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# Writing for Tunnelling Journal - a personal view

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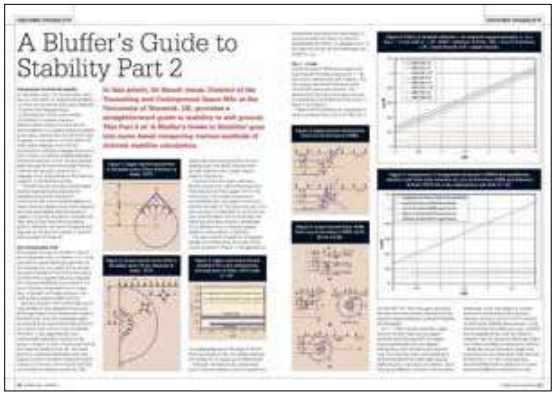
A Bluffer's Guide to Stability Part 1


A Bluffer's Guide to Stability Part 2

The openning spreads for Benoit's first two 'Bluffer's Guide' articles published in March and May 2014

## How it came about

In Summer 2011 and Spring 2012 I made two quite reckless commitments. I'm very proud now of the success I made of them both but have to admit that at the time I only signed up out of sheer ignorance of the enormity and complexity of the projects I was undertaking. I'm grateful for that ignorance in a way - I might never have agreed to either if I had known how difficult they were going to be!

In July 2011 after 11 years working in industry, I agreed to be the Director of a new MSc in Tunnelling and Underground Space at the University of Warwick, set up with the support of the British Tunnelling Society. At the time, there were only three other tunnelling MSc's in the world and no comprehensive textbooks that covered anything beyond tunnel construction methods in any kind of detail. Two months later I started at Warwick one week before the first cohort of students arrived.

What I did not know at the time was that an academic (or team of academics) are usually given several months, or even a year, to prepare a curriculum and teaching materials for a new MSc course. I was also blissfully unaware that my teaching workload was 2-3 times larger than what is considered 'normal' for an academic. For each new topic I had to synthesise the available literature through the prism of my own experience, decide what it was most important for the students to know, work out how to deliver it in a form that would make sense to them and enable them to apply it to real situations. In some cases, I was preparing lectures, tests, workshops and example problems right up to the night before teaching.

The following Spring my second foolhardy decision was to agree to write a regular column for Tunnelling Journal. At the time Tunnelling Journal was nearly 2 years old, and I was really impressed by the overall quality of the publication and its articles. Tris Thomas asked me to write a piece in each issue focussing on various technical aspects of tunnelling. I was intrigued by the idea of acting as a bridge between academia and practice. Some articles could be mini literature reviews, some perhaps could be more like opinion pieces or blog posts. The intensive work I was already doing synthesising the literature and making it accessible and useful for the students could be repurposed to produce articles for practising engineers, or an article could form the basis of a new or updated lecture. "How efficient!" I thought. "What a good way to raise the profile of the MSc!"

I went on to write 32 consecutive articles over 5 and a bit years. Tris was a brilliant editor. He encouraged me to make the articles as technical as I liked, with as many equations, citations and graphs as I pleased. He never changed a word (except just once replacing "teeny weeny" with the correct technical term: "very small"). All those fiddly equations, citations and graphs were reproduced flawlessly, and some articles ended up being a lot longer than 3 pages!

The looming, immoveable deadlines were sometimes a huge struggle to stick to alongside my already punishing teaching schedule. Each article took between 2 and 7 days to write, often in the evenings and at weekends. However, looking back, I'm genuinely very proud of this body of work; undertaken in laughably naïve optimism but carried

## A List of Tunnelling Journal articles

| No. | Issue | Title | What was it about? |
|---|---|---|---|
| 1 | Apr/May 2012 | A loaded question | Stresses in tunnel linings |
| 2 | Jun/Jul 2012 | Waterproofing sprayed concrete tunnels | |
| 3 | Aug/Sep 2012 | Structural form of tunnel linings | How shape changes the loading |
| 4 | Oct/Nov 2012 | Competence | |
| 5 | Dec 2012/Jan 2013 | Being analytical | Analytical methods |
| 6 | Feb/Mar 2013 | Resilience | |
| 7 | Apr/May 2013 | The future is smart and sustainable | |
| 8 | Jun/Jul 2013 | The most difficult question? | Prediction of ground movements |
| 9 | Aug/Sep 2013 | Critical infrastructure | |
| 10 | Oct/Nov 2013 | Stresses from strains | Back-calculating stresses from measured strains in a tunnel lining |
| 11 | Dec 2013/Jan 2014 | Strength Monitoring Using Thermal Imaging | |
| 12 | Feb/Mar 2014 | A bluffer's guide to stability part 1 | |
| 13 | Apr/May 2014 | A bluffer's guide to stability part 2 | |
| 14 | Jun/Jul 2014 | A bluffer's guide to stability part 3 | |
| 15 | Aug/Sep 2014 | Roundup of the 7th International Symposium on Sprayed Concrete | Summary of papers presented at this symposium in Sandefjørd, Norway |
| 16 | Oct/Nov 2014 | The Warwick MSc 3 years on | |
| 17 | Dec 2014/Jan 2015 | Case studies | How to write a case study |
| 18 | Feb/Mar 2015 | Segmental lining joints | |
| 19 | Apr/May 2015 | Segmental linings – longitudinal effects | |
| 20 | Jun/Jul 2015 | Horizontal ground movements part 1 | |
| 21 | Aug/Sep 2015 | Horizontal ground movements part 2 | |
| 22 | Oct/Nov 2015 | Probabilistic methods | Probabilistic tunnel design methods |
| 23 | Dec 2015/Jan 2016 | Tunnel junctions | Design of tunnel junctions |
| 24 | Feb/Mar 2016 | Carbon reduction in tunnelling | |
| 25 | Apr/May 2016 | Tunnel design guidance review | |
| 26 | Jun/Jul 2016 | Fibre reinforced concrete tunnel linings – a review of new guidance | |
| 27 | Aug/Sep 2016 | Rotational stiffness of radial joints in segmental tunnel linings | |
| 28 | Oct/Nov 2016 | Long term settlements due to tunnelling | |
| 29 | Dec 2016/Jan 2017 | Overview of technology in today's tunnelling projects | |
| 30 | Feb/Mar 2017 | Blow-out failures part 1: frictional soils | |
| 31 | Apr/May 2017 | Blow-out failures part 2: purely cohesive soils | |
| 32 | Jun/Jul 2017 | Materials design for tunnel linings | |

through by an increasing conviction that the articles were useful and interesting to those who read them.

### Why were these articles worth writing?

My aim was to "act as a bridge between academia and practice", but what does this mean and why is it necessary?

Most academic research output is presented in the form of journal or conference papers. These start with an introduction setting out the current academic consensus and end with a discussion and conclusions demonstrating how it has changed as a result of the new findings. However, this isn't necessarily any help at all to an engineer who wants

An excerpt for Benoit's first article for TJ 'A Loaded Question' published in May 2012. Below that, his favourite article, published in July 2013, 'The most dificult question'.

to incorporate new knowledge into their work. First of all, due to space constraints, introductions and discussions in academic papers are often very concise. Secondly, academic papers tend to put academic research into context only with respect to existing past and possible future academic research, completely ignoring both the current state-of-the-art of tunnel design and construction and how these new findings could be used by industry to make improvements. For instance, there is very rarely space made in an academic paper to work through a real world example of a tunnel design, to show how new knowledge should be applied in practice, or to compare say, a new method of modelling the behaviour of segmental lining joints with existing methods.

Lastly, to read and understand a technical academic paper takes time. It helps if you already know the area, but even then, there are often lots of cited papers to look up, and a lot of detail to pick through. Some papers are now made available for free on the internet, but many still are not, and you can only read them if you already have a journal subscription or pay a one-off fee. Academics have ready access to virtually all of the available journals through their university libraries, but for many in industry this is a time-consuming practical and financial barrier to knowledge and engagement.

Therefore, there is a pressing need for much more of the academic engineering research that is going on in the world to be synthesised, put into context and presented in a way that makes it easy to incorporate into industry practice. This is what I set out to do.

## What did I write about?

A list of all the articles is given in the table on the previous page. They are all available for free from Tunnelling Journal's digital archive on their website.

The first article, "A loaded question" was an easy one – the measurement of stresses in tunnel linings was partly the topic of my doctoral thesis. It sets out the philosophy of tunnel lining design in soft ground, and why we need to measure stresses in tunnel linings to properly calibrate design models.

The second, "Waterproofing sprayed concrete tunnels" showed how penetration of water through concrete can be calculated and came to the conclusion that in most cases water will only penetrate through cracks or joints and not through the intact concrete during a typical design life of 100-200 years. If a waterproof membrane is installed that is bonded to the primary lining, then water pressure will only act at crack or joint locations, resulting in a very low water load on the secondary lining. This argument subsequently found its way (without citation!) into the marketing materials of most sprayed waterproof membrane suppliers.

I am particularly proud of 8, "The most difficult question?", because my friend Jiang Su told me that reading it made him miss his train stop. It's also quite funny. If you are going to read just one, then choose this.

Another corker is "Stresses from strains" (10), which is very critical of back-calculation methods


A Loaded question


The most difficult question?

used to estimate stresses in shotcrete tunnel linings based on lining displacement measurements. Since I wrote that in 2013 I have used a variant of the 'rate of flow method' to back-calculate stresses from strains measured by strain gauges in the Heathrow Express Terminal 4 Station Concourse Tunnel. Strain gauges are far more accurate than optical surveying and the results compare well with stresses measured by tangential pressure cells at the same locations. This will hopefully be published at some point this year – get in touch if you'd like a pre-print sneak peek!

In soft ground tunnelling, the main consideration when selecting the construction method is face stability, a fact largely ignored by textbooks on construction methods. It therefore formed the backbone of the MSc 'Underground Construction Methods' module. Students learnt to calculate drained and undrained stability for open face tunnels, as well as EPB machines and slurry TBMs. They also learnt how ground freezing, grouting and dewatering improve stability. The teaching materials from this module were condensed into articles 12, 13 and 14 "A bluffer's guide to stability". To my knowledge this is the only literature review of the subject since Mair & Taylor's Themed Lecture at the ICSMFE in 1997, and is much more detailed.

The performance of segmental lining joints has been a fast-changing area of research in the last 10-15 years. Article 18 was a mini literature review that summed up all the latest research and its implications for design. Article 27, "Rotational stiffness of radial joints in segmental tunnel linings", followed a year or so later, and gave examples of how to calculate rotational stiffness of a radial joint

with different types of packer between the joint faces. It also showed how rotational stiffness is not constant but varies with rotation angle and how both plastic and bituminous packers cause much larger bending moments than a (hypothetical) linear elastic or a (real) plywood packer. This was a completely novel result and is an important detail to consider in the design of segmental linings.

In 2017, near the end of my long run of articles, I wrote a two-parter on blow-out failures. Blow-outs are an under-appreciated risk and there has been very little research done on them. I described different blow-out mechanisms, reviewed calculation methods and gave guidance for designers, but the lack of research in this area is in itself something industry engineers need to know about, both to guide their own practice but also to motivate them to exert pressure on academics and research funders to rectify this and other such worrying omissions.

When I started, I kept a list in the back of my notebook where I collected ideas for future articles. I made a rule that if there were ever fewer than 3 ideas in the list I should think about stopping. Perhaps I will start keeping a list again. When I do, my first choice of publication will always be Tunnelling Journal.

### Was it all worth it?

I sincerely hope that some of these articles have been useful to my fellow engineers working on tunnelling projects. I certainly enjoyed writing them, and many of them helped with the development of teaching materials for the Warwick Tunnelling and Underground Space MSc. The MSc curriculum and these articles, updated and augmented with more topics and examples, form the basis of the textbook I am currently writing for Taylor & Francis. 'Soft Ground Tunnel Design' will be available (I hope!) later this year.

Sometimes recklessness leads you to interesting places.

## References

Mair, R. J. & Taylor, R. N. (1997). Bored tunnelling in the urban environment. Theme Lecture, Plenary Session 4. Proc. 14th Int. Conf. Soil Mechanics and Foundation Engineering, Hamburg, Vol.4, pp.2353-2385.