LETTER TO EDITOR

Comments on Rick Henry Paper in Vol. 34 No. 2 September 2021

"INNOVATION – THE NEXT BIG THING OR THE NEXT BIG FAILURE?"

Dear Sir,

I highly commend Rick Henry for his excellent paper regarding 'innovation' in the context of NZ structural engineering and building construction. To do full justice to the issues that Rick has raised would take up multiple volumes, so I just attempt to add a few comments to important technical examples he has included, and add a few suggestions at the end.

Auckland Harbour Bridge:

The only slight disagreement I have with what Rick has written is in relation to the 'slender spans' and 'flexibility' of the Auckland Harbour Bridge (AHB) 'clip-ons'. It is true that the main plates forming the box sections are thin (to say the least) and section depth is very shallow at mid-span, but according to Bob Norman (then Deputy-Commissioner of Works) when he spoke to our class in 1980, the original design section depth at mid-span was considerably smaller until he intervened.

The design of these clip-ons did not involve otherwise good engineering trying to be too efficient. At around the same time as the design and construction of the AHB clip-ons were underway, two bridges designed by the same firm collapsed during construction with multiple fatalities – the West Gate Bridge in Melbourne and one at Milford Haven in Wales. The report from the commission of inquiry into the West Gate Bridge is outstanding (comprehensive, concise – about 6mm thickness of foolscap-sized paper, and damning). To be fair, around the same time, three other steel box girder bridges collapsed during construction: one in Austria, one in West Germany and one in East Germany. In totality, the systems being employed may have been new and 'innovative' but there were considerable 'cavalier' attitudes involved, and poor engineering, poor detailing and poor material selection.

My main point – irrespective of whether a type of construction is routine or innovative, the fundamentals of good sound engineering, documentation and construction, with competent, experienced and ethical people involved at all stages must always apply. The ongoing litany of failures and mistakes that fill the issues of the CROSS reports prove that.

Hollowcore (and other precast floor units):

My understanding is that one of the main drivers for the introduction of precast floor systems in NZ buildings was the time consuming and costly nature of the formwork of the time – I cannot say 'formwork systems' because the formwork was constructed on-site from individual boards, and I think was generally only used once. It is clear, in my opinion at least, that engineers, the construction industry and NZ as a whole would have been better served by putting the 'innovation' into the formwork systems (as most other developed countries did) and maintaining the skill base and productivity of our concrete workers.

I disagree with Professor Park's statement that is quoted: *"Even if there were no reason to doubt the validity of* ***extrapolating*** *the results of design and construction procedures that were originally developed for cast-in-place concrete …"* I cannot see how the precast floor units were an 'extrapolation' when, as I have written several times before, in many ways these precast floor systems never complied with the detailing requirements for one-way in-situ slabs in the governing concrete standards that applied over time. Worse, as numerous forms of precast concrete became dominant, the governing concrete standards were written as if concrete construction was predominantly cast in-situ, with only a few add-ons to supposedly cover some aspects of precast.

Precast Wall Panel Base Connections:

It must be borne in mind that the relatively long but not long enough types of threaded insert shown were (despite their relatively loose thread fit and resulting slip) an enormous improvement over the ridiculously shallow TCM anchors that were often previously used (although not usually for full base fixity) and the 'innovative' Grade 500E starter bars that were fracturing on rebend, or, worse still, not quite fracturing. Even improved details such as using Grade 300E starters will count for little if the bending and rebending of the starters does not comply with specified good practice. All too often, I see such starters still being flattened hard against panels, and/or being bent far beyond the 180 degrees of total bend recommended.

Poor Ductility in Lightly Reinforced Concrete Walls:

Lightly reinforced walls, and more heavily reinforced walls with a single layer of reinforcement, have been and remain an extremely common and widespread form of construction in NZ. These include cantilever wall panels used in warehouse type buildings (as per the previous section), and those used in apartment and office buildings. In 2003, in response to my Open Letter, one of the comments was "We have been studying precast wall panels for 11 years now". Eighteen years later ("29 years now"), in SESOC Journal Vol. 34 No. 1 April 2021, Richard Fenwick and S P Llano point out numerous deficiencies in our current state of knowledge, the fact that NZS 3101 codifies singly reinforced walls with very low axial loads for in-plane actions and for out-of-plane actions separately but not for combined loading, a lot more work needs to be done, and it all needs to be properly codified.

To the above I would add the need to properly study and codify precast floor support details for such walls (and doubly reinforced walls as well), including the effect these support details may have on the overall performance of the walls. There are multi-story apartment buildings (in

Auckland at least) that have been built using singly reinforced walls, and now we have experts saying there are very significant unknowns and issues to be resolved. This is simply not good enough.

Unstiffened (and Stiffened) Gusset Plates for BRBs

Bi-directional demands are only part of the problem with BRB systems. I am no expert on these, but I have recently done quite a lot of research into the available design information and recommendations regarding BRBs for the last class of my mentoring course.

A properly fabricated BRB from a well-established and competent supplier is a wonderful thing – capable of very considerable cyclic inelastic response whilst maintaining full load carrying capacity.

However, that is only the BRB brace itself, and without the rest of the lateral load resisting system, outstanding BRB performance counts for nothing.

Certainly, gusset plate analysis and design, including the rotational stiffness of the supporting members, the out of plane effective length and stability, and the effect of out-of-plane deformation on the gusset plates, is complex and difficult.

However, buckling and tearing of beam and column flanges and webs adjacent to the edges of the gusset plates, and the serious risks posed by and the need for reliable suppression of the concentration of inelastic demand and soft-storey effects, are also very important. To ensure the latter does not occur, non-linear time-history analyses under earthquake loading are likely required, even when strongback frames are introduced.

Torsional Actions on the Concrete Slotted Beam and Lessons from That

One aspect about the development of the concrete slotted beam by Des Bull and his post-graduate students that most impressed me was the consideration of the primary torsion on edge beams, resulting from the eccentric loading from the precast floor units, from the very start.

However, I cannot understand how this knowledge seems to be completely ignored when it comes to considering the assessment and likely retrofitting of existing precast floor systems supported by ductile reinforced concrete frames. After a "$\mu = 6$" beam has developed and cycled through full plastic hinge formation at its ends, and suffered the additional cracking damage due to beam elongation, how can the torsional strength and stiffness of the beam be any better than the undamaged torsional strength and stiffness of a slotted beam lacking a concentration of hanger bars to the loaded side? Yet when I ask this question of experts involved in this research, I am told torsion on these damaged beams it is not a problem. I remain unconvinced.

Premature Failure of Post-Tensioned Anchors Used In Rocking Walls

Rick describes the premature failure of post-tensioned anchors (to unbonded post-tensioning cables) in rocking walls, with the anchors having been developed for static loads only.

In the Anchorage Earthquake of 1964 (only 45 years before the testing described), was'nt failure of end anchorages to unbonded post-tensioning cables in slabs one of the more spectacular and famous types of failure observed and recorded?

"The ability for ideas to be shared and debated is essential..."

Rick is completely correct when he states:

> *"The ability for ideas to be shared and debated is essential to the development of innovative solutions. …. Sharing experiences of not only the successes but also the failures will go a long way to preventing repeated failures or the continued use of a design or product that does not work as intended."*

Unfortunately, such critical debate can be very dangerous to those engineers and others in the industry who need to be speaking out the most, because of the threats and use of defamation laws and the like that are often made.

Before discussing this, I wish to repeat two observations made by others:

- Profits are privatised, but losses are socialised (said in relation to very expensive failures of various building products over the years, and not just 'leaky homes').
- Once a brand new building has its Code Compliance Certificate, the level of earthquake performance required of it is not compliance with the current Building Code, but simply that the building is not 'earthquake prone' (given the expressed attitude of at least one council when the discovery of design deficiencies rendered the council's Code Compliance Certificate for a new building not worth the paper it was printed on).

I know two structural engineers (one of whom has spoken publicly about this) who have had to endure very serious threats for simply doing their job and finding multiple design deficiencies in buildings owned by their clients but which were designed by other engineers. These good engineers were fully vindicated, but in the meantime they had to endure threats of crushing defamation lawsuits and the like. Engineers and lawyers who make such threats, should be struck off permanently. If an engineer believes he/she has done nothing wrong, then he/she should be prepared to front up and prove that through debate, and public debate if need be, not through secretive and not-so-secretive legal threats.

But it gets worse. In relation to 'leaky buildings', the estimate of total costs and losses were initially estimated at $1 billion, then $11 billion, then $22 billion. In 2019, in his book Rottenomics: The Story of New Zealand's Leaky Building Disaster, Peter Dyer raised the estimate (for dwellings alone) to $47 billion.

My understanding is that several years ago, a timber scientist was sued and suffered crippling financial losses

because he questioned the effectiveness of a new type of timber treatment that was intended to prevent rot of timber used internally.

Certainly, once a major building product or structural system has become established, there will be powerful commercial interests associated with the supply and sale of that product or system and those interests will vigorously resist any restrictions, as long as they continue to make money. Wider technical interests will not be the sole regard. Imagine if a litany of lawsuits due to product failure meant those same commercial interests would have to pay out a fortune in damages. The manufacturing or supply company could disappear overnight, likely leaving the losses to be socialised through taxpayer assistance to the affected if the problem was widespread.

Clearly, laws have to be changed to protect the people willing to actually engage in meaningful debate of the type Rick quite rightly proposes.

Another change that has to be made to ensure the sharing of ideas and essential debate relates to the peer review process in engineering journals. Many areas of structural engineering have competing 'factions' with fundamentally different approaches – the 'truth' may lie at one extreme or the other, or perhaps in between: or maybe both factions are wrong.

In far too many instances (but fortunately not the SESOC Journal from what I can see), a proposed paper from researchers or engineers from one faction will be peer reviewed by a person from the other faction, and publication may be stopped, not because of absolutely demonstrable nonsense being expressed but perhaps due to professional disagreement or even jealousy. This sort of nonsense has to stop. Unless the proposed paper is clearly nonsensical, the best approach is to allow the paper to be published and then for the opposing faction to engage in a debate with the authors in the publication, for the benefit of the readers.

As readers of the letters to the editor section of this Journal would be aware, I do not share Rick's faith in the role of technical societies to resolve these issues. Even if they were prepared to properly address these issues and speak out accordingly, they currently lack the power to effect the systemic changes necessary in each instance, and simply lack the resources and the ability to allocate necessary funding for testing or research.

Some Additional Points

Our freedoms and rights and constitutional protections as New Zealanders have been under slow but serious attack for decades now, with the attack quickening over the last two years.

However, one freedom that I wish to see removed (because it is no real freedom, only a potential danger), is the freedom to import any building product from anywhere in the world, and expect beleaguered engineers or building inspectors to prevent disasters. Readers will be aware of issues with imported defective bolts and steelwork, but the worst example I have ever heard of was revealed in a North & South article in 2009. A building inspector was describing how shower units from China made from plate glass were being imported into NZ, and horrific future injuries were only being prevented (to some extent at least) through conscientious building inspectors checking for this. Apart from the odd piece of so called 'modern art', building products are installed in buildings and other structures, and there is absolutely no reason to allow non-compliant products across the border.

Rick mentions problems potentially created from 'mixed building systems'. Mixing of different systems is often done on a job-by-job basis, supposedly to minimise cost on that particular project, but the number of combinations and permutations of different floor, gravity frame and lateral load resisting systems being used is quite staggering. We would be far better off to minimise the number of (combined) systems being used, finally confirm proper and comprehensive design and construction methods for those systems, and train the work force how to build those systems properly and efficiently.

We actually have the money and resources to do the following – we need to increase the number of experts we have researching and developing structural systems, with the first priority being to resolve fundamental issues with the most commonly used forms of construction, and to get the necessary design guidance in one place in a coherent and useful form, not spread across a myriad of papers published in multiple journals. For our key systems, that needs to be done in short order.

Greg MacRae has advised that in Japan and other jurisdictions, if a building design or new structural system is proposed that is not covered by existing codes (either because it is truly innovative, or is too much of an extrapolation beyond existing proven bounds) a standing technical committee reviews what is being proposed, and stipulates what testing and analyses are required to verify that what is being proposed will perform as claimed, and be fully code-compliant.

That approach should apply to the importation of new materials and systems, and prior to the establishment of manufacturing facilities in NZ. We need and want good products and systems, but we cannot afford to have any more bad ones introduced.

The Most Effective Vehicle to Address These Problems

Rick has correctly identified many problems relating to existing buildings and current practices caused by ill-considered innovation over the last six decades or so, and he wishes to not only address these current problems, but to eliminate or at least significantly reduce the chance of similar ill-considered innovation-related problems occurring in future.

The only mechanism I can see being able to properly address these problems is the type of technically competent, bureaucrat-free Ministry of Building and Construction I have been proposing for years now, complete with a carefully selected oversight board.

Only such a ministry can, in short order, do such wonderful things as:

- Build up a sufficient body of key experts able to work near full time to sort out and resolve the problems and unknowns present in our current building systems and practices;
- Provide funding for associated testing and analyses;
- Through a planned and coordinated funding of other research activities, guide other researchers to, at least in the short term, concentrate on the things we need answers to, not the researcher's latest new idea;
- Provide the standing technical committees that ensure the proper testing, verification and design methodologies are developed before an innovative product or method is released, and not after it has been established;
- Ensure that the codes, standards and design guides are coordinated, so that, in a simple and comprehensive way, all major building systems are properly and clearly codified in as few different documents as possible;
- Foster genuine debate and invite searching critique;
- Enforce compliance.

A technically competent and ethical ministry would have the power and the will to say "Stop that now" or "This is banned' and enforce it, and not issue statements like "It is unlikely that it will be able to demonstrate that this system complies with the Building Code."

Regards,

John Scarry

SESOC Member

CITATION

Hamish McKenzie is awarded Life Membership of the Structural Engineering Society of New Zealand in recognition of the significant contribution he has made to the practice of structural engineering in New Zealand through professional support and standards development and in recognition of his significant contribution to SESOC as a Management Committee member and President of the Society.

Hamish's qualifications include a BE (Civil) with First Class Honours from the University of Canterbury. He is a Chartered Professional Engineer. Hamish was made a Fellow of Engineering New Zealand in 2020.

Hamish has over 25 years experience as a consulting Structural Engineer in a variety of roles and locations in New Zealand and overseas. Hamish is Principal, Structures with Holmes Consulting, based in Wellington.

His recent project experience includes the seismic strengthening and assessment of a number of well-known Wellington buildings including Parliament Buildings, Wellington Town Hall, Majestic Centre and the Wellington Railway Station. Hamish has also led the Structural Engineering delivery of a new Air-Traffic Control Tower at Wellington International Airport and the refurbishment and strengthening of the 1960's Aurora Centre using fluid viscous dampers (a first in New Zealand).

Hamish is a recognised leader within the Structural Engineering community in New Zealand. Hamish served as SESOC President for two years until 2021. In his term as President he devoted many hours working with Engineering New Zealand on responses to issues facing the profession and he continues that involvement.

He is a member of the Engineering New Zealand Programme Challenge Group, the C5 Evidence Project, the Precast Floor Assessment Monitoring Group, the Systems Report Working Group, a Structural CPEng Practice Assessor and is Project Director for the Low Damage Seismic Design project. Hamish is a keen advocate of professional standards and as a member of the Occupational Regulation Working Group, he led SESOC's submission on occupational regulation and championed looking upon it as part of a quality life cycle.

As a nationally and internationally respected structural engineer and for his tireless devotion to the profession, Hamish McKenzie is a worthy recipient of the award of Life Membership of the Structural Engineering Society of New Zealand.

SESOC President

Michelle Grant

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