ACSEV NEWS

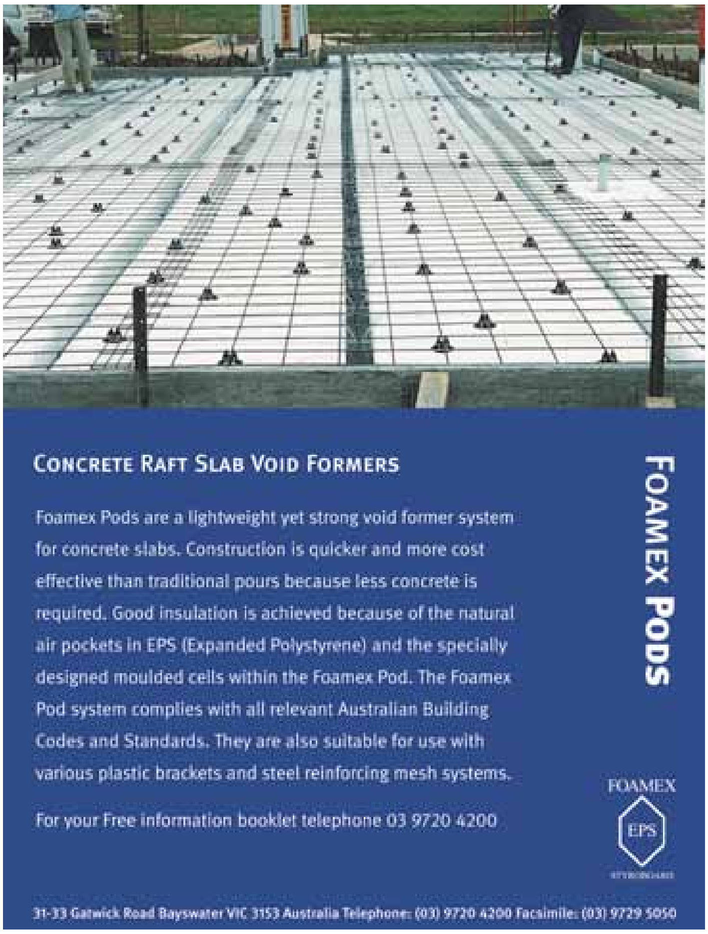
ASSOCIATION OF CONSULTING STRUCTURAL ENGINEERS (Vic).
Associations Incorporation Registration No. A0026069J

WWW.ACSEV.ORG.AU

June - Sept 2011, ISSUE 183

Performance of buildings during Cyclone Yasi

THIS ISSUE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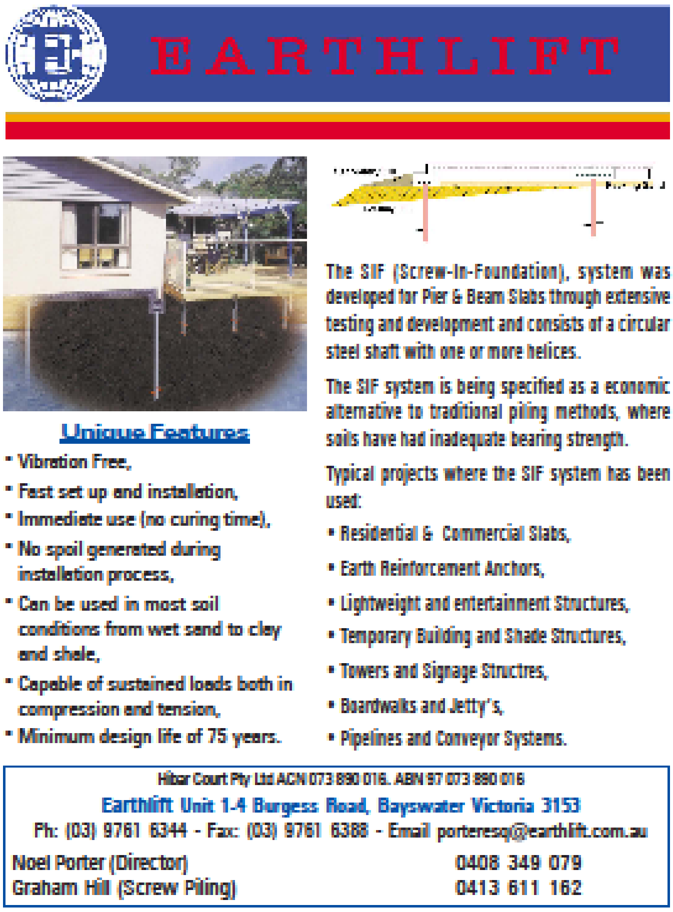
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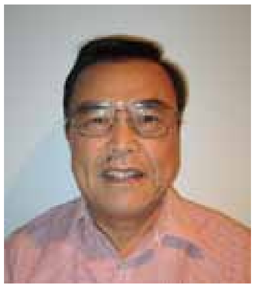
Noel Porter (Director) 0408 349 079
Graham Hill (Screw Piling) 0413 611 162

PRESIDENT'S REPORT



October is always an important month of the year for ACSEV. It is the ACSEV AGM on the 19th October. It has the added significance this year in that we will be asking members (financial members) to vote on a special resolution to update the ACSEV constitution, to reflect the changes in technical activities that the Association is now involved in, and also to bring the Constitution in line with the Model Rules issued by Consumer Affairs Victoria. It will be passed if 75% of the members present vote in favour of this proposed special resolution.

We look forward to your attendance to vote for the adoption of the new Constitution and also partake in the election of the new committee. We have also arranged for Tim Gibney and John MacFarlane to discuss the recent changes to AS2870 and how it affects design engineers.

This year ACSEV has also embarked on a new venture, as a special service to ACSEV members, to run low cost but intense half-day training seminars on specific design software.

On the 23rd of June, 2011 the first training seminar on CADEsuite V3 design software was successfully conducted. The forthcoming seminar on Structural Toolkit V4 design software is scheduled to take place on the 3rd of November, 2011.

We have had tremendous response and it has been so overwhelming that I am pleased to report that the committee aims to conduct a "second take" of these seminars. We also aim to cover a range of other software products over the next 12 – 18 months. Details in this regard (via the electronic medium) will be announced further down the track.

Summer and the festive season are fast approaching – a reminder that ACSEV Annual Dinner is on the 12th November. I look forward to the pleasure of your company (& your partner) for the occasion and perhaps also to reminisce on a successful and memorable year.

On behalf of ACSEV committee, I wish everyone a Happy and Festive Season.

Francis Hsieh
ACSEV President

Use of Shape Memory Alloys as a Smart Material

Associate Professor Bill Wong

Department of Civil Engineering, Monash University, Melbourne, Australia 3800

1. Characteristics of shape memory alloys

Shape memory alloys (SMA) are special metals which exhibit unique mechanical and thermal properties such as shape memory effect and super-elasticity. Shape memory effect is the ability for the alloy to undergo large plastic deformations and subsequently to return to its original form upon heating above a specific phase transformation temperature. Super-elasticity is the recovery of large strains during mechanical loading and unloading under isothermal conditions.

The earliest reported use of the term 'shape recovery' was by Chang and Read (1951) while working with gold-cadmium alloys. The most common type of shape memory alloys were discovered by William Buehler and his co–workers in 1962 while working at the Naval Ordnance Laboratory. The commercial version of these alloys is made of nickel (Ni) and titanium (Ti) and is commonly known as Nitinol manufactured in the USA.

The shape memory effect of these alloys is demonstrated by a thin wire made of NiTi shown in Figure 1. The wire shown in Figure 1(a) is initially straight but subsequently bent into an irregular shape as shown in Figure 1(b). The wire is then dropped into a beaker containing hot water of above 60oC and instantly regains its original shape as a straight wire shown in Figure 1(c).

(a) initial shape: straight wire (b) bent wire dropped in hot water (c) initial shape recovered

Figure 1. Shape memory effect of NiTi SMA

The ability for SMA to exhibit the shape memory effect is mainly due to temperature rise through the phase transformation region in which the microstructure of the materials changes from its martensite phase at low temperatures to its austenite phase at high temperatures. The phase transformation temperatures depend on a number of factors and can be determined typically by Differential Scanning Calorimetry (DSC). A typical differential scanning calorimeter is shown in Figure 2.

Figure 2. Differential scanning calorimeter

Factors affecting the phase transformation of SMA include the precise amount of chemical composition, the manufacturing history, the heat treatment temperatures and the stress level at which the materials are subjected to. Figure 3 shows results of the effect of heat treatment temperatures on the phase transformation temperatures of SMA samples made of NiTi (55wt%Ni, 45wt%Ti) using DSC tests carried out in the Department of Civil Engineering at Monash University (Sadiq, et. al. 2010). In Figure 3, the top lines represent the heating of the samples from martensite to austenite while the bottom lines represent the cooling from austenite to martensite after subjecting the samples to different heat treatment temperatures. It can be seen that during the cooling process, an intermediate R-phase may also occur. As each phase transformation occurs over a range of temperatures, the phase transformation temperatures are usually described as As (austenite start) and Af (austenite finish) for a martensite to austenite phase transformation, and Ms (martensite start) and Mf (martensite finish) for an austenite to martensite phase transformation.

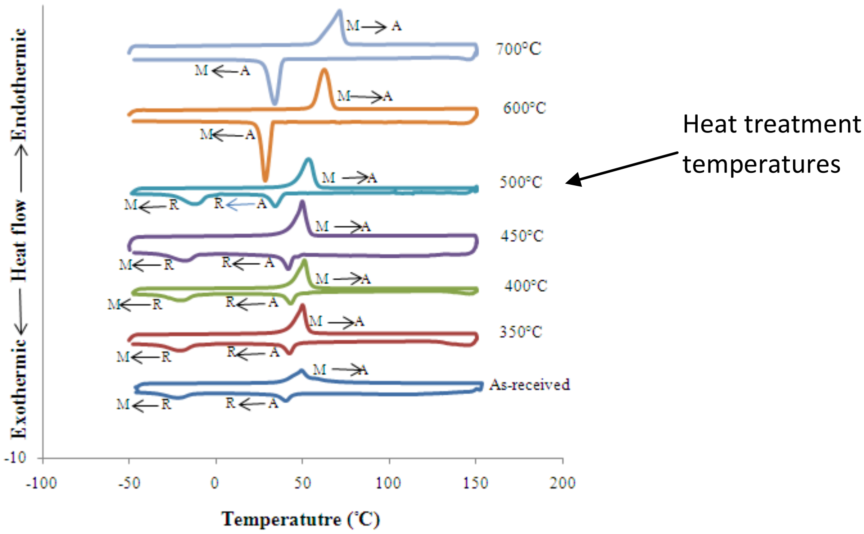


Figure 3. Effect of heat treatment temperatures on phase transformation of shape memory alloys

Apart from the shape memory effect, SMA also possess super-elastic characteristics. The features of super-elasticity are schematically shown in a stress-strain diagram in Figure 4. At low temperatures below Mf when the sample is in its martensite phase, it behaves like typical ductile metals except that it can deform with very large strains at virtually constant stress. Upon unloading to zero stress, a residual strain exists. If the sample is then heated to a temperature above Af without constraint, the stress path follows that of the thick dash line for the austenite phase in Figure 4 and reverts back to the origin of the stress-strain diagram. At this point, the sample regains its original shape.

If the sample with the residual strain is constrained when being heated to a temperature above Af, a recovery stress will be induced as shown in Figure 4. This recovery stress pertains to a value on the stress path in the austenite phase where, for further loading, the ultimate stress at fracture could be more than 1000 MPa. It is this recovery stress which many industrial applications have been able to exploit. In most applications, temperature is raised to above Af by supplying heat energy through electrical means.

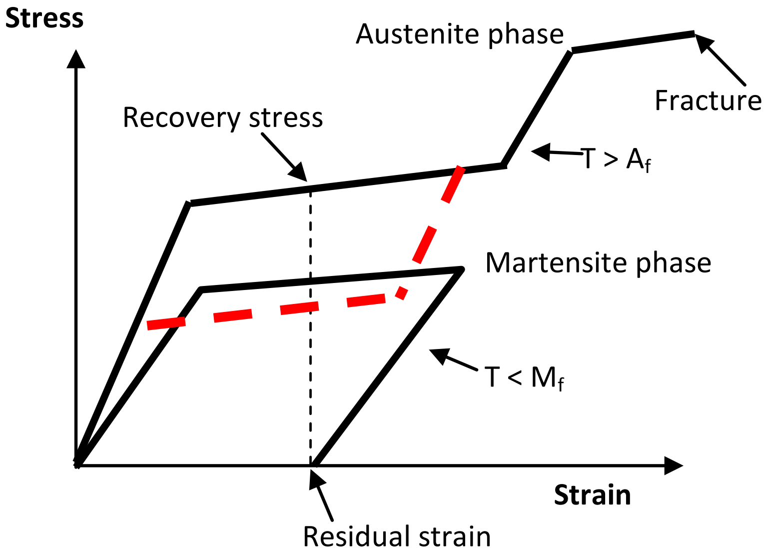


Figure 4. Super-elasticity and shape memory effect of SMA

2. Applications of shape memory alloys

The special characteristics of SMA enable the materials to find the way in many industrial applications. Due to the complexity of the thermo-physical properties of SMA and their sensitivity to chemical composition, the design of any application of SMA requires a thorough understanding of its behaviour.

The aerospace industry is a major user of SMA such as couplings for tubing connections where the phase transformation occurs only at very low temperatures. To release the grip of the coupling, extremely low temperature must be applied to enable phase transformation to occur. The new Boeing 787 Dreamliner uses SMA for shape control of the rear part of the engine to reduce engine noise.

The medical industry uses SMA for various purposes such as the manufacture of artificial body parts, stents for blocked blood vessels, guide wires for medical procedures and super-elastic orthodontic devices.

2.1. Structural engineering applications

In recent years, there have been many developments of SMA for structural engineering applications. Using SMA actuators as dampers for vibration control of bridges becomes increasingly popular (Graesser & Cozzarelli

1991). In such applications, a pre-strained SMA rod is attached to the structural component of the bridge. When excessive vibration of the bridge is detected, an electric current is passed through the rod so that temperature of the rod changes and a pulling force is generated to achieve the damping effect. The actuation requires careful control of the relation between the input voltage and the generated force. Large amount of research has been carried out on SMA actuators. Typical examples are Wilde, et. al. (2000) for use of SMA on bridges and Dolce, et. al. (2000) on buildings. An overview of the use of SMA's damping capability for structures is presented by Humbeeck (2003).

Experimental evidence showed that SMA wires can be used in 'smart bridges' (Maji & Negret 1998; Li, Li & Zhang 2007) where exceptionally heavy loading is detected and the beams in the bridge are temporarily strengthened. The strengthening is achieved by installing SMA in the concrete beams as part of the reinforcements. Through electrical heating of the wires, a tensile force is generated to counteract the bending induced by the loading and the beam is strengthened for the duration of the heating.

At high temperatures, the stiffness of SMA may increase by 3-6 times and its strength by 3-5 times of that at low temperatures. The 'shape memory' capability also enables the SMA materials to be used as a rehabilitation tool when the structural system is accidentally overloaded beyond its serviceable limit. Li, et. al. (2006) demonstrated that SMA wires embedded in a concrete beam can be used to close the concrete cracks temporarily in the beam which was subsequently strengthened by carbon fibre reinforced polymer plates. In this investigation, the wires were heated by electric current for closing the cracks.

Due to the peculiar characteristics of SMA, it is possible that the alloys can be used to enhance safety of structures during extreme conditions such as fire. For the alloys to undergo such high temperatures, the heat transfer process is important in monitoring the stress and strain variation over a wide temperature range. Therefore, an understanding of the thermal characteristics of SMA at high temperatures is important. Unfortunately, test results for the thermo-mechanical properties of SMA at such high temperatures are virtually non-existent. An exploratory project for strength enhancement of steel beams in fire is being undertaken in the Department of Civil Engineering at Monash University. The concept is illustrated in Figure 5 in which the beam subjected to a load is strengthened by a pre-strained SMA wire underneath. When the temperature of the wire rises due to the fire, a force due to the recovery stress is generated, subsequently reducing the bending effect imposed by the load. Initial tests showed that this concept was feasible and the deflection of the beam was reduced dramatically during the fire.

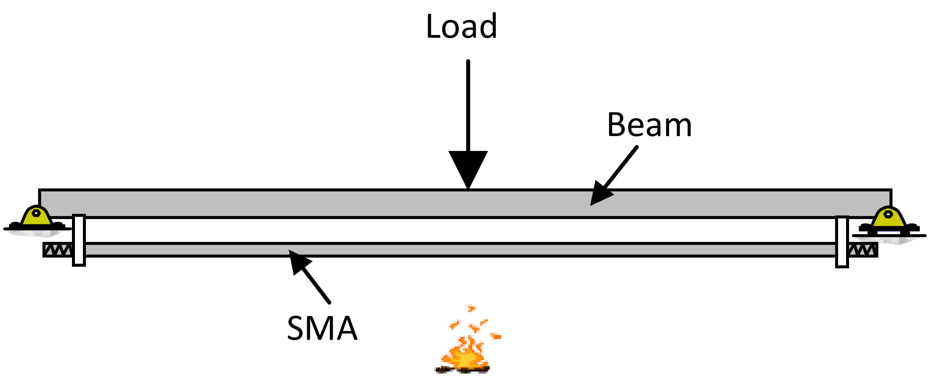


Figure 5. Steel beam strengthened by SMA wire in fire

3. Conclusion

Use of shape memory alloys has become increasingly popular in various fields of applications. Their use in structural engineering has a great potential due to a number of advantages over other metals including the shape memory effects, super-elasticity and corrosion resistance. The fact that these alloys are relatively unknown in the Australian civil engineering fraternity and can only be procured from overseas is a hindrance to its further development in Australia. This situation may change very quickly as more countries have started manufacturing these alloys and taking advantages of their superior properties.

REFERENCES

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Graesser, E. J. and Cozzarelli, F.A. (1991). “Shape-memory alloys as new materials for aseismic isolation”. J. Eng. Mech., ASCE, 117(11), 2590-2608.

Humbeeck J.V. (2003). Damping capacity of thermoelastic martensite in shape memory alloys. J. of Alloys & Compounds, 355, 58-64.

Maji, A.K. and Negret, I. (1998). “Smart prestressing with shape-memory alloys”. J. Eng. Mech., ASCE, 124(10), 1121-1128.

Li, L., Li, Q. and Zhang, F. (2007). “Behavior of smart concrete beams with embedded shape memory alloy bundles”. J. Intelligent Mat. Syst. Struct., 18, 1003-1014.

Li H., Liu Z.Q., Ou J.P. (2006). Experimental study of a simple reinforced concrete beam temporarily strengthened by SMA wires followed by permanent strengthening with CFRP plates. Eng. St., 30, 716-723.

Sadiq, H., Wong, M.B., Al-Mahaidi, R. & Zhao, X.L. (2010), “The effects of heat treatment on the recovery stresses of shape memory alloys”. Smart Materials and Structures, 19(3), 035021.

Wilde K., Gardoni P., Fujino Y. (2000). Base isolation system with shape memory alloy device for elevated highway bridges. Eng. St, 22, 222-229.

Canterbury shakes put STIC building to the ultimate test

The offices of the Structural Timber Innovation Company (STIC), EXPAN's developer, have certainly been put through their paces when it comes to seismic resistance – enduring thousands of aftershocks that have hit Canterbury since the devastating quakes of February 22 and June 13.

The unique timber engineering technology has proved its worth – standing unscathed in the face of the region's seemingly relentless ground movement.

The two-storey building at the University of Canterbury is the base for STIC CEO Rob Finch and his team, and a showcase for EXPAN timber structural technology. It's now also become a standing testament to the seismic protection offered by EXPAN's LVL timber construction, remaining entirely intact and undamaged on February 22, and beyond.

Canterbury University's College of Engineering Associate Professor Dr Stefano Pampanin is not surprised at how well the building has performed through the series of earthquakes and aftershocks.

"The building fulfils the promise of this technology – to emerge from a major earthquake, or in this case, several major earthquakes, with no structural damage."

On top of the hits Mother Nature has thrown at the STIC offices, the EXPAN technology had undergone extensive laboratory testing at The University of Canterbury's College of Engineering laboratories.

A 2/3 scale model of the building was put through a range of movements and loads that an earthquake can inflict on a building, with simulations of differing intensities of shaking, and different lengths, including many approximate magnitude 8 quakes, resulting in no structural damage.

The building itself was first assembled in the College of Engineering lab, where it was subjected to intense slow motion pulling and pushing pressure, again, coming out structurally sound. It was then dismantled, and reassembled at its current location on the University lawn – showing another beauty of EXPAN, that it enables buildings to be dismounted, and remounted at another site.

The STIC building will continue to tell the story of the performance of timber technology long term, with instrumentation onsite that reads acceleration of an earthquake, and tracks building movement.

While Stefano's not surprised at the building's performance, as one of the researchers behind the technology, he's certainly proud at how well the showcase structure has stood up to the region's considerable seismic activity.

"February 22 was an intensely powerful earthquake, so it put the building to a huge test, and it's come out unscathed."

"We are now able to raise the bar, and offer technology that meets demand for buildings that do more than stand up to an earthquake, but remain viable. We have the opportunity, with technology developed right here in Christchurch, to give a much higher protection, not only from loss of life, but building damage – both crucial factors in the planning of a safer, economically strong, new city."

ACSEV members wanting more information and access to design guides for Australia - visit expan web site and sign up as Licensees in the resource section.

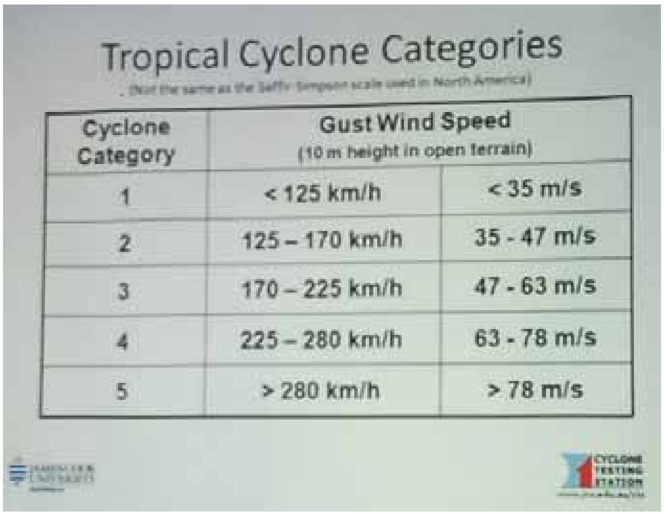
www.expan.co.nz

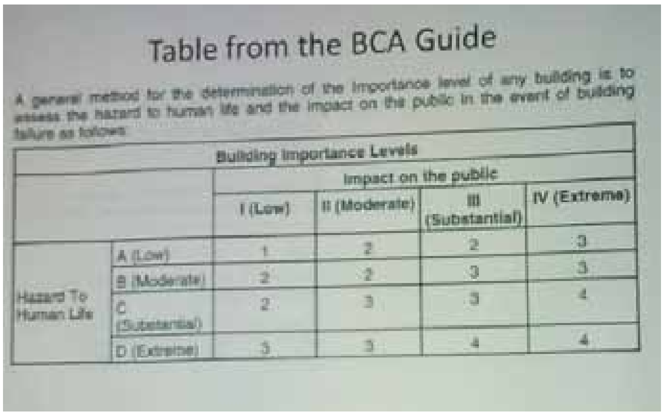
Structural performance during tropical cyclones

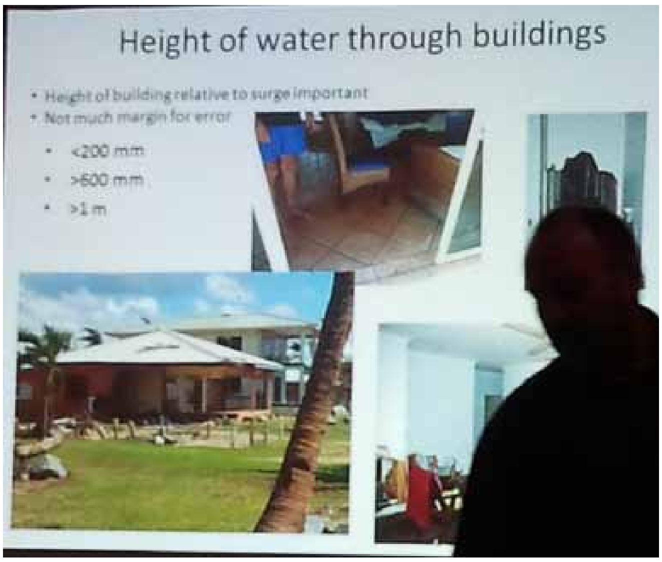
In August the technical meeting was presented by David Henderson, from James Cook University, on the structural performance during tropical cyclones. The basis of his presentation was tropical cyclone Yasi from earlier in the year, in which he dicussed the calculation of wind loads using AS1170.2 and also the standard for wind loads on residential structures AS4055.

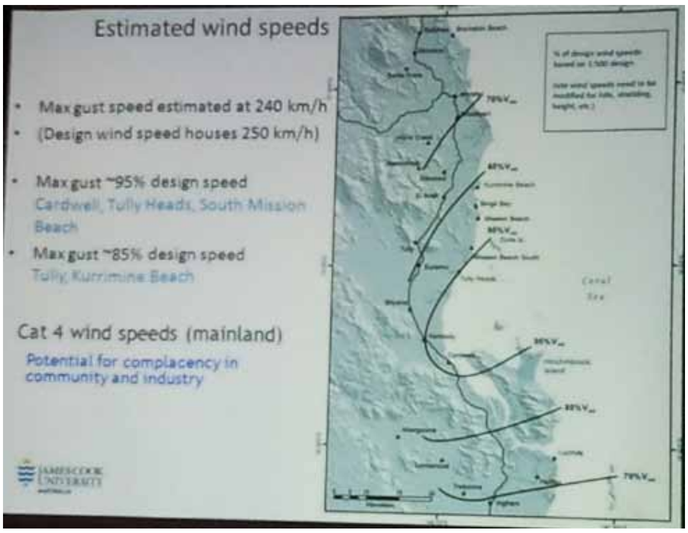
As part of their wind tunnel testing at JCU, David and his team have developed simulations showing very high wind pressures along roof edges, which demonstrated the need for local pressure factors in these areas. Another major topic of discussion was the use of dominant openings when designing for wind and allowing for internal pressures. He showed us several examples of structures that would have been considered impermeable but suffered damage to a window or the roof cladding, leading to large positive internal pressures and extensive damage. We were also reminded that once an opening is created, the pressure wave travels through the structure at the speed of sound so failure can occur very quickly.

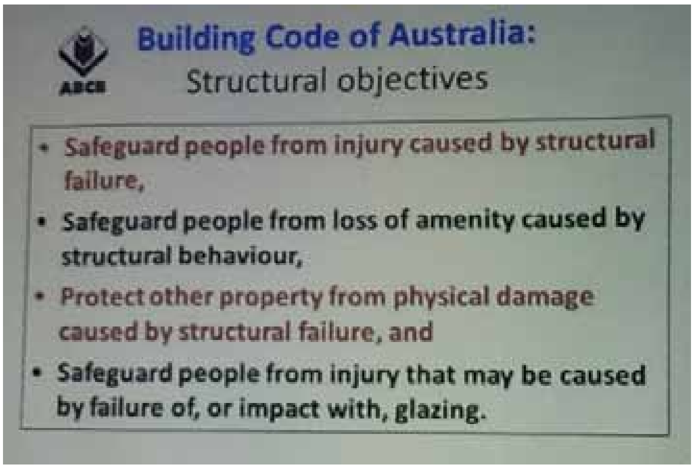
The meeting was well attended and David gave a very thorough and informative presentation while also demonstrating great expertise in responding to questions from the members.

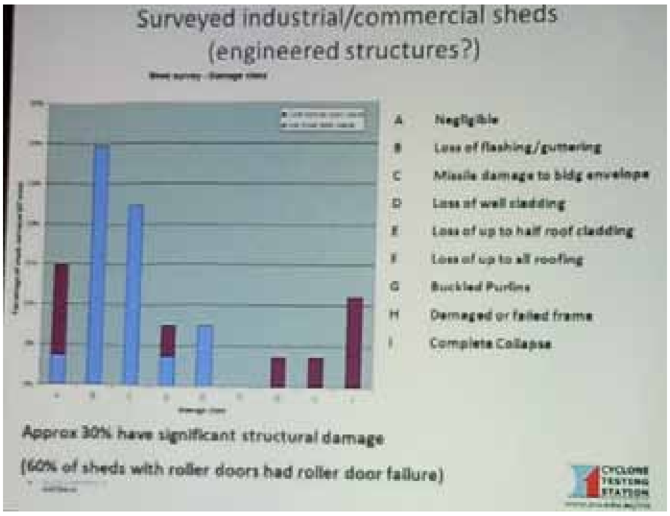


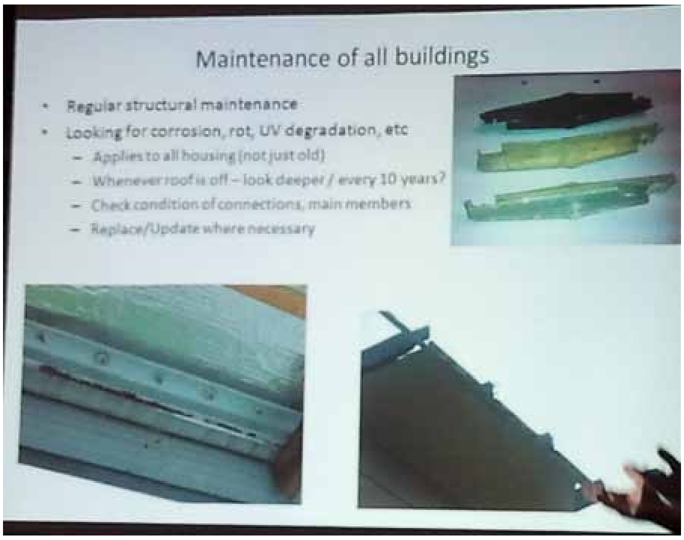


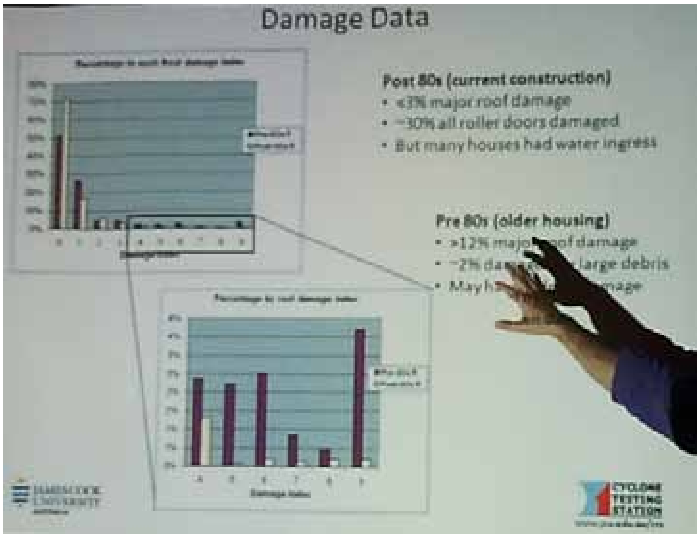


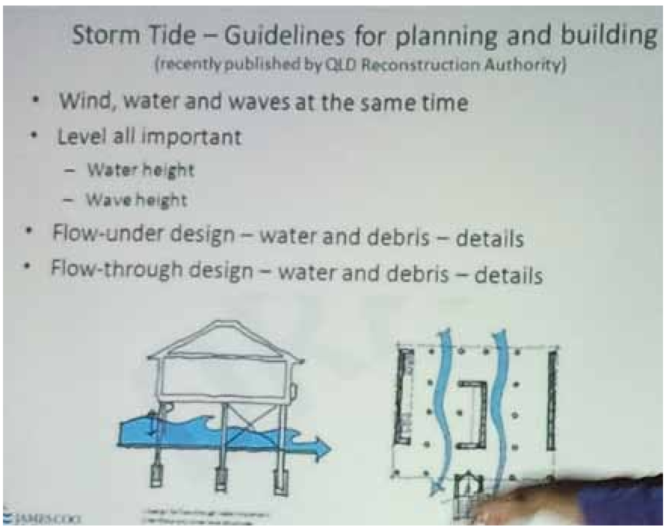


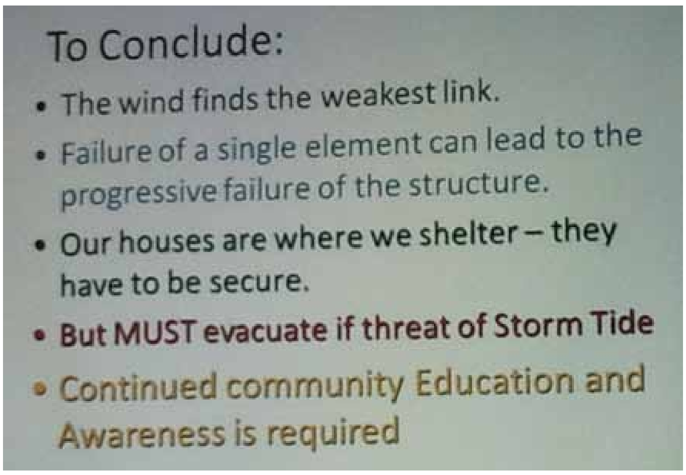

Building Code of Australia:
Structural objectives
ABCB
Safeguard people from injury caused by structural failure,
Safeguard people from loss of amenity caused by structural behaviour,
Protect other property from physical damage caused by structural failure, and
Safeguard people from injury that may be caused by failure of, or impact with, glazing.


Surveyed industrial/commercial sheds
(engineered structures?)
A Negligible
B Loss of flashing/guttering
C Missile damage to bldg envelope
D Loss of wall cladding
E Loss of up to half roof cladding
F Loss of up to all roofing
G Buckled Purlins
H Damaged or failed frame
I Complete Collapse
Approx 30% have significant structural damage
(60% of sheds with roller doors had roller door failure)
CYCLONE TESTING STATION


Maintenance of all buildings
Regular structural maintenance
Looking for corrosion, rot, UV degradation, etc
– Applies to all housing (not just old)
– Whenever roof is off – look deeper / every 10 years?
– Check condition of connections, main members
– Replace/Update where necessary


Damage Data
Post 80s (current construction)
<3% major roof damage
~30% all roller doors damaged
But many houses had water ingress
Pre 80s (older housing)
CYCLONE TESTING STATION


Storm Tide – Guidelines for planning and building
(recently published by QLD Reconstruction Authority)
Wind, water and waves at the same time
Level all important
– Water height
– Wave height
Flow-under design – water and debris – details
Flow-through design – water and debris – details


To Conclude:
The wind finds the weakest link.
Failure of a single element can lead to the progressive failure of the structure.
Our houses are where we shelter – they have to be secure.
But MUST evacuate if threat of Storm Tide
Continued community Education and Awareness is required

Australian Standards

AS/NZS 1170.0 2002	Structural design actions - General Principles
AS/NZS 1170.1 2002	Structural design actions - Permanent, imposed and other actions
AS/NZS 1170.2 2011*	Structural design actions - Wind actions
AS/NZS 1170.3 2003	Structural design actions - Snow and ice actions
AS/NZS 1170.4 2003	Structural design actions - Earthquake
AS 1288 - 2006	Glass in buildings - Selection and installation
AS 1288 Supp 1 - 2006	Glass in buildings - Selection and installation (Supplement to AS 1288 - 2006)
AS 1428 (set) - 2010*	Design for access and mobility - General requirerments for access - New building work
AS 1684 - 2011*	National Timber Framed Construction
AS 1720.1 2010	Timber structures
AS 2550 (set) - 2011*	Cranes, hoists, and winches - safe use set
AS 2870 - 2011*	Residential slabs and footings
AS 3600 - 2009	Concrete structures
AS 3610.1 - 2009	Formwork for concrete - Documentation and surface finish.
AS/NZS 3678 -2011*	Structural Steel - hot rolled plates, floor plates and slabs
AS 3700 Set - 2007	Masonary structures Set
AS 3740 - 2010	Waterproofing of domestic wet areas.
AS 3959 - 2009	Construction of buidings in bushfire prone areas
AS4055 - 2006	Wind loads for houses
AS 4100 - 1998	Steel structures
AS 4299 -1995	Adaptable housing
AS/NZS 4490:2011*	Timber - solid - Stress grade for structural purposes.
AS/NZS 4360 : 2004	Risk Management
AS 5100 Set - 2007	Bridge design Set
AS/NZS ISO 9001 : 2008	Quality management systems - Requirements
HB 50 - 2004	Glossary of building terms
HB 330-2009	Living in bushfire-prone areas

* Note: The following standards have recently been revised and re-issued.

WEB LINKS

Timber advisory	www.timber.org.au
Concrete institute of Australia	www.concreteinstitute.com.au
Cement Australia	www.cemaust.com.au
Cement Concrete and Aggregates Australia	www.concrete.net.au
Australian Steel Institute	www.steel.org.au
Building Commision of Victoria	www.buildingcommission.com.au
Australian Stainless Steel Development Association	www.assda.asn.au
Forest & Wood Products Australia	www.fwpa.com.au
The Australian Timber Database	www.timber.net.au
Wood Naturally Better	www.naturallybetter.com.au
Galvanizers Association of Australia	www.gaa.com.au

GENERAL CALENDAR

20 October 2011
PacRim Stainless 2011 - Smart, Strong, Sustainable
Novotel Twin Waters Resort , Sunshine Coast, QLD
WWW.ASSDA.COM.ASU

5th November 2011
National Seminar Series - Design Guidance to AS3600-2009: Concrete Structures
Holmesglen Tafe
www.concreteinstitute.com.au/

7th November 2011
Managing risk in structural steelwork
Location: 65 Queens Road, Melbourne, VIC
Venue: The Sebel, Albert Park
www.asi.com.au

14 November 2011
Building Simulation 2011 Conference: Driving better design through simulation.
University of Technology Sydney (UTS) - Aerial Function Centre Level 7 UTS Building 10, 235 Jones St, Ultimo, NSW

20 November 2011
Fundamentals of Post Tensioning

20 November 2011
18th International Corrosion Congress
Perth Convention & Exhibition Centre , Perth, WA

5 December 2011
Australasian Association for Engineering Education Conference 2011
Esplanade Hotel , Perth, WA

TECHNICAL MEETING PROGRAM - 2011

19 OCTOBER
AGM and Monthly meeting
Speaker: Tim Gibney
Time: 5:30pm drinks; 6:30pm dinner; 7:30pm AGM followed by technical presentation; 9:30pm evening close
Venue: Box Hill Golf Club

12 NOVEMBER
Annual Dinner

DECEMBER
No Meeting

JANUARY 2012
- no meeting

FEBRUARY 2012
- TBA

Polystyrene External Cladding Fact Sheet

In recent years, residential and commercial buildings in Australia have seen a dramatic increase in the use of innovative, external wall cladding products and/ or systems which are not dealt with in the BCA as Deemed-to-Satisfy (DtS) building solutions.

This Fact Sheet refers to the BCA Volumes One and Two and focuses on all buildings (Class 1 -10 buildings) with the purpose to promote weatherproof construction methods.

Download fact sheet from
www.buildingcommission.com.au

ACSEV FEE SURVEY

A sample of ACSEV members were surveyed in 2005 with regards to fee scales. The results printed below do not include GST:

EXPERT WITNESS:	$180 - $300
PARTNER/PRINCIPAL:	$150 - $250
SENIOR ENGINEER:	$130 - $180
ENGINEER:	$90-$130
DRAFTSPERSON:	$60 - $90
OFFICE ADMIN.:	$50 - $80

GST must be added to the above rates.

In addition, vehicle costs should be charged at the RACV scale.

Members are not bound by this schedule. Clients

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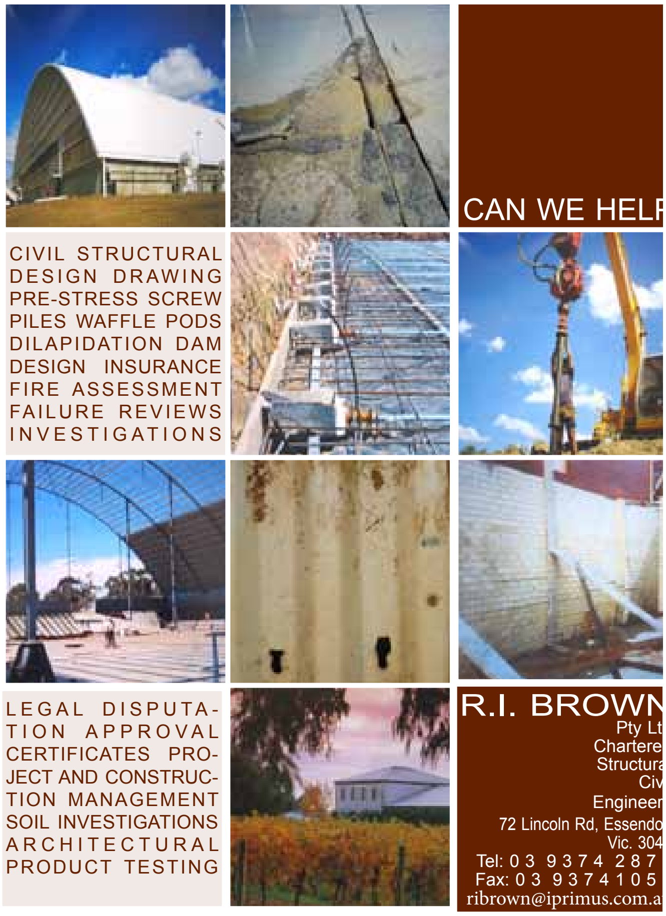

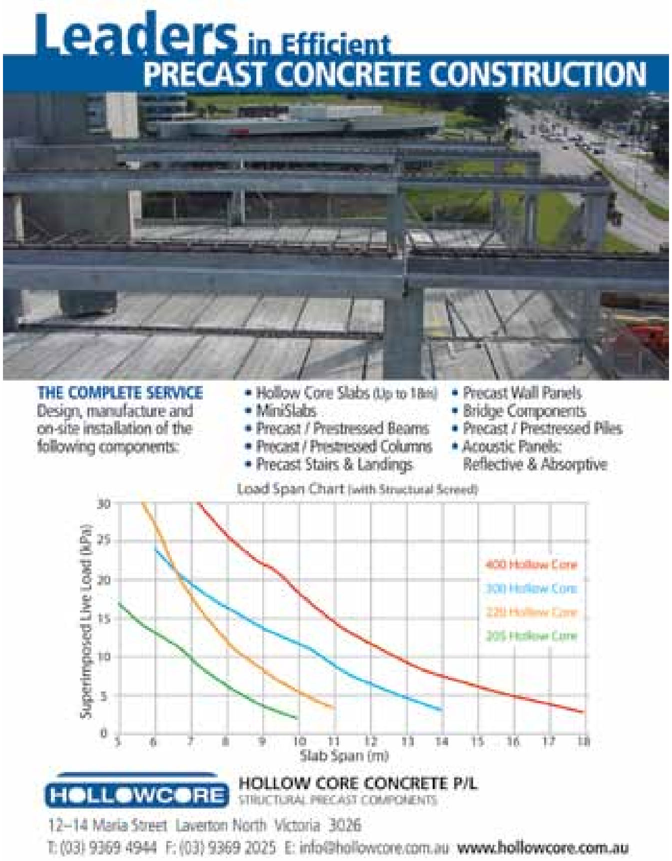

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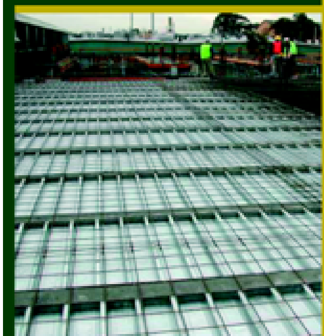

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For a technical manual, and further information contact Barry Ellis.

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