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Report prepared on behalf of Expert Opinion Services
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CERTIFICATION OF STRUCTURAL SYSTEM

for

Dincel and Associates Pty Ltd

by

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20 March 2014

Our Ref: J084829

Dincel & Associates Consulting Engineers
101 Quarry Road
ERSKINE PARK NSW 2759

Dear Sirs

AFS WALL SYSTEM
STRUCTURAL ENGINEERING REVIEW AND ASSESSMENT

I have conducted an Expert Review and Assessment of the attached "AFS Wall Structural Assessment" prepared by Dincel & Associates Consulting Engineers.

The AFS Wall System consists of closely-spaced metal channel sections, cellulose-based fibre cement sheets that are pre-glued to the metal channel sections on both faces, and conventional steel bar reinforcement as shown in Figure 1. The void between the fibre cement sheets is then cast with concrete to form a reinforced concrete wall with the fibre cement sheets remaining as a substrate after the concrete has cured.

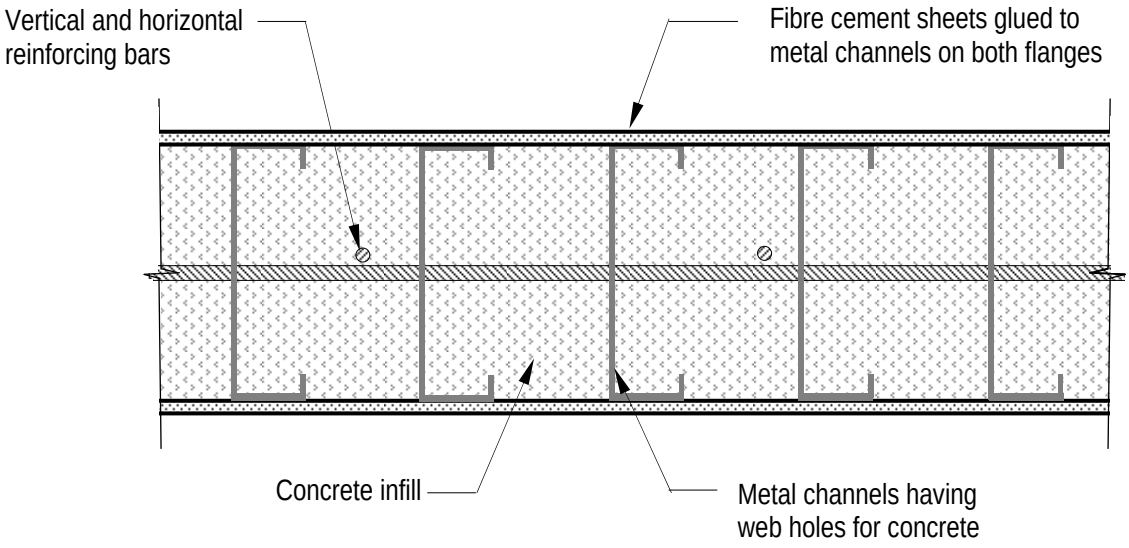


Figure 1: Schematic plan view of AFS Wall System.

This Expert Review and Assessment deals specifically with metal channel sections that are embedded in concrete and its compliance with AS3600-2009 Concrete Structures (Incorporating Amendment No. 1).

I am satisfied with the explanations given by Dincel & Associates in their Assessment that:

(1) The AFS Wall System is an Alternative Solution which cannot be designed to comply with the "deemed to satisfy" conditions of Specification A2.3(2) Fire Resistance of Building Elements : Rating of the Building Code of Australia and of AS3600-2009 Concrete Structures.

The non-compliance of the minimum cover rules for durability and for fire classifies the AFS Wall System as being an Alternative System, rather than one that meets a "deemed-to-satisfy" condition.

(2) The metal channel sections of the AFS Wall System must have a prescriptive concrete cover to satisfy Section 4 of AS3600-2009 "Design for Durability".

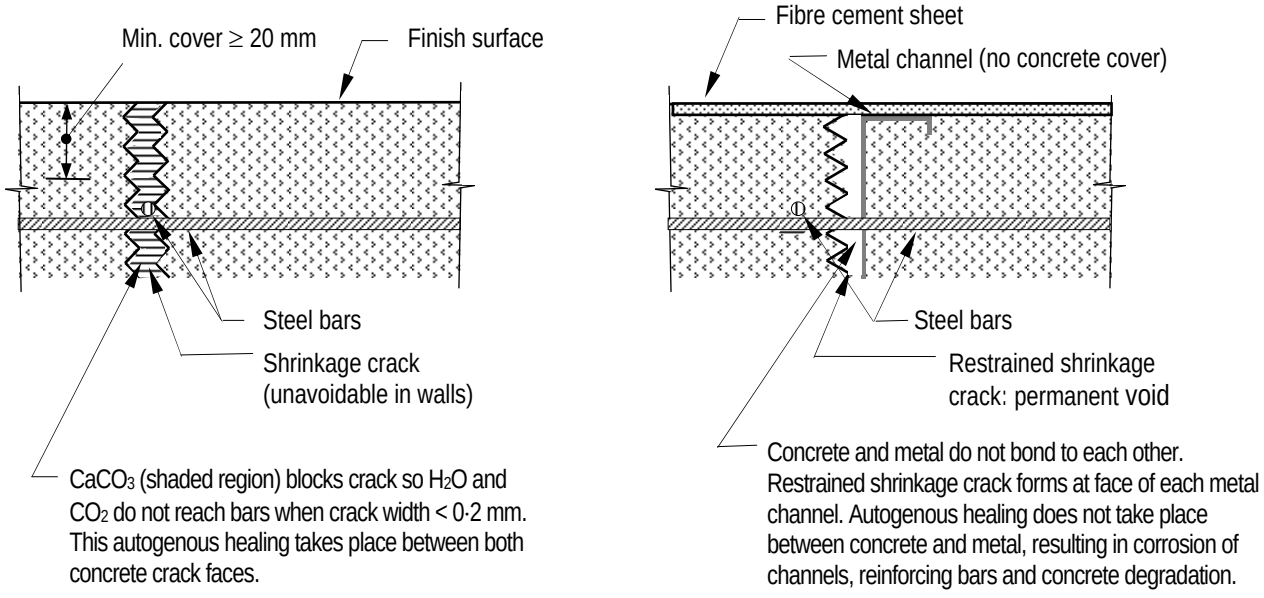
Irrespective of whether the metal channel sections are used for structural or non-structural purposes, the absence of necessary concrete cover initiates crack paths between the concrete and metal channel sections, as detailed in Dincel & Associates' Assessment, and which may lead to corrosion of the steel reinforcing bars and of the metal channel sections themselves. A fundamental requirement of concrete structures is that concrete cover is required to provide autogenous healing of the concrete, so that crack paths do not allow for the ingress of external contaminants to the metal components to cause corrosion of the steel reinforcement and / or degradation of the concrete itself. This is illustrated in Figure 2, which compares these processes for a conventional concrete wall with removable formwork and the AFS Wall System.

It is also important to note that AS3600-2009 does not allow galvanising, epoxy coating or even waterproof membranes to reduce the concrete cover below the *minimum* cover requirement. It is the obligation of the Structural Engineer to ensure that the life of a structural wall shall comply with Clause 4.1 of AS3600-2009, which requires a minimum life of 50 years ± 20%.

(3) Appendix B of AS3600-2009 requires that an Alternative Solution can only be used if it has been tested for the serviceability condition (i.e. a minimum lifetime requirement of 40 years) and the strength condition. The testing requirement Appendix B of AS3600-2009 is only applicable to Alternative Solutions; systems that comply with the "deemed-to-satisfy" condition do not need to be tested.

Clause 2.3 of Appendix B of AS3600-2009 also requires that an alternative solution can only be used within its test parameters. For example, if a wall undergoes fire testing, the Alternative Solution cannot

be used for loads and wall heights that exceed those considered in the tests or for wall thicknesses and concrete grades that are less than those considered in the tests. It is important to note that the loading apparatus used in the fire testing laboratory does not consider the loading eccentricity that will be encountered at the façade and internal walls that carry varying floor slab spans.



(a) Conventional concrete wall with removable formwork

(b) AFS Wall with permanent metal sections

Figure 2: Comparisons of cracking and autogeneous healing processes.

As noted in Dincel & Associates' Engineering Assessment, honeycombing and air voids are a significant concern that is associated with permanent formwork having porous surfaces. Air voids may cause reduced fire, acoustic and durability performance. This concern would be further exacerbated by the use of fibre cement sheets as formwork, narrow wall thicknesses and the presence of horizontal reinforcement and metal channels as an obstruction to free concrete flow.

When porous formwork such as fibre cement sheet is used, it is desirable for the bottom of the wall to incorporate removable formwork as in the case of masonry block walls. This would confirm the quality and consistency of the concrete fill.

(4) The integrity and safety as a result of delamination of the fibre cement sheets, and particularly those of façade walls under fire conditions, need to be carefully considered by Design Engineers. As explained in the Dincel Assessment, the adhesive attaching the fibre cement sheets to the

metal channel sections will be severely compromised under fire conditions (AFS Wall Systems fire tests show that delamination occurs within 15 minutes of a fire event). Concrete subjected to fire will also generate internal pressures that assist in debonding and hence in delamination of the fibre cement sheeting from the concrete infill, as reported in the fire tests.

Based on the evaluation of the Dincel & Associates' "AFS Wall Structural Assessment", I conclude that:

(i) The AFS Wall System does not comply with Clause 4.10.3.7 of AS3600-2009 by not having the minimum cover needed to the flanges of its metal channel sections.

(ii) The AFS Wall System can only be used as a fire wall for the load, height, thickness and concrete grade for which it was tested in accordance with Appendix B of AS3600-2009. The structural engineer must consider the design eccentricity when comparing with test loads.

Yours faithfully

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on behalf of UNSW Global Pty Limited

APPENDIX A

Curriculum Vitae

Expert Opinion Services

CURRICULUM VITAE	Professor Mark BRADFORD

Qualifications

- Bachelor of Science (BSc), University of Sydney, 1977
- Bachelor of Engineering (BE) (Hons 1), University of Sydney, 1979
- Doctor of Philosophy (PhD), University of Sydney, 1984
- Doctor of Science (DSc), University of New South Wales, 1988

Present Position

- **Director**
  Centre for Infrastructure Engineering and Safety
  The University of New South Wales
- **Australian Professorial Fellow**
- **Scientia Professor**
  The University of New South Wales
- **Professor of Civil Engineering**
  The University of New South Wales

Areas of Expertise/ Special Interests

- Structural Engineering
- Steel
- Concrete and Composite Structures
- Engineering Mechanics
- Numerical Modelling

Affiliations

- Fellow, Australian Academy of Technological Sciences and Engineering (FTSE)
- Fellow, Institution of Engineers, Australia
- Fellow, Institution of Structural Engineers (UK)
- Member, American Society of Civil Engineers
- Member, American Concrete Institute
- Member, Australian Steel Institute
- Chartered Professional Engineer (CPEng), Australia
- Chartered Engineer (CE), UK
- Professional Engineer (PE), USA

Employment Experience

1998 to present	**Professor of Civil Engineering** The University of New South Wales
2004–2009	**Federation Fellow**
2002–2004	**Australian Professorial Fellow** The University of New South Wales
1992–1998	**Associate Professor in Civil Engineering** The University of New South Wales
1986–1992	**Lecturer / Senior Lecturer in Civil Engineering** The University of New South Wales
1985	**Postdoctoral Fellow** University of Warwick, UK
1984	**Postdoctoral Fellow** University of Sydney
1983	**Engineer** Wholohan Grill and Partners, Sydney

Profile

Scientia Professor Mark Bradford is Director of the Centre for Infrastructure Engineering and Safety and Professor of Civil Engineering at The University of New South Wales.

His research areas are in structural engineering, primarily in steel structures, composite steel-concrete structures and in numerical applications. In recognition of his track record in this research, he was awarded Australian Professorial Fellowships in 2002 and 2010 by the Australian Research Council. He was awarded in 2004 a highly prestigious Federation Fellowship by the Australian Government to undertake research in the general area of fire loading on engineering structures. He was the only structural engineer to hold a Federation Fellowship, and was the first civil engineer to hold an Australian Professorial Fellowship. Also in 2004, The University of New South Wales conferred its "Scientia" title on Professor Bradford; a title awarded by the university after international peer evaluation for its pre-eminent professorial scholars.

Professor Bradford's work has had significant impact, both internationally and nationally. He serves on the editorial board of a dozen international journals, and on four Standards Australia committees in the areas of structural engineering and metallurgy (one of which he chairs). He is the author of a number of books in steel and composite structures which are used around the world. Professor Bradford has also presented many seminars, keynote and invited talks at international symposia and research institutions. He has extensive experience as a consultant in many aspects of structural engineering, and particularly in providing expert opinion in cases of litigation.

Service

- Chairman, Committee BD/23 Structural Steel, Standards Australia (SA)
- Member, Committee BD/1 Steel Structures, SA
- Member, Committee BD/32 Composite Construction, SA
- Member Committee BD/92 Evaluation of Structures, SA
- Member, College of Experts for Engineering, Mathematics and Informatics, Australian Research Council (2010 to present)
- Member, Expert Advisory Committee of Engineering and Environmental Science, Australian Research Council (2001–3)
- Vice President, ASCCS (2000 to present)
- Secretary, International Conference on Structural Stability and Design (1995)
- Chair, 16th Australasian Conference on Mechanics of Structures and Materials (1999)
- Co-Chair, Conference on Advances in Structures: Steel, Concrete Composite and Aluminium (2003)

Editorial & Advisory Boards

- *International Journal for Numerical Methods in Engineering Computers and Structures*
- *Thin-Walled Structures*
- *International Journal for Structural Stability and Dynamics*
- *Engineering Structures*
- *Advances in Structural Engineering*
- *Steel and Composite Structures*
- *Hong Kong Institution of Engineers*
- *Interaction and Multiscale Mechanics*
- *Australian Journal of Structural Engineering*
- *Electronic Journal of Structural Engineering*
- *Advanced Steel Structures*
- *Institution of Engineers, Singapore (Journal A)*

Research Grants

- 17 Nationally-Competitive Australian Research Council Grants since 1998

Publications

- 15 books
- 11 book chapters
- 250+ journal papers
- 190+ conference papers

Keynote, Plenary And Invited Presentations

- Fourth International Conference on Structural Engineering, Mechanics and Computation, Cape Town, 2010
- Ninth International Conference on Steel, Composite and Hybrid Structures, Leeds, UK, 2009
- Sixth International Conference on Advances in Steel Structures, Hong Kong, 2009
- Australia–Japan Joint Workshop on Steel and Composite Structures, Sydney, 2009
- Twelfth International Conference on Civil, Structural and Environmental Engineering Computation, Madiera, Portugal, 2009
- Seventh EUROMECH Conference on Solid Mechanics, Lisbon, Portugal, 2009
- Fifth International Conference on Thin-Walled Structures, Gold Coast, 2008
- Fifth International Conference on Coupled Instabilities Metal Structures, Sydney, 2008
- International Conference on Structures and Granular Solids, Edinburgh, UK, 2008
- Ninth International Conference on Composite Structures Technology, Athens, Greece, 2008
- International Symposium on Innovations in Structural Steel, Singapore, 2008
- Second International Symposium on Innovative Design of Steel Structures, Hong Kong, 2008
- Third International Conference on Steel and Composite Structures, Manchester, UK, 2007
- Fifth International Conference on Advances in Steel Structures, Singapore, 2007
- Third International Conference on Structural Engineering, Mechanics and Computation, Cape Town, 2007
- Vietnam First International Conference on Modern Design and Construction of Steel Structures, Hanoi, 2007
- Eighth International Conference Steel, Composite and Space Structures, Kuala Lumpur, Malaysia, 2006
- International Conference on Composite Structures Technology, Gran Canaria, Spain, 2006
- International Symposium on Advances in Steel and Composite Structures, Hong Kong, 2005
- Aust. Conference on Mechanics of Structures and Materials, Perth, 2004
- International Symposium on Innovation and Advances in Steel Structures, Singapore, 2004
- Second International Conference on Structural Engineering, Mechanics and Computation, Cape Town, 2004
- International Symposium on Worldwide Codified Design of Steel Structures, Hong Kong