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Report prepared on behalf of Expert Opinion Services
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AFS WALLING SYSTEMS

for

Colin Biggers & Paisley
Your reference: David Miller

by

Mark Bradford
Scientia Professor & Professor of Civil Engineering
Australian Laureate Fellow,
Centre for Infrastructure Engineering and Safety
Faculty of Engineering,
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CSR Building Products Limited
Locked Bag 1345
North Ryde BC, NSW 1670

Dear Sirs

AFS LOGICWALL® SYSTEM – CORROSION DURABILITY REVIEW

I have conducted an expert Review and Assessment of the attached 'AFS Logicwall® System – Corrosion Durability Review' prepared by AFS Products Group Pty Limited. My review is to be considered in conjunction 'AFS Wall System Structural Engineering Review and Assessment', which I undertook for Dincel & Associates Consulting Engineers (the Dincel Report) on 20 March 2014.

I acknowledge my description of the AFS Logicwall® System in the Dincel Report, and of the additional AFS-recommended Dulux AcraTex coating. Dulux provides comprehensive guidance for its AcraTex coating product [1], which carries a 10 year guarantee.

Your description of the mechanism of carbonation of the concrete core wall is acknowledged and appears in many if not all texts on concrete technology. In addition to my description of the System in the Dincel Report, I acknowledge the use of CSR Ceminseal^{TM} Wallboard [2] as the fibre cement sheeting. The Ceminseal^{TM} Wet Area Systems Manual [2] claims the systems using it are based on 'AS3740 Waterproofing of Wet Areas within Residential Buildings'.

I note the use of hot-dipped zinc coating (galvanising) of the steel channel sections in the AFS Logicwall® System, and of their total minimum coating of 275 g/m^2 (19·2 μm on the faces of the channels) to AS/NZS 4792:2006 'Hot-dip Galvanized (Zinc) Coatings on Ferrous Hollow Sections, Applied by a Continuous or a Specialized Process'. The (Informative) Clause C3 (f) *Use in concrete* of AS/NZS 4792:2006 notes "Although an immediate reaction occurs between zinc and the highly alkaline constituents of freshly laid concrete (or mortar), this quickly diminishes because of the formation of a passivating layer of calcium hydroxyzincate on the embedded galvanized coating. The subsequent slow carbonation of the concrete assists the process. During carbonation, the pH of the concrete falls below its initial value of about 12·5." The (Informative) Clause C3 (g) *pH effect* of AS/NZS 4792:2006 notes further that "Since zinc is an amphoteric metal, it is rapidly attacked at pH values below 6 and above 12·5.

As noted in the Dincel Report, restrained concrete shrinkage has the potential too, and almost universally does, cause cracking. For a conservative estimate, with a channel spacing of 140 mm and a (high) final shrinkage strain (from autogenous and drying components) of 1000×10^{-6} and without any restraint, the concrete between two adjacent channel sections has the potential to shorten by $140 \times 1000 \times 10^{-6} = 0{\cdot}14$ mm; this being indicative of an upper bound on the crack width. Eurocode 2 [3] suggests a crack limit of 0·3 mm and so while I believe having quantitative data would be helpful, it can be concluded that such a small crack width would be unlikely to allow the ingress of materials that may contribute to corrosion. In addition, this simplistic calculation does not account for the presence of horizontal reinforcement, which provides restraint to this shrinkage and the value of 0·14 mm is an upper bound on the crack width between two channel sections.

Based on the permeability of the system as being 0·6 g/m^2/24 hours at 1kPa, I have performed a peer assessment of your calculations and agree that 2 metres of rainfall per

annum (Cairns, Qld) is appropriate for Corrosivity Category C5 that is invoked in Galvanizers Association of Australia 'Atmospheric Corrosion Resistance of Hot Dip Galvanized Coatings' [4], and will result in the ingress of 4·4 kg/year. This places the protected channel sections into a Class 1 Corrosion Category, for which Table 2 of ISO 9223 [5] quotes a corrosion rate of less than 0·1 μm/year, with a service life of 19·2/0·1 = 192 years against corrosion.

I acknowledge your claim of certification by the British Board of Agrement, and agree with its draft certificate and that "concrete walls constructed with the system will have a service life of not less than 80 years provided they are designed in accordance with section 6. The formwork system will have a similar service life provided it is protected from damage by the external and internal finishes of the wall construction (constituting a 'mild' exposure environment) and these are adequately maintained".

You have pointed out that another organisation provided stay in place formwork made from galvanised steel channel sections and fibre cement sheeting on projects commencing in the 1980's. In specific terms of historical performance, I have not heard of any corrosion issues related to the use of the AFS Logicwall® system using corrosion-resistant galvanised steel channel sections, 6 mm Ceminseal fibre cement sheets that are pre-glued to the metal channels on both faces and coated as appropriate and with conventional bar reinforcement as would be designed by a structural engineer.

I conclude that based on the information provided in the Dincel Report and in your Corrosion Durability Review:

1. The AFS Logicwall ® System contains metal channel sections that are corrosion resistant and in accordance with Clause 4.10.3.7 of AS3600:2009 does not require minimum cover;

2. Provided the System is protected and maintained adequately as per the AFS Design Manual and the British Board of Agrement certificate, your Document "AFS Logicwall® System – Corrosion Durability Review" demonstrates that the System meets the durability requirements of AS 3600:2009; and

3. Given compliance with AS3600:2009 as per 1 and 2 above, the AFS Logicwall® System will comply with the BCA requirements as a "deemed to satisfy" system.

Yours faithfully

MARK A BRADFORD
PhD DSc FTSE DistMASCE FIStructE FIEAust PE CEng CPEng

Director of Research and Founding Director
Centre for Infrastructure Engineering and Safety
Australian Laureate Fellow
Scientia Professor and Professor of Civil Engineering
The University of New South Wales

on behalf of UNSW Global Pty Limited

References

[1] Dulux. http://www.dulux.com.au/specifier/our-brands/dulux-acratex/products

[2] CSR. http://www.cemintel.com.au/Pages/Product/Constructive%20Solutions/Universal%20Wall/Ceminseal.aspx

[3] British Standards Institution. BS EN 1992-1-1:2004 Design of Concrete Structures. General Rules and Rules for Buildings. BSI, London, 2004.

[4] Galvanizers Association of Australia. Atmospheric Corrosion Resistance of Hot Dip Galvanized Coatings. Advisory Note Gen 12/2. GAA, Melbourne, April 2012.

[5] International Organization for Standardization. ISO 9223:2012 Corrosion of Metals and Alloys – Corrosivity of Atmospheres – Classification, Determination and Estimation. ISO, Geneva, 2012.

APPENDIX

Details

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

- **Research Director and Founding Director**
  Centre for Infrastructure Engineering and Safety
  The University of New South Wales
- **Australian Laureate 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)
- Distinguished Member, American Society of Civil Engineers
- Fellow, Institution of Engineers, Australia
- Fellow, Institution of Structural Engineers (UK)
- Member, Australian Institute of Company Directors
- Member, American Concrete Institute
- Chartered Professional Engineer (CPEng), Australia
- Chartered Engineer (CE), UK
- Professional Engineer (PE), USA

Employment Experience

2011-	**Australian Laureate Fellow** The University of New South Wales
2010	**Dean, Faculty of Engineering and Information Technology** University of Technology, Sydney
2004–2009	**Federation Fellow**
2002–2004	**Australian Professorial Fellow** The University of New South Wales
1998-	**Professor of Civil Engineering** 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 Research and the Founding 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. 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, and in 2010 an equally prestigious Australian Laureate Fellowship to lead a research team in sustainable framed building design. He is the only structural engineer to hold either a Federation or Laureate Fellowship, and was the first civil engineer to hold an Australian Professorial Fellowship when awarded in 2001. 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. Of a membership that exceeds 145,000, Professor Bradford is only the second Australian Distinguished Member of the American Society of Civil Engineers in its over 160 year history. 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. 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 and was Engineers Australia's Eminent Speaker in 2013. He has extensive experience as a consultant in many aspects of structural engineering, and particularly in providing expert opinion in cases of litigation.

Service

- Member and Immediate Past 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 (2010-2012)
- Member, Expert Advisory Committee of Engineering and Environmental Science, Australian Research Council (2001–2003)
- Vice President, ASCCS (2000)
- 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)
- Chairman, Composite Structures VII (2013)
- Vice President and President Elect, American Society of Civil Engineers Australia Section (2013-)
- Deputy Chair, National Committee for Mechanical and Engineering Sciences, Australian Academy of Science (2012-)

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*
- *Structures; Institution of Structural Engineers*
- *Steel and Composite Structures*
- *Interaction and Multiscale Mechanics*
- *Australian Journal of Structural Engineering*

- *Electronic Journal of Structural Engineering*
- *Advanced Steel Structures*
- *Institution of Engineers, Singapore (Journal A)*