Some thoughts on Competence

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Who am I and who are we.

BHAL are a two-man team of engineers (with one new part timer) with a growing if disparate backup.

If we have a specialism, it is thinking about difficult problems, though we are also trying hard to develop a scalable income stream that will allow us (for now, and just my son Hamish as time goes on) to continue thinking and developing new ideas. And just occasionally to have time off.

The main stream of that just now is the work we have done on developing an inspection tool for 3D photogrammetric models and equipment and methods for gathering the photos needed to build the models. They are reasonably fully described at https://www.billharveyassociates.com/bom/99-rutters though that was done 22 months ago and there have been many developments since then.

We are always on the lookout for new developments in equipment. Perhaps The latest BLK3D from Leica combined with the tools we are developing should transform the business of masonry bridge inspection. https://www.billharveyassociates.com/bom/120-a-decade-on .

Incidentally, Bridge of the Month is one of my attempts to teach what I have learned about Masonry bridges in 40 years of research and consultancy. I am also writing a book and recording talks based on parts of it.

Why me on this session?

Because Richard follows me on twitter and follows BoM and knows how much I care about and particularly think about, the issues of competence. The original request was for me to reprise the BoM from October which was done as a recorded talk.

I don't feel that repeating it is particularly worthwhile because it can be watched here https://www.billharveyassociates.com/bom/118-westgate-collapse . Perhaps I could ask you to do so in advance of our discussion.

What to talk about then?

I have been agonising about this for two weeks. One thought was looking at the work we did on Cleddau Bridge 10 years ago but then I realised I was in the middle of a review of a Network Rail code of practice and a research project on viaduct behaviour.

I also think a lot about the philosophy of engineering and just what it is that divides engineering from science. So let's start with that.

What is engineering?

The old ICE thing about "Directing the great forces of nature for the use and benefit of mankind" has fallen out of use for a number of reasons, many of them good, but it does tell us something.

Civil and Structural engineers design and build stuff.

We set about modifying our environment to suit our needs and desires.

We don't think nearly enough about the knock on effects of the changes we make, but I don't want to concentrate on that here because:

Abusing the earth's resources in a wrong headed attempt to modify things that already exist is not acceptable. Both in design and maintenance we need to do it right. But that means knowing what right is.

So, part of my answer to what is engineering is that first of all it is about confidence. Ted Happold liked to say that structural design is about developing the confidence to build. What he didn't say (because it is assumed) is that it is vital that the confidence is well founded, and all too often, in the modern world, it is not.

I think we can say that the confidence of the railway engineers of the 19thC was well founded. They were pushing way beyond the boundaries of science but to a large extent they did so on the basis of thinking about the consequences of being wrong and guarding against those consequences.

It was well into the 20th Century that the theories of plastic behaviour were developed and not till at least 1965 did they start to be applied (by Jacques Heyman) in my field of masonry bridges.

What is Failure?

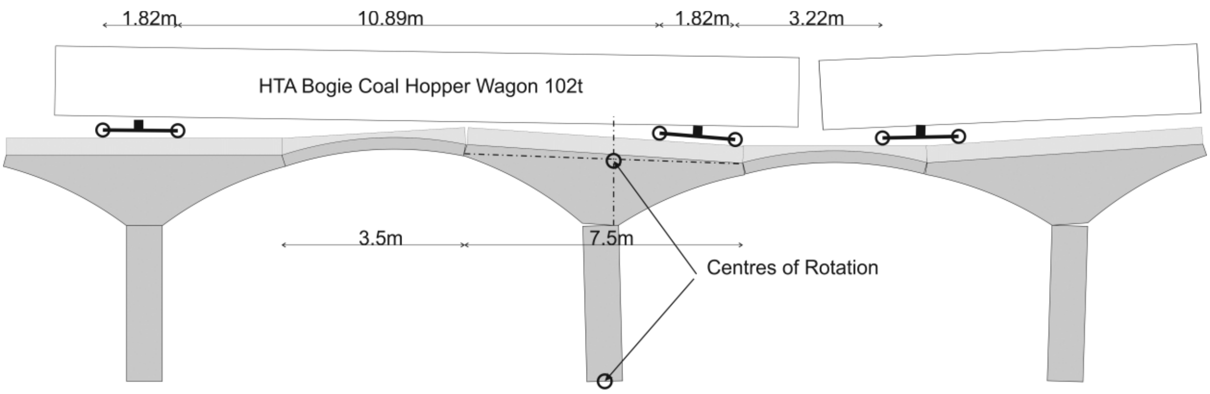
Every engineer worth his salt lives in constant low level anxiety about this sort of thing (edit 2024: image removed due to rights issue).

Perhaps the most important lesson here is that the plastic theorems only protect us if there are alternative load paths. Cantilevers, as here, and simply supported spans as at Westgate, or indeed to come closer to the present, the FIU footbridge, provide no alternative load paths and there is no protection.

Masonry Viaducts

My main thread of work at the moment is on masonry viaducts. It turns out here that the alternative load paths I thought (back in 1986) were available are not, and here we begin to consider the issue of competence.

There are secondary load paths in the spandrel walls and parapets but they are relatively fragile and don't necessarily give us much to spare. We need MUCH more knowledge, yet, about what is actually happening but I believe this is a reasonable picture of the problem.



And the damage that accrues has got to here:

So, if we start with a wrong understanding, bad things are likely to happen. If, instead of engaging with the issue we then treat the symptoms by patching the gap we compound the issue in many ways. But it does provide a steady income for the contractors who these days, employ the consultants and soon sack them if they don't provide a steady stream of easy and well paid work.

Junk Codes of Practice.

The first point here is that we desperately need to row back from "Standards" to "Codes of (Best) Practice."

A code of practice title says unequivocally that it is simply a codification of current best thinking. A standard gives the entirely wrong impression that it is correct in every detail.

Network Rail standards are a particular bugbear, not least because the practices they promulgate get picked up as gospel and transferred without question to fresh places.

I am currently involved in reviewing the standards for masonry bridge repairs. This comprises 16 relatively sparsely populated drawings, each one containing too much (repeated and often contradictory) text written in large capitals. A good sample is this clause which seems to be repeated on many drawings.

> 2. THE VERTICAL EXTENT OF REPAIR BEING LIMITED BY SITE CONDITIONS AND POSSESSION TIMES.

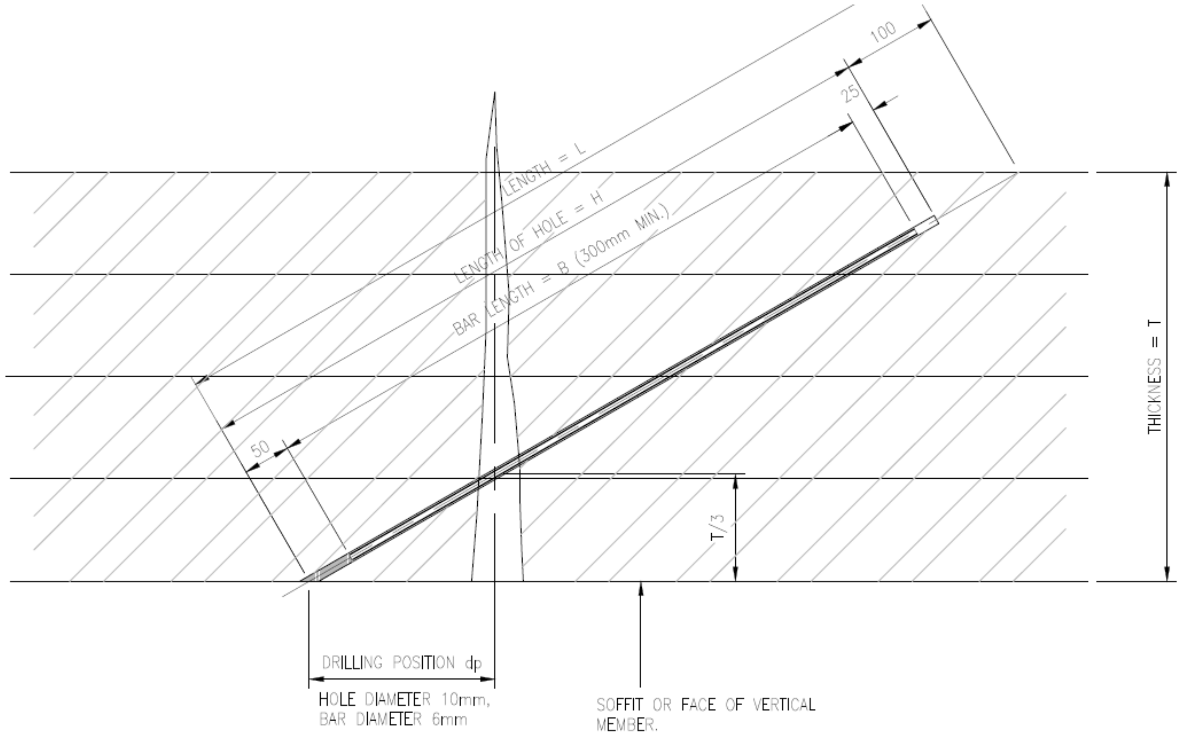
It purports to be a numbered clause but isn't even a complete sentence. We might think we know what it means but how can we be sure.

A much bigger issue is the details themselves. I have long been agitated by the issue of “stitching” cracks. When I raise this I am told “We know it works because the bridges don’t fall down after we have done it.”

That is absolutely not a test, let alone a fair test.

In a typical stitching operation, traditionally,a 25mm rebar is grouted into a diagonal hole through a ring. In the latest details, that bar is reduced to 6mm diameter in a 10mm hole. Further bars go in on opposite diagonals at 500mm centres. So the bar is being expected to hold a force that could not be resisted by 0.25m^2 of brickwork. It may be “strong” enough but even a 25mm bar isn’t nearly stiff enough to do anything useful. If you do set about measuring the result, you find that the deflection across the crack under live load does not change. (I know, I have done it but no one else EVER has so far as I can tell).

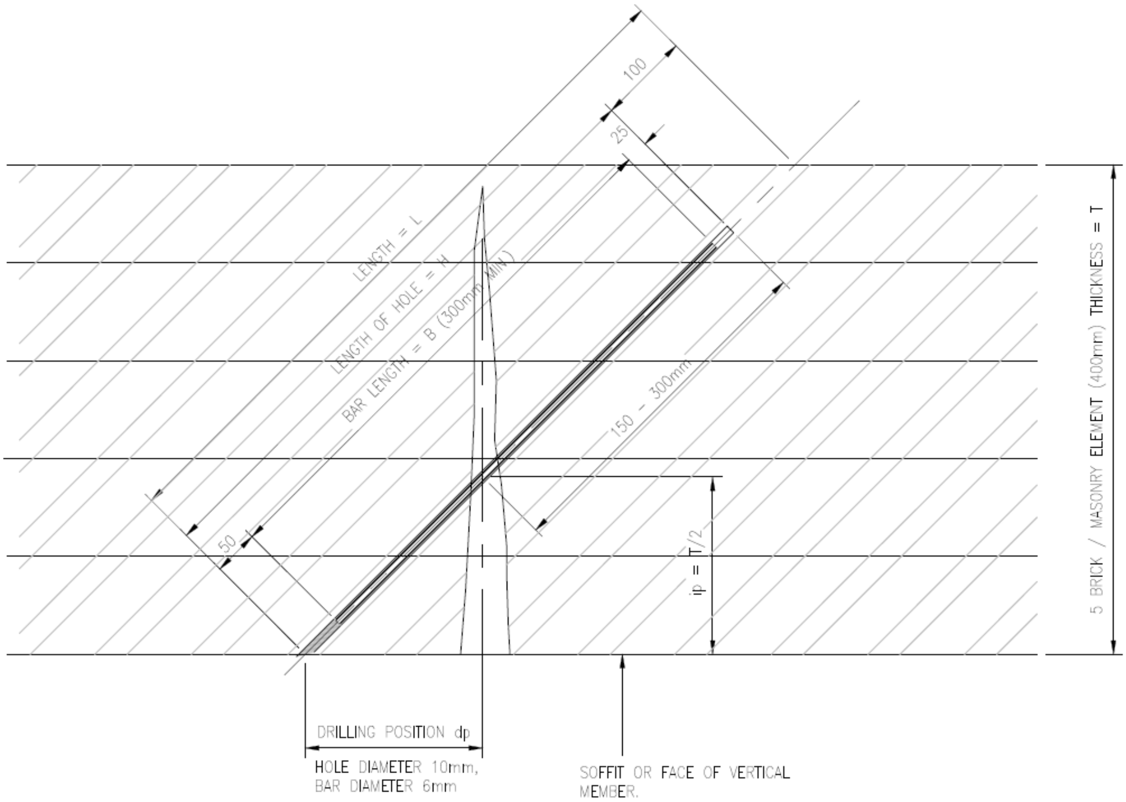
Here is one such detail:



TYPICAL SECTION AT 30° CROSS STITCHING OF ROTATIONAL CRACK IN ARCH OR VERTICAL MEMBER

SCALE 1 : 5

And for a shear crack:



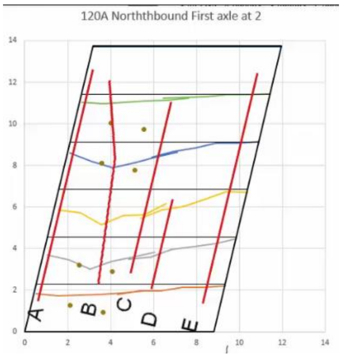
TYPICAL SECTION AT 45° CROSS STITCHING OF SHEAR CRACK IN ARCH STRUCTURAL ELEMENT

One obvious question is how does one recognise the difference between a rotation and a shear crack?

Then there is the fact that, at 45^o, 75mm *1.414 is only 106mm so the hole will only just enter the upper ring and the bar will stop 20mm short. In the 30^o example, the idea that a bar anchored only 100mm in a brick can hold anything purposeful is quite laughable. It will simply pull out and probably do no further damage but not do anything that might be regarded as good.

The bridge where I measured the after movement had 9 longitudinal cracks through the whole span. Here is a mirrored plan view.

That is after repair. It had been lined with plastic from 2006 to 2015.



The lines in the plan image show the 6 cracks not greater than 1mm wide that were recorded before the lining went up. Below is a limited view of how it looked when the linings came down.

The most important question is WHY. Before that, we have to answer WHAT has happened. But what has happened is mired in history and will take a great deal of digging out. The piers of this span have been reskinned in engineering brick using post metrication bricks. There must surely be a record of why that was done? One suggestion was that the cracks were a result of whatever the problem in the pier was. But there is a stone skewback of some substance between these two parts.

Over the years since we found this I have seen four more skew bridges with similar cracks. Is the cause the same? Finding and identifying systematic damage of similar types is vital to enhanced understanding. So competence extends into the way these things are recorded.

So, what is competence?

And what is a competency (I am just assuming that the y is added to make competence countable).

I would argue that the FIRST requirement of competence as an engineer is the ability to question your own ideas and those of your predecessors. That is not simply to say, in the modern way, "I don't believe that" but to try to follow the thought processes that got us to this proposal and to question each step. To test it.

It is very similar to the need to follow the load through every step in its passage from point of application to effective dispersion in the ground. That isn't, perhaps Westgate but it is Cleddau and FIU and Vancouver, and Quebec and Loddon and Sept Isle's and……..All attributable to local buckling in an unconsidered location. Not a failure of calculation but a failure to calculate. And lest you think it is mostly in steel, there is always Schleipner. The model has to represent some aspect of real behaviour in a defensible way.

How do we get to Next?

Let's begin with an unpopular opinion.

The core teaching of engineering has been gutted over the past thirty or so years by a series of relentless pressures.

First, for very good and defensible reasons, grammar schools were abolished and teaching was directed to the general good instead of concentrating on the best and letting the rest catch what they could. The worst outcome (weaponised by Ofsted) has been "teaching to exams" which means coaching students on how to pass exams rather than teaching them to think in different disciplines and letting the exams take care of themselves. The evidence of cheating at Eton a few years ago shows that even the “best” schools are on this slippery slope.

Then, there has been endless dilution of the number of engineers in the teaching community who have field experience. The engineering institutions have been complicit in this pressing for Institution Membership but encouraging use of a calculatedly academic route which requires no experience beyond the university.

Perhaps the most damaging aspect is the commercialisation of the consultancy business. I am not looking back on the old partnerships as a golden era. After all, Westgate and Cleddau (then Milford Haven, only the names have been changed to protect the not so innocent) collapsed under the old regime. But commercialisation has meant commodification of engineering. Profit is best accrued by following pre-determined steps without question. That extends to the level of directors signing off reports they haven’t read because the QA only requires that they sign it, not that they review it.

Most parties to engineering have come to think of it as a Quality Assured Process. But QA requires that you first write down what you are going to do, then then record the process of doing it. There is no room for actual thinking and questioning in that.

If a graduate engineer is given a task, they are mostly inclined to think they “must” be able to do it or they wouldn’t be asked. They maybe find “one that has been done earlier” and follow the route, hand it in and the boss signs it off without looking so the lesson is reinforced. The boss in question came up through the same system and is being treated in the same way in his new role. Pedalling back from this is going to be pretty hard but people will die in ever increasing numbers if we don’t.

I think the first step is to train a core of reviewers to step in and audit things like bridge assessments. Only if broken processes are called out will we ever improve. If inadequate reports were returned with a 0/10 see me, the companies would quickly learn that they are not sitting on a cash cow but they are trying to profit from a business on which lives depend.

And that is how we get to actual competence.

As to competency? I imagine that, for example, knowledge of and ability to apply CS454 might be regarded as a competency but it is far from being a competent assessor of masonry bridges.

And, I believe that the training for inspectors will (possibly has) make matters worse by being almost entirely about process not understanding.

There are some further notes and appendices below. Perhaps I can pick this line from the second!

What is worse, over the years, engineers have come to think that these bridges are robust and don't fail, so they have become much less careful with their inspections and measurements.

Appendix One Hannah Arendt

I have just been listening to "in our time" about Hannah Arendt. She came up with the expression "the banality of evil" and there was some discussion of what she meant. The point seems to be that Eichman did evil things as a thoughtless bureaucrat. He had no internal conversation, no introspection.

That set me thinking, at three in the morning, about engineering being handled in a thoughtless bureaucratic way. It is partly to do with the seriousness of what we do. Do we acknowledge that all we can do is our best or do we fret that we can never be good enough? And if the latter, how can we then manage our lives in such a way that we can live with ourselves and sleep at night.

The bureaucratic way of thinking provides such escape but requires a hierarchy in which the member at the face of the danger can shelter behind instruction from someone who believes themselves in some way better, but is so far removed from the consequences of decisions that there is no proper link.

If I employ someone to write a set of rules of engineering, if I set up a committee to oversee that work, then am I absolved of responsibility for the outcomes? At the other end of that train, does working within the boundaries of a set of rules somehow absolve me of responsibility?

The process leads to a situation in which adherence to the rules is seen by all parties as both necessary and sufficient. If the rules are found to be unworkable they are somehow changed, but the concept of them being wrong is never considered.

Engineers work in a world in which the laws of physics are immutable but not understood, or worse, wrongly understood. Modern physics does not really impact on structural engineers. The refinements of Einstein are too fine grained to impact on the effects of Newtonian mechanics. Even Newton, though, worked in that four-dimensional world of space time. Structural engineering is largely taught as a two-dimensional exercise, only extended into three dimensions in later stages. Even dynamics and fatigue, where time is an essential part of the problem, are often treated as two dimensional. The stress here changes with time and that change causes the "strength" to change in some way but then we are only looking at the two dimensions of stress and time.

I work in the narrow field of masonry bridges. Over my 40 years in the field I have become progressively aware of the dire results of attempts to simplify the problems. That simplification begins with conceptualising the arch as the structure and everything else as somehow “load”. Even a bare arch occupies three-dimensional space and defies attempts to narrow its behaviour to two dimensions.

That brings us to questions of conservatism. We are taught the need to make conservative (read safe) assumptions. To do that, it is necessary to understand behaviour well enough to know what is conservative. When the whole philosophy of design changes, as it did early in my career, mapping the outcomes of design may seem appropriate but all that really matters is the consequences. If your aim is that a beam should have a very similar apparent capacity, the fact that the capacity is arrived at through a different process can be masked but may have deep consequences, for people see rules as things to explore the boundaries of. The new rules may lead to a new way of formulating a solution but the formulation is driven by the codified rules not the underlying laws of physics.

This is all very hypothetical. Some concrete, tangible, examples are needed. To do that I need to set out the different design philosophies. In my youth, safety of structures was seen as an issue of setting a safe working load. In steel design, we began with a strength called the guaranteed yield stress. We could then design a beam such that the anticipated load never caused the stress anywhere to exceed that guaranteed yield. That concept was mapped into concrete, where the material is inherently more variable and providing a guaranteed strength is not really possible. In any case, the guarantee is masking a statistical situation in which what is being offered is a capacity from which it is extremely unlikely to fall short. The new philosophy recognised that variability and noted that there is always a chance of a load being exceeded. Either because of inherent variability (how much does a bed weigh?) or because of a fundamental change in design (can I put a water bed on this 18th century floor).

My point here is that if the concept of analysis is built around a safe working load and not around basic physics, it becomes inherently dangerous to apply new fundamental rules of design without properly investigating the corresponding rules of analysis.

If the arch were the entire structure of an masonry bridge it would still be complicated by being wide and continuous. If we conceive the possibility of simplifying the problem to two dimensions by considering an effective strip to carry a particular load, we can then conceptually calibrate the strip on the basis of outcomes. We (the arch bridge community) carried out tests and noted the point at which cracks first became apparent. We then juggled our distribution model so that a load that caused a crack would be deemed just unsafe. If our distribution model was fundamentally wrong, that rule is only safe for the particular bridges tested. It cannot be extrapolated safely. It is NOT a model

So let's get a little more concrete. During the first world war, Tanks proved damaging to masonry bridges. The army needed to be able to decide rationally whether to begin to take a squadron over a bridge. After the war AJS Pippard developed a simplistic rule that he (not unreasonably) believed would provide that rationale.

His analytical work had to be hedged about with assumptions. One of those was that the load could be considered to occupy an effective strip of arch. That, in itself, is fundamentally untrue but the next step compounds the error. His distribution model to calculate the effective strip assumed that there was a major element of distribution through the fill and then another component from the arch, essentially working in transverse bending. He applied his load at the crown because that was where distribution was least and he believed that the distribution effect would outweigh the more onerous bending condition with the load at the quarter point. That gave him a two-dimensional structure.

He regarded the whole self-weight of the bridge as acting vertically and treated the arch as parabolic and the road as horizontal so the effect of that load could be treated by direct integration.

He recognised that there would also be longitudinal distribution but declared that there were already too many assumptions and treating the live load as a line would surely be conservative (as well as easy to calculate).

He also reduced the mathematical complexity by treating the arch as pinned at each end so there was only one degree of redundancy.

The arch was treated as an elastic rib which was centred at the intrados, though the span to rise ratio at the centre line is only slightly different and there might be a reasonable case for regarding the span on the centre line as being the same as that on the intrados.

In his first calculation he sought a no tension result (Thrust remains everywhere in the middle third) but found that to grossly underestimate the load at which the observed first crack developed. He (or rather his research assistant Leticia Chitty) then tried middle half. Eventually they found that if they used an arbitrary compressive stress limit at the crown the results for the bridges that had been tested produced a reasonable correlation.

Every one of those steps was rational within the environment in which he was required to work.

Finally, having produced a complex equation relating load to compressive stress, he plotted it and used a curve fit to reduce the complexity. I will not set out the terms in the original equation but will merely present it to demonstrate the complexity.

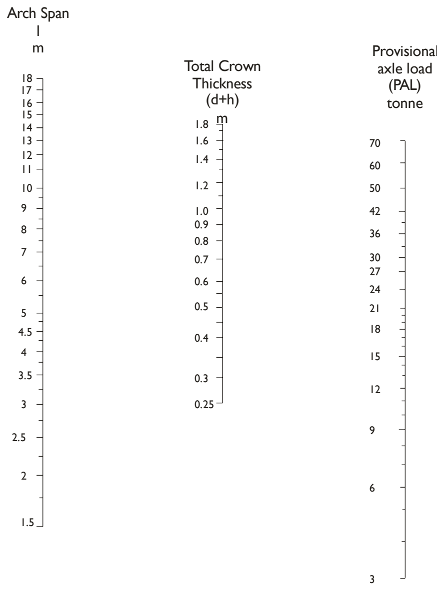
$$Capacity = \frac{\frac{256\sigma hd}{S} + 128\rho Sh\left(\frac{r}{28d} - \frac{1}{21} - \frac{h+d}{4r}\right)}{\left(\frac{25}{r} + \frac{42}{d}\right)}$$

By plotting a curve of that result for arches of 4:1 span to rise ratio, they were able to create a simpler curve where the result was everywhere less than the detailed one. That equation is more familiar:

$$W_A = \frac{740(d+h)^2}{S^{1.3}}$$

Here, S is the span, h is the depth of fill at the crown and d is the ring thickness at the crown.

That enabled him to produce a graphical slide rule for use in the field where no calculation would be possible.



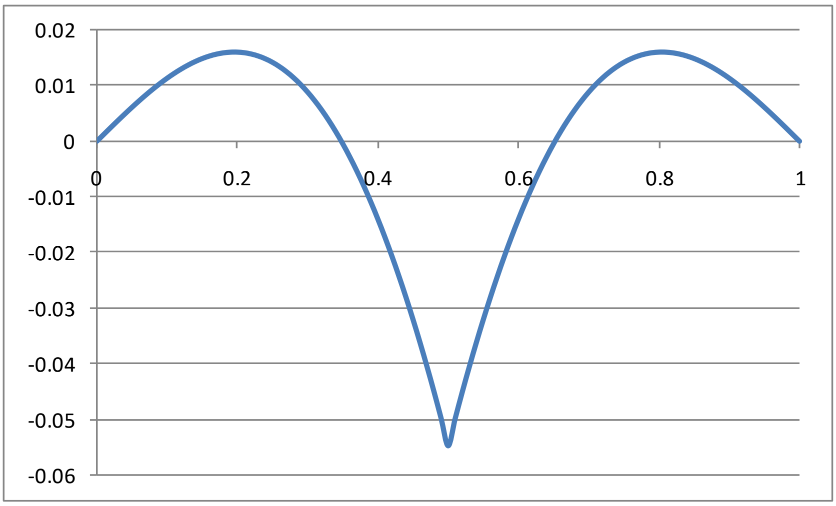
To compute the Provisional safe axle load you mark the span on the left hand column and the total thickness at the crown on the centre one, then project a line on to the third and read off the result.

I guess the first relaxation was "not to be used if h>d" was re-interpreted as make h the measured value up to a maximum of d. One suspects that is not as conservative as we think. There were a multitude of multiplying factors to allow for different span rise ratios, different shapes, different joint thicknesses and quality. Finally, a factor for condition which was essentially a guess.

Down the years there have been further modifications.

Oh, we can use a computer to do longitudinal distribution, forgetting Pippard's caution.

When they did that on the railways in 1971 they used an influence line for crown moment which looks like this.



Then they considered single axles and bogies, but the bogie axles were placed 2m apart which isn't common even now. The load from each axle was placed on one sleeper and then distributed at 1:1 through the fill so the spread of load was 0.25m + depth (probably at the crown). For the double axle they used a spread of 2.5m + depth, which is wrong in two ways. 2.5 should be 2.25 and for the first metre of depth, the two axles remain independent. If the load on the arch is distributed to a udl over 2.5m+, the most onerous place to put it is symmetrically across the crown. If the two axles are independent, no matter how little, the worst case will always be with one axle central.

By that time, of course, MEXE was nearly 50 years old and engineers had become blasé. How often have I been told "No arch has ever failed if it passed MEXE." Well, this arch (Figure 1) passes MEXE at a 40 tonne capacity and the damage was done by 22.5 tonne axles. And "but it hasn't collapsed" isn't an answer because MEXE was based on safe working load. Neither is it a valid answer to say "but the condition has changed". This damage is undoubtedly caused by live loads. Meanwhile, engineers were happy to modify MEXE to give higher capacities because they "knew" it was safe. One National Authority briefly inserted a proviso that the condition factor should be doubled before applying it. So if the engineer gave it a value of 0.4 which would mean that immediate repairs were needed, it would simply be changed to 0.8 because 0.8 is over conservative.

Figure 1 GSW bridge with broken voussoirs

There is a sense in which we have left MEXE behind, but its legacy lingers on. The distribution model for transverse spread is still used in all more modern 2D analyses, so refinement is given with one hand and taken away with the other. There is good reason to suppose that distribution is more something that happens as the thrust flows through the arch not as the load spreads through the fill. That means an element of the distribution depends on arc length not on fill depth. Such a distribution alters the shape of the thrust line so that a mechanism failure can never happen. Instead we get the sort of local damage shown in Figure 1.

And we are still required to apply a condition factor based on photographs of typical damage with arbitrary (in the true sense, decided by an arbiter) numbers attached.

If we are to have a hope of reasonable predictions of capacity we need (at least) both a new distribution model and a new criterion of failure.

The banality of bridge assessment

What has all this to do with Hannah Arendt? Begin with the bureaucracy of bridge assessment. Arch bridge assessment is easy. Put the required numbers into a program and out pops the answer. It can be done by junior engineers working as drones. I interact with many of them. When I say to them that the dimensions appear to be wrong, perhaps because they are just the wrong sort of number, they will usually reply that they must use the numbers they are given. If I get to speak to the bosses, I find myself arguing about how accurate it needs to be and “anyway, the client is not prepared to pay for a remeasure”.

Some of the senior engineers involved in drafting and redrafting the codes dislike the idea of engineers using judgement so they (without thought) make the judgement at one more step removed and write instructions not guidance.

The various codes for arch assessment are very dubious things. They are built on sand and extended beyond defence. Even when built at the same time by the same people, no two bridges are alike. The only real way to judge their response is to look at them, and perhaps to measure the response.

Engineering, like medicine is an area where the juniors must speak truth to power. If the truth is hidden from them, they can never do that. With luck, the consequences will not be fatal.

Appendix 2 - Engineering is the real world

I have been exercised for some time about the fact that engineers work in the real physical world but often distance themselves from that. The issue is particularly severe in the area I work in (essentially masonry bridges, though I do other stuff too). In the UK we have two codes of practice for arch bridge assessment (and note the change of terminology there, Masonry Bridge/Arch Bridge). They are similar, but differ in a number of ways. The differences imply a lack of contact with the real world and are driven by the ubiquitous cry of "not invented here". Or if you prefer, "we can do better than that". But there is no value in doing "better than that" with imaginary world ideas if they don't relate to the real world.

Dr Dykes, when installed as chairman of the Scottish branch of IStructE many years ago defined Structural Engineering as follows:

"Structural engineering is the art of modelling materials we do not understand into shapes we cannot analyse to carry loads we cannot define (to foundations …) in such a way that the public at large has no reason to suspect the extent our ignorance."

How does this impact on masonry bridges? Well, they are built of masonry which is a composite material made from very variable components.

Figure 2 Typical brickwork, variable bricks and mortar

If we are looking at a railway era bridge built of brick, the bricks were probably made from local earth fired in a temporary kiln. The brick layer's labourer will have selected the best for the shell but the lower grade bricks will have been used up in the interior. The lowest quality of all, the bits that broke up in handling, could be used as fill further up the construction and brick dust, mixed with lime mortar would often act as a pozzolan creating a type of cement. The mortar may also have been made from locally burnt lime which would also have been fired in a local kiln and slaked on site or even used as “hot lime”. Mortar, then, was another very variable material. So, we haven’t a hope of properly understanding the materials.

The shape is clearly defined and easily measured, or is it? If the arch were the structure, that might be so, but as Ted Happold liked to say, all structures are systems of interconnected stiffnesses. In that sense there are few structures interconnected in more complex ways. Most masonry bridges have spandrel walls on the sides which are perhaps two orders of magnitude stiffer than the arch itself. Between the walls might be some concrete or masonry in the lower levels and perhaps soil fill above. The fill acts as dead weight but also resists deformation of the arch. If the bridge has masonry parapets, they inescapably form part of the structure. So, we don’t really know the shapes.

The loads we have to assess for are actually well defined, though the nature of the definition (at least on the railway) is rooted in history and does not relate well to the way masonry bridges respond to load. And of course, the way the bridge responds to load is what we really need to know. Here we come to differences. Codes of practice are usually written by old men (we might hope for the future to engage old women too). The chances of having young engineers engaged are pretty slim, except in the role of draughting, producing the text at the behest of the elders. Many of those involved are not used to working with modern computing equipment so that rules like those for distribution of load through the structure follow patterns that are easy to implement in hand calculations but singularly difficult on computers. What is worse, they are simplified for hand calculation in ways that move the result away from reality.

And then there are foundations. Modern structural engineers are usually able to treat their foundations as essentially rigid. Such response to load as they exhibit is very small, and has an even smaller effect on the behaviour of the structure. That is absolutely not true of masonry bridges. The bridge is much stiffer than the foundations in most cases so movement of the foundations has a significant effect on the stress patterns in the bridge, often more than the direct live load stresses.

And that brings us to public perception. The general public see masonry bridges as almost part of the earth. Spectacular events may remove them but they also change the landscape and become part of it. What is changing is that bridges are starting to fail under traffic load, despite the fact that current assessment tools say that they have ample capacity. Assessment now requires much more thought than it did. If the calculations say OK and the bridge is failing then the calculations are clearly wrong, or based on the wrong perceptions. We are getting perilously close to being found out, if not by the public then at least by the bridge owners. Network Rail, in particular, are paying for assessments that cannot tell them anything useful. What is worse, over the years, engineers have come to think that these bridges are robust and don't fail, so they have become much less careful with their inspections and measurements.

As the first line of support for the Archie-M program I see many assessments and all too often find myself as the first person providing any guidance to a young graduate who has been presented with an inspection report and my program and told to get on with analysis.

Masonry bridge assessment is not a "process" that can simply be followed and QA-ed. Separating inspection and assessment is the height of foolishness since it distances the engineer from the structure and open eyes and an open mind are the primary requirements. A young engineer who has not, or has not been given time to, or even has not been encouraged to think about the nature of construction of the bridge is just going through the motions. What they produce is of no real value except to fill a space on the shelf and put a tick in the record. Bridge owners who accept and pay for such reports are as negligent as the companies that provide them. Better not to look at all than to claim to have looked but to have had your eyes closed.

Appendix – 3 A brief note on records

For perhaps 500 years, all bridge records were kept on paper. Before that there were probably no records. Over the past 40 years we have seen the slow development of bridge databases. They have produced no noticeable improvement in outcomes and have cost vast amounts of money. What has gone wrong and what needs to be done?

A "database" that is simply a different way of storing paper records adds no value and has costs associated with:

- Writing the software
- Input of the data
- Storage and backup
- Retrieving the data
- Adding data in a sensibly structured way.

Largely as a result of lack of trust, but partly through total lack of understanding, The bridge "owning", bridge assessing and the IT group at eg Network Rail seem to have been locked in a battle for many years. Both sides have a sensible case to make but both also have a case to answer.

Let's begin with the faults on the engineering side, which is our main concern at the BOF.

Someone decided a database was the way forward but offered no real design, or argument as to what might be needed and what might be useful. The task was delegated, probably to IT because the computer is at the core of what can be done. They ask the engineers what is needed and the engineers probably begin with a sulk about someone taking over their realm. They then say here is a batch of records. Build us a database. The IT folk have no idea what the structure needs to be or how to rationally break the information down. The engineers, at least, have been given no additional resources to do this.

So let's consider some of the questions that one could usefully ask of a properly constituted database:

- How many single span over line bridges are there on this line?
- What are their recorded spans? Do these make sense?
- What are their recorded shapes? Is there a pattern?

I don't need to go on. I have yet to see a database that could answer these.

If I add to this the note, recently discovered, that Amey, for example, routinely resample their photos to around 1Mb before adding them to pdf reports but then DESTROY THE ORIGINALS. Bridge records should always have the highest resolution photographs that can be obtained. Storage costs are no longer significant.

Enough.

Bill Harvey

18th Jan 2020