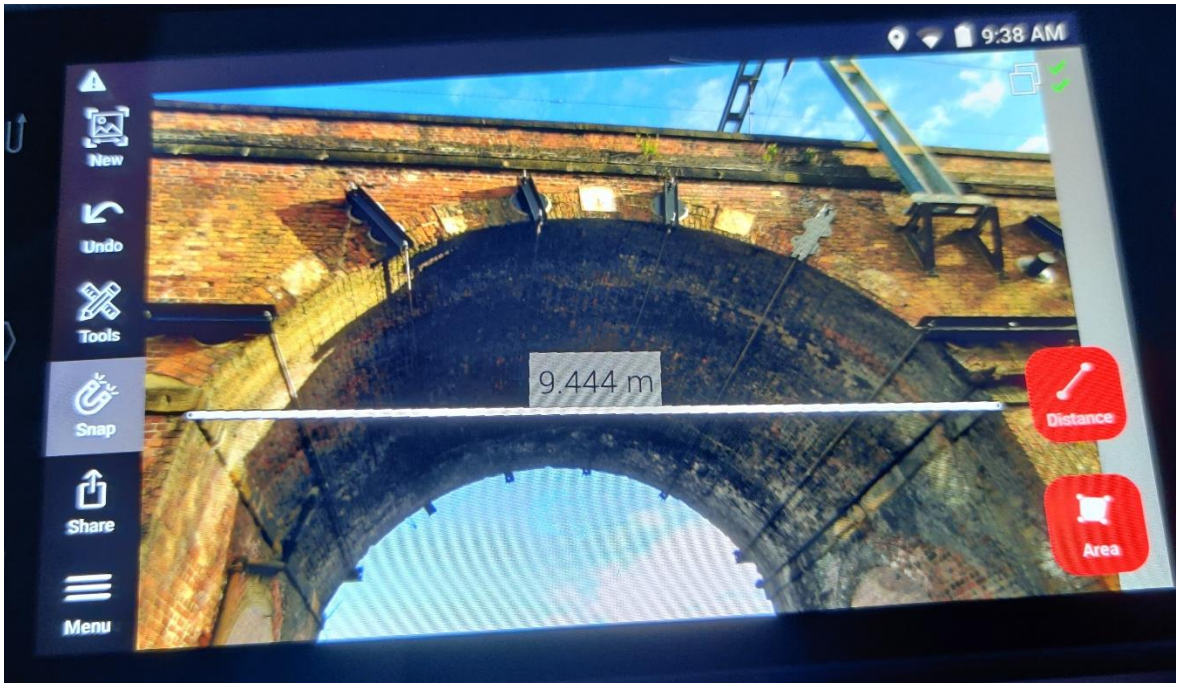
I thought now would be a good time to review where we are and where we are going. It is the end (we hope) if the Covid year. As I write, I am aware that I haven't given or received more than a handful of hugs in eight months. I coped remarkably well with the loneliness while I could get out on my bike, but once my hand was broken in late September things began to drag a bit and I was conscious of just not getting stuff done. Despite that, I am also very aware of how lucky I am to have work that I love and think of as more than a hobby. Twenty years on from leaving the academic world I still take every opportunity I can to interact with students. I feel I have a lot to give yet.

What is so striking about my life, though, is how much I am still learning. Much of what goes in here is stuff I have noticed for the first time. I am proud that Hamish, too, is anxious to find new and better ways of doing things and to hope to make enough money for that to remain viable. This month, there is a new technology that is likely to prove transformational in the world of masonry bridge inspection.

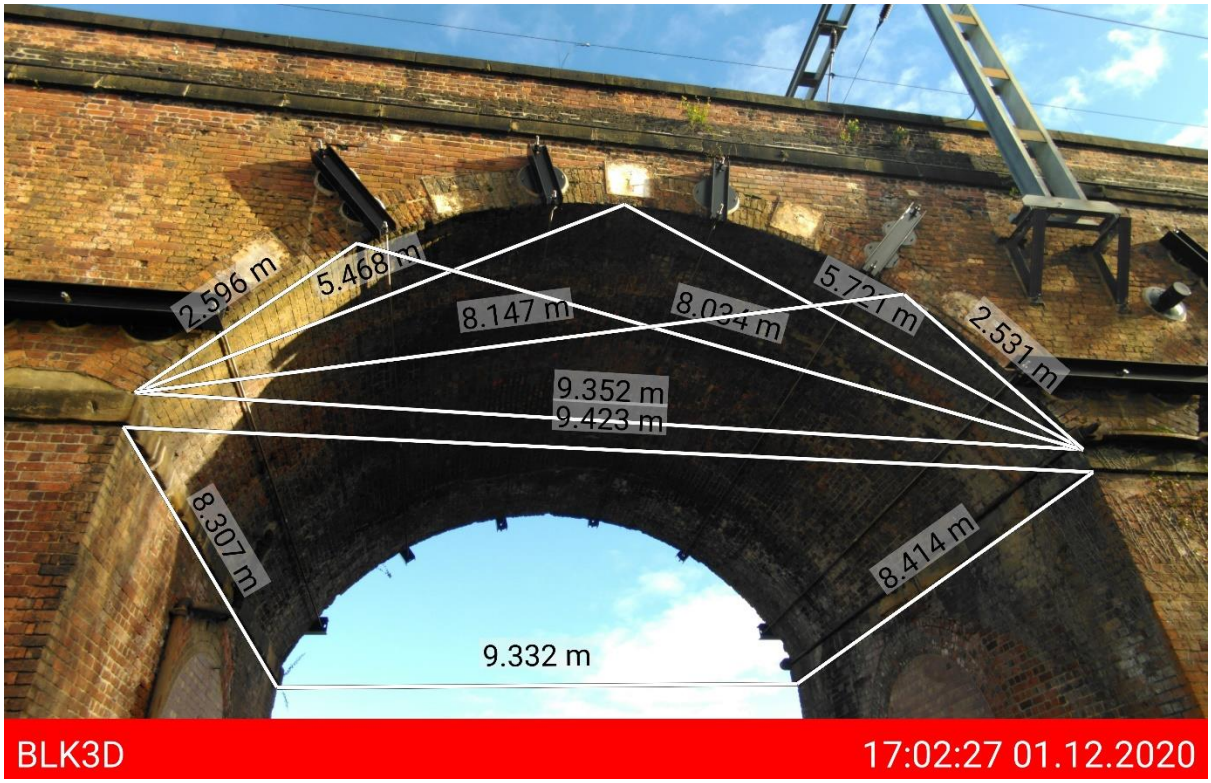
So, here we go with a look at what is coming. Leica have recently introduced a series of black instruments they call BLK. There is a small-scale tripod scanner and one that you can literally carry around and scan as you go, but the latest is in a different league so far as we are concerned. The first two are still £40k devices. The BLK3D is a £4k device and is, in our view, appropriate technology.

The BLK3D is a little larger than a smartphone. (In fact it runs Android, which means the same device could be used for field data collection.) It has a pair of cameras in diagonally opposite corners in a stiff frame. These are calibrated for angle and distance to provide a binocular (stereo) image, processed on the device so measurements can be taken. They work at more than adequate accuracy for masonry bridge surveys.

I was doubtful about this measured span from first use at a viaduct in Wakefield.



31 feet seemed unlikely but the Disto produced exactly the same value, and this is measured about 6m above the ground. That's a photo of the BLK3D screen it is also possible to store multiple measurements and download the image.



The slope measures allow us to calculate the radius from:

$$R = abc/4\sqrt{s(s-a)(s-b)(s-c)}$$

Archie-M will do that for you if you select Two Tape method of measurement.

	Dims		s-		Ft	
a	9444		1071.5		30.98	31
b	5762		4753.5		18.90	
c	5825		4690.5		19.11	
abc	3.16975E+11					
		sqrt term	2.5122E+14			
a+c+c	21031	4*sqrt	63399723.3			
s	10515.5					
Radius	4999.6				16.40	16.5
Angle Rad	2.4417					
Angle deg	139.90					

Here I have converted dimensions to feet and rounded, seeking sensible numbers where possible.

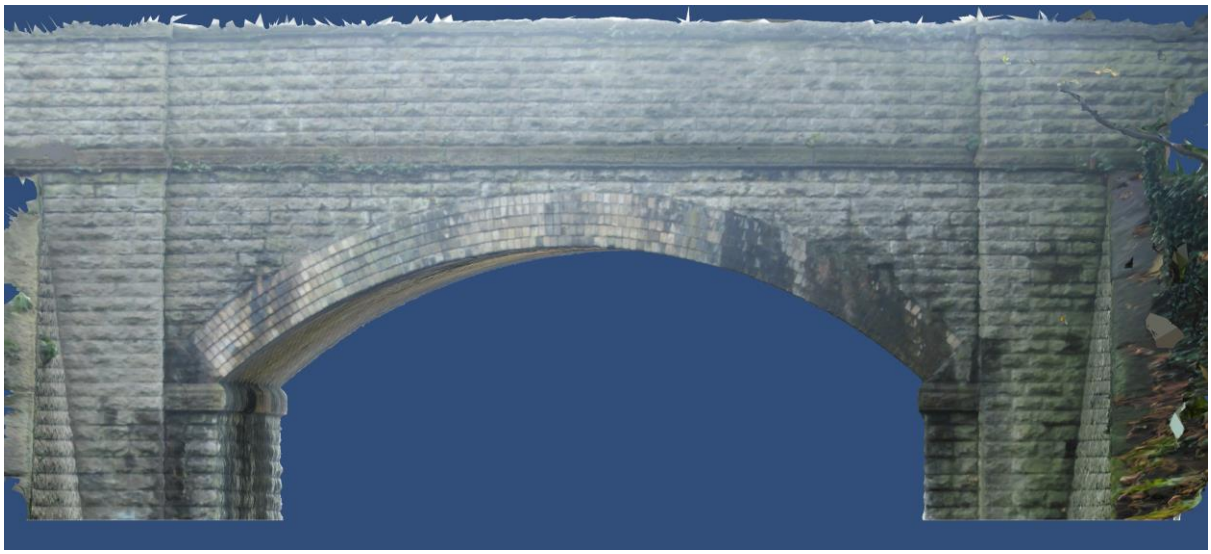
The best fit seems to be 31ft span, 16.5ft radius and 140 degrees included angle and I would be happy to run with those numbers as input to Archie.

The rest of the dimensions in the next two pictures show the extent and power of this little device.

But there's more we can do. RealityCapture recently added support for the device, and can take the stereo pairs along with tilt data from the BLK3D, and use the extra information to scale and level models.

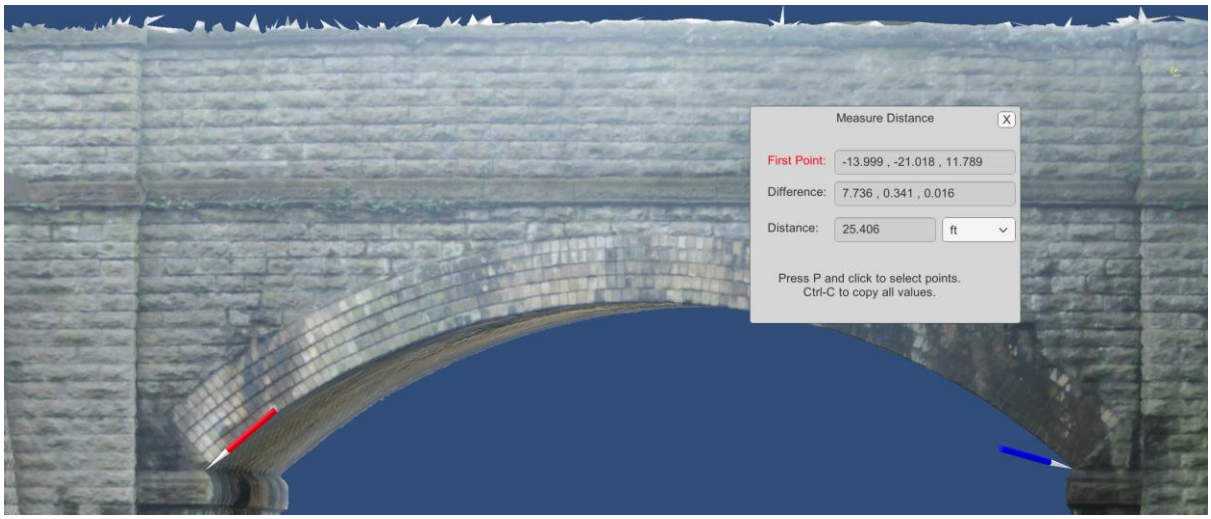
There is a disused railway just round the corner from Hamish and a bridge crosses it here. Hamish spent 20 minutes with the BLK3D. Less than 30 minutes of processing produced a model which can

be viewed readily on Sketchfab. The resolution is much less than we usually produce but is still useful. Indeed far more useful than the definition available from a typical laser scan.



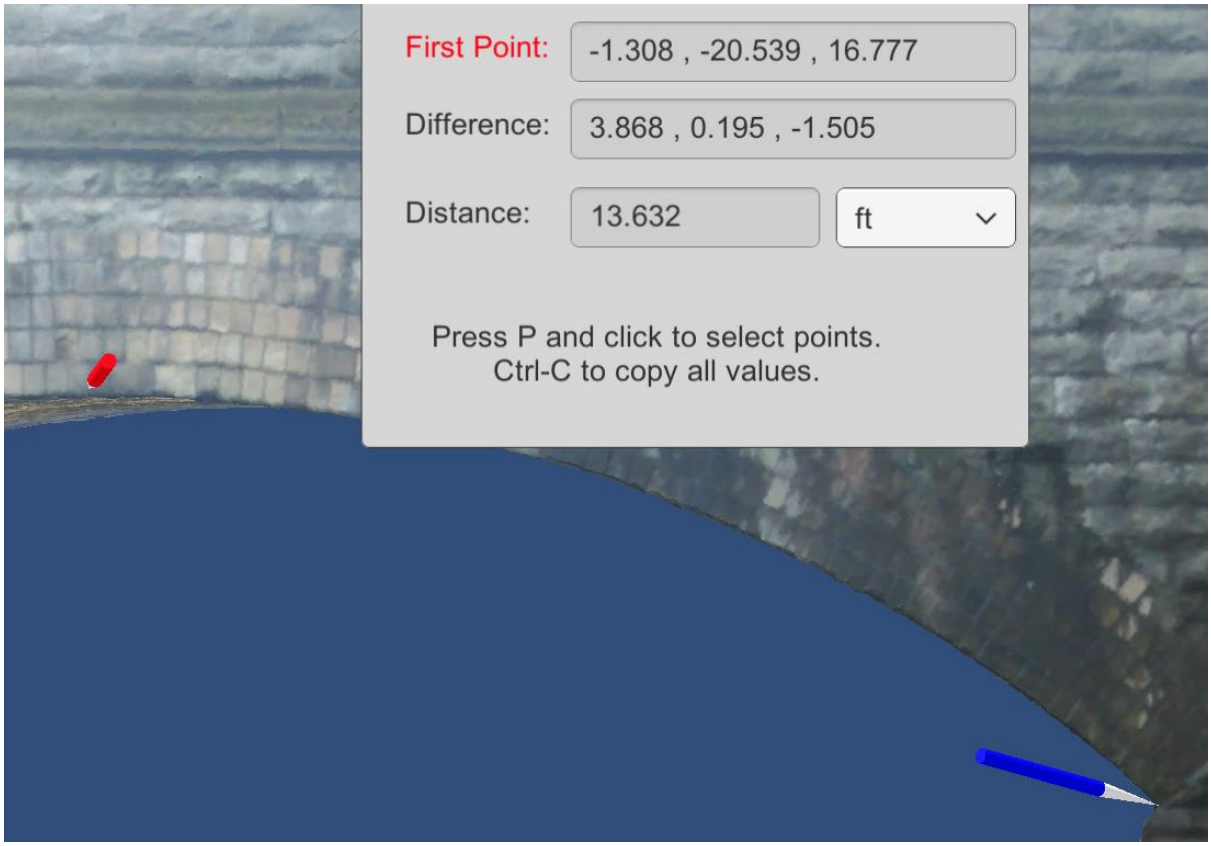
Putting that model into our viewer (soon to be released as Reveal4D we think) lets us do all sorts of things with it.

First, we can measure the span:



Notice we have x,y,z difference. The z is negligible, but the y is not so the points I have picked are not quite on the axes. I can choose to measure in feet or m and feet are always more interesting with masonry bridges.

If I drag the red pencil to the crown, the z gives us the rise of the arch.

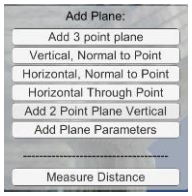


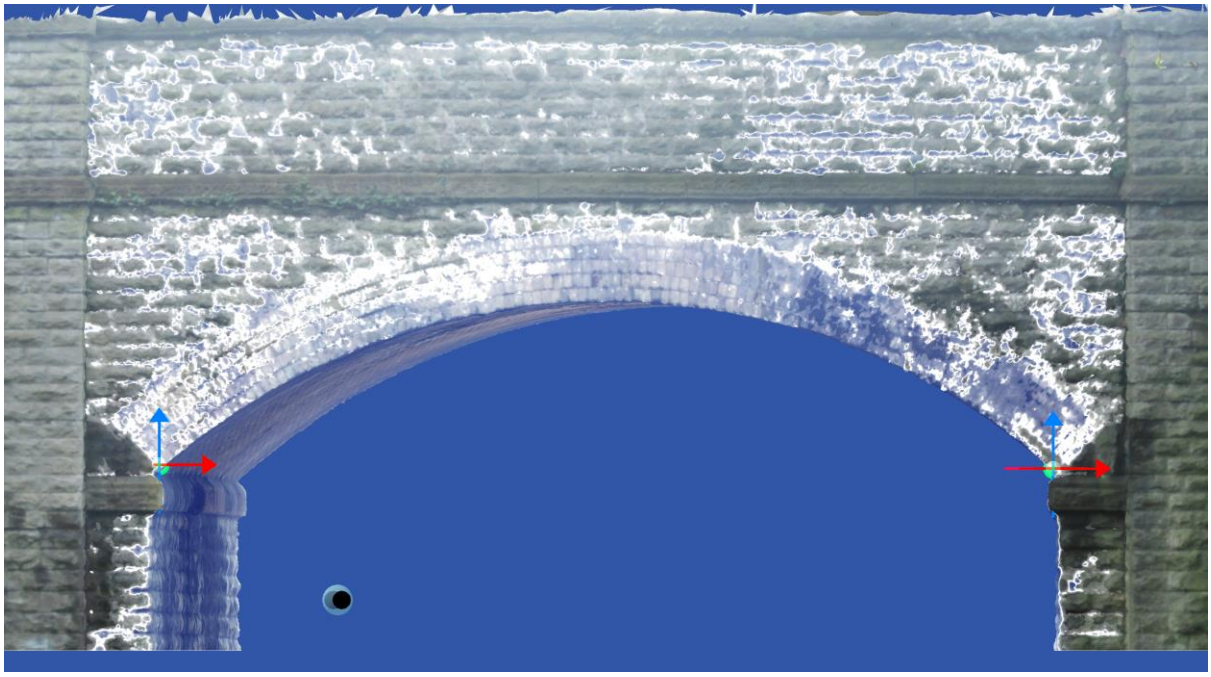
Though the overall distance is in feet, the x,y,z are not. This will be fixed soon. We can copy the measurements to the clipboard so we can paste them into Excel. Here, the difference row does land as feet.

-1.308	-20.539	16.777	12.691	0.64	-4.937	13.632

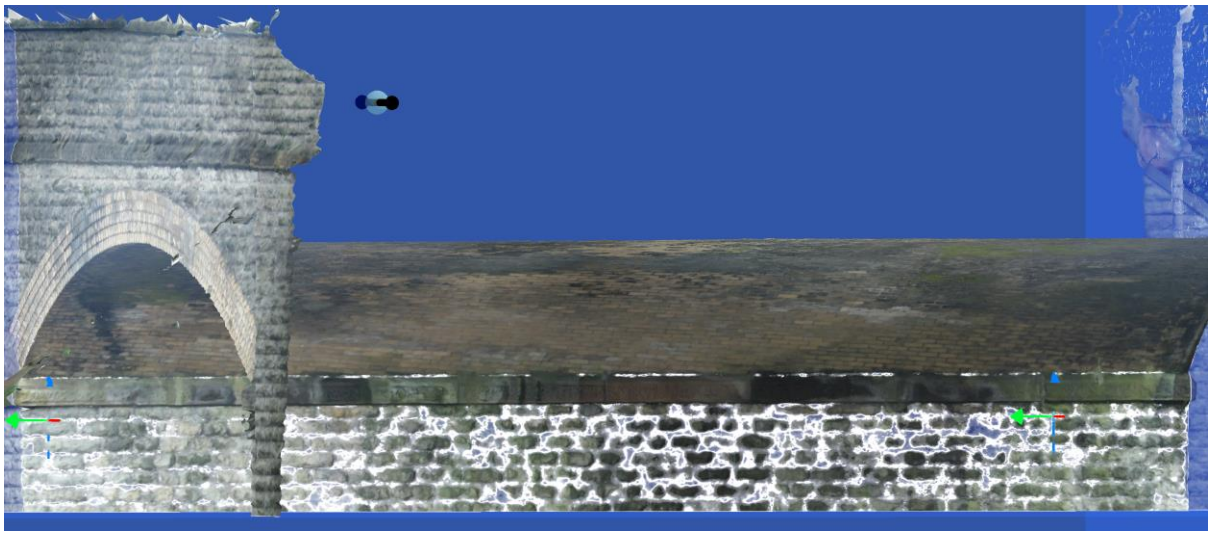
Obviously this was built with a 5ft rise and I would expect the square span to then be 25ft. What is the skew? In time we'll add tools for measuring angles. But we can get there quickly enough without them.

We can add a 2-point vertical plane (the two points define the direction). In the first instance, parallel to the face.





Notice how there is a patch above the crown and slightly left, where the plane creates no white contours. This area is well above the camera positions, and we need to be careful about interpretation, but this is almost certainly a bulge in the masonry, and one that would not be detected in a hands touch survey.



Here, the contours show the abutment face to be flat.

We can extract values for these planes from the model and paste them into excel to measure the skew.

Offset	Direction cosines				Angle	
from Origin	x	y	z		ATAN2	Degrees
6.239521	-0.0515798	0.9986688	0		1.622399	92.96
-3.788347	0.9986329	-0.05227125	0		-0.0523	-3.00
			skew angle degrees			5.95

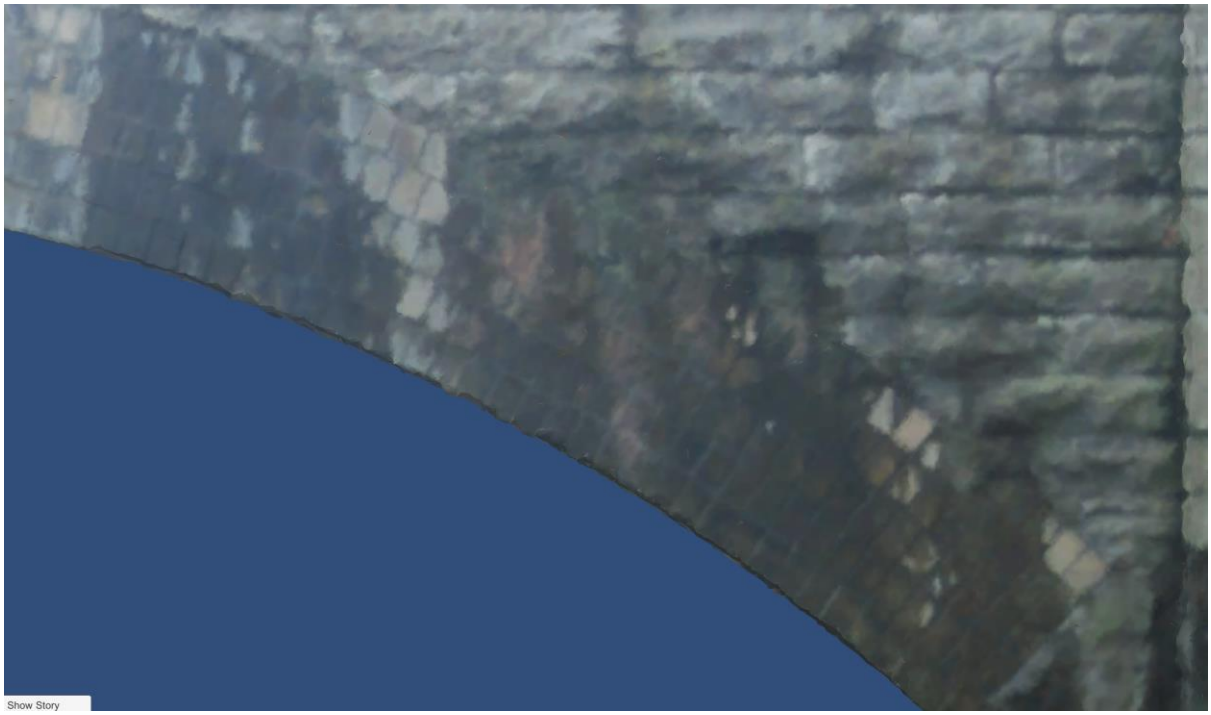
So the bridge has a skew of 6 degrees.

We can drag those planes to the opposite face and that shows the other spandrel and other abutment to be parallel. Copying out the details of those two planes we find a more precise value for the span.

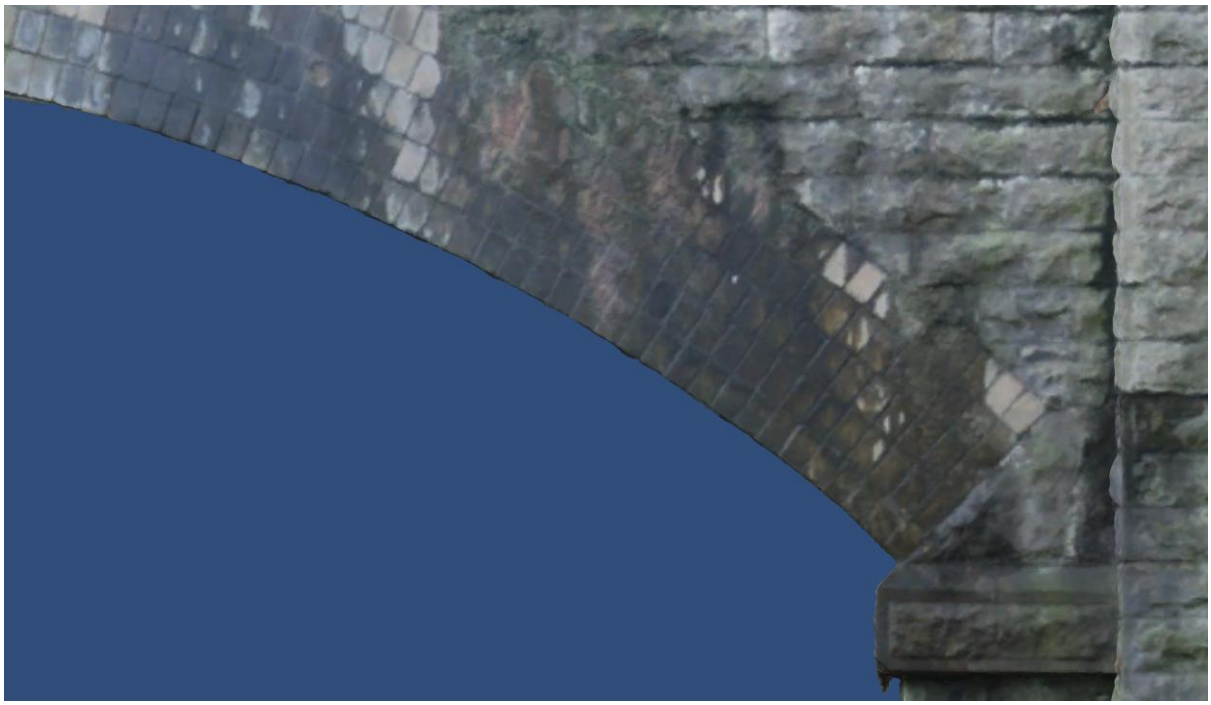
3.789334	-0.99863	0.052272	0
-3.94118	-0.99863	0.052272	0
7.730513	m		
25.36258	ft		

Measured directly, the smallest span was 25.5ft so perhaps these dims aren't perfect. They are, though as good (if not better) than most bridge dims I see.

So that is with just the BLK3D. However, RealityCapture can use that as a base to scale and level a model using more detailed photos. A further ten minutes with a quality camera produced 101 photos which we built into the model. The day was dull and the photos not as close as we would normally do but the improvement is worthwhile.



BLK3D only.



With 101 higher resolution photographs. The extra pictures added a little to the processing time but these are relatively low photo counts.

When viewed from below.

Figure 2 Soffit from BLK3D only

Figure 3 Soffit with 101 photos from SONY A7Rii

Figure 4 Comparing the edge

The difference is particularly marked at the edge of the soffit where the flare in the BLK3D lens prevented clear photography, though it didn't disrupt the geometry of the model.

It is, though, still visible at mid width away from the flare.

Within the width the difference is less marked though still discernible.

We would normally expect to use one or two thousand photographs for such a model, which results in much greater resolution. It can even deliver more than can reasonably viewed in 3D by producing orthophotos.

The scale of model I regularly deal with on my laptop, plugged into a 40” 4k TV as a monitor is of remarkably high resolution. The screen grab below is from a model of a bridge 50m long 7m wide and 10m high.

The same photos as used for that model were reprocessed to provide higher resolution local models for detailed examination as seen below. Such a small, high detail model can be very quick to load and again, my laptop can load two models at the same time so I can switch between them without having to rebuild.

So, that was at least partly advertising. We are, for the time being, doing photography and site measurement as well as building the models and preparing Reveal4D for market. We typically have to develop new ways of getting cameras to suitable places for each job. With arch bridges, drones are of limited use. There are often narrow gaps – between arch and river, or elevation and trees. The quality of drone capable of taking high resolution photos looking up square to the crown is likely to remain expensive. For railway bridges flying a drone near a live track is rarely appreciated. We think that the BLK3D may be a game changer for providing decent control dimensions without requiring specialist skills and heavy – and much more expensive – equipment.

Reveal4D is so named because it (already) has many features not discussed here. Some of them were covered in BoM99 but there has been a good deal of development since then. Remember that all these features are available and useable on a modest laptop.

There we are. 10 years of BoM completed and that is the back of the torrid year 2020. I wish everyone a much happier new year. I may be 73 but there is far too much I still want to do for me to be prepared to “go gentle into that good night”. I am hoping I won’t need to wait long for my turn at the vaccine, though I won’t be getting rash when I have had it.