CSR Building Products LIMITED
Level 5, Triniti 3
39 Delhi Road, North Ryde
NSW 2113 Australia
Locked Bag 1345, North Ryde BC
NSW 1670 Australia
T 61 2 9235 8000
F 61 2 8362 9013
www.csr.com.au
ABN 55 00 8631 356

AFS Logicwall® System – Corrosion Durability Review 28 April 2014

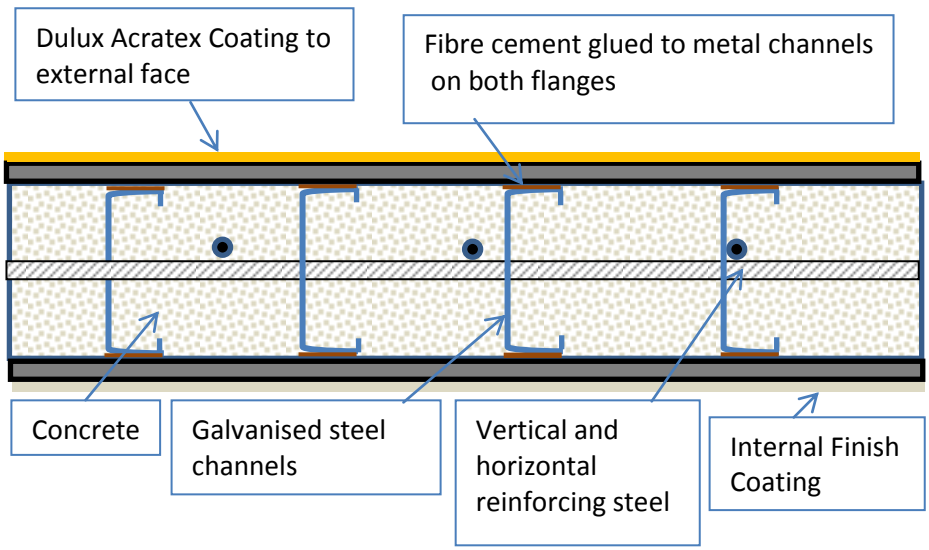
Document aim

The aim of this document is to prove the AFS Logicwall® system meets the durability requirements of AS3600 with particular reference to the embedded galvanised steel channel sections.

Brief description of the Logicwall® system

The AFS Logicwall® system consists of closely spaced corrosion resistant galvanised steel channel sections (Z275), 6mm CSR Ceminseal Fibre Cement (FC) sheets that are pre-glued (Bostik Structural Adhesive) to the metal channels on both faces, and conventional steel bar reinforcement. The void between the FC sheets is then cast with a concrete mix to form a reinforced concrete wall with the FC sheets remaining as a permanent façade or lining system after the concrete has cured. The FC sheets are then coated with AFS recommended internal or external coating systems (Dulux Acratex) to ensure total system integrity

Note: Technical and performance details of components of the system can be found in AFS Design Manual (#3)



Applications of Logicwall®

Logicwall® systems are commonly found in applications where a load bearing wall is used either as an internal party wall or in conjunction with façade elements to form an exterior structural, weather tight and aesthetic walling solution in the construction of apartments and commercial buildings. The AFS Logicwall® System consists of the structural load bearing concrete wall with an external façade system consisting of the Dulux Acratex coating and the fibre cement sheets bonded to the structural wall.

Structural reinforced concrete wall

The reinforced concrete wall is designed and installed in accordance with AS3600 with the AFS Logicwall® system acting as permanent formwork. The reinforced concrete wall includes the concrete and reinforcement. The embedded, galvanised (corrosion protected) steel channel sections, the FC sheeting and coating systems take no part in the structural design of the wall.

Carbonation effects in the structural core

In conventional concrete structures atmospheric carbon dioxide will penetrate the concrete and dissolve in any free water available to form carbonic acid. Over time this will neutralise the free lime and reduce the alkalinity of the core. In conventional concrete any embedded components which are not corrosion resistant are protected by sufficient concrete cover. Typically at least 20mm of cover is required to protect non-corrosion resistant elements in conventional concrete construction. This cover will ensure that there remains adequate free lime given the constant ingress of water and hence carbonic acid converting the available lime to calcium carbonate thereby lowering the protective alkalinity

AS3600 requires that embedded items with less than Table 4.10.3.2 covers, typically 20mm, are to be corrosion protected. This is to ensure that these items are protected from corrosion as the effects of carbonation reduce the alkalinity of the concrete.

The façade elements of the AFS Logicwall® system comprising the virtually impervious coating (Dulux Acratex) and the fibre cement reduce the available water and hence potential levels of carbonic acid available to reduce the protective alkalinity of the structural core.

The embedded galvanized steel channel sections in the AFS Logicwall® systems are corrosion resistant due to the 20 micron, AS2312 Z275, zinc coating which together with the protection from carbonation afforded by the facade system ensures a high level of durability in respect of the potential effects of carbonation compared with conventional reinforced concrete construction.

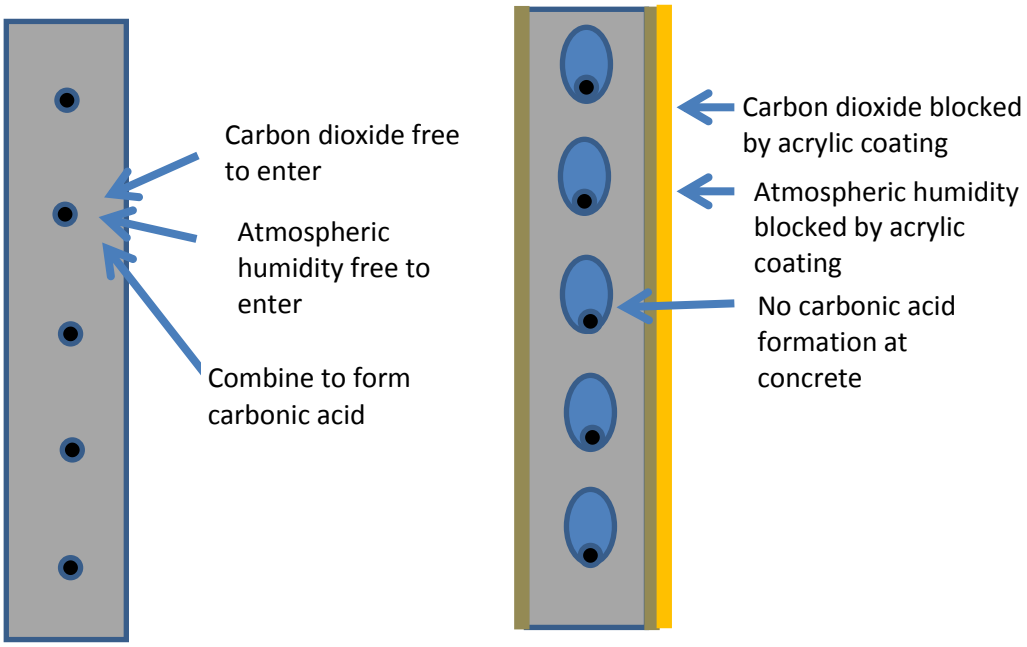
Durability of the structural system

The load bearing functions of the wall are achieved using the reinforced concrete core system. The galvanised steel channel sections take no part in the load bearing function

and are therefore treated as embedded items under AS3600. AS3600 Concrete Code allows for the determination of the exposure classification taking into account protective surface coatings. The standard accepts an appropriate severity of exposure being assessed for the purpose of determining the durability of the system (AS3600 Note 9 Table 4.3). The key durability consideration in the system relates to the corrosion resistance of the embedded galvanised steel channel sections and their environment.

The corrosion protection mechanisms in place are:

1. Z275 hot dipped zinc coating to the steel webs providing corrosion protection to the studs. Zinc is effective as corrosion protection over a wide range of pH values. This coating is minimum 275 g/m2 in total which is 20 microns in thickness to each face of the steel webs.
2. An alkaline rich environment as a result of the release of lime during the hydration of cement in the structural core provides further protection for the steel webs. (#2)
3. The system is isolated from the external environment by the façade elements comprising the galvanised steel channel section flanges, polyurethane adhesive, 6mm fibre cement sheet, and the recommended Dulux Acratex coating system which includes a final Dulux Acrashield impermeable coating. This isolation ensures that carbonation is eliminated and an alkaline rich environment maintained. The diagrams below detail the build-up of the system and compare the carbonation mechanism of the Logicwall® system with a conventional concrete wall.



In a conventional concrete structure the carbonation process commences from placement of the concrete as there is no impediment to the entry of carbon dioxide and humidity to the concrete matrix. It is therefore essential that there is sufficient concrete cover between the reinforcing steel and the exposed surface of the concrete to maintain the protective alkalinity over the design life of the building.

In the Logicwall® system there is a drying tendency to the building interior causing a very low humidity behind the acrylic coating and fibre cement sheet protective layers. There is no ability to replenish moisture behind the protective layer and the carbon dioxide molecules are very much impeded by the acrylic coating. This ensures a carbonation process is unable to reduce the alkalinity at the surface of the structural core so the protection of the galvanised webs is maintained.

The internal regions of the structure are protected by the low internal humidity of the building environment minimising the rate of carbonation to ensure the protective alkalinity is maintained in the region of the corrosion resistant stud webs.

Durability of the Façade System

The façade system consists of the applied coating, and fibre cement sheet bonded to the galvanised stud flanges which are at the surface of the structural core system. The corrosion protection mechanisms in place for the façade system are:

1. The Z275 coating to the stud flanges
2. The protection from exposure from the façade coating system which is maintained to Dulux Acratex requirements for the intended life of the building
3. An alkaline rich environment available from the fibre cement sheet and the surface of the structural core.
4. Polyurethane adhesive coating applied to the stud flanges during manufacture

Methodology for Predicting System Durability

The design for durability of the structural core of the AFS Logicwall system has the objective of achieving a minimum expected life of 50 years +- 20% as is the case with other systems of concrete construction using the AS3600 code.

Embedded Item Durability

In an April 2007 Technical Bulletin, Cement Concrete and Aggregates Australia[(#4)] show that at 5.5% moisture content concrete has a vapour emission of 25 grams/m2/24 hours.

The total permeability of the applied Dulux Acratex coating, Ceminseal fibre cement sheet with waterblock technology and the polyurethane adhesive is 0.6 g/m2/24hrs at 1 kPa.

1 kPa pressure would require wind driven rain at 120 kilometres per hour to achieve this pressure and hence permeation rate of water. Therefore the equilibrium moisture content of the concrete even with constant 120km/hr. wind driven rain will be less than 5%.

A study from the American Galvanisers Association [(#5)] determined expected service life for a galvanised article in soil with high chlorides, a pH of 9.4 and at 5% moisture. This study defines service life as coating consumption time plus 25%. After

discounting this 25% factor back, this study has determined that zinc would corrode at the rate of 0.38 microns per year.

This would predict that the 20 micron coating could be expected to last for more than 50 years. This is seen as a conservative figure as the expected pH of concrete in which the item is embedded is >11. Carbonated concrete has a pH in the vicinity of 9.

External Wall Façade System Durability

The external façade system durability has been assessed using an analysis of the exposure of the stud flanges to atmospheric corrosion.

This assessment compares the rate of zinc loss known to occur to galvanised surfaces in a highly aggressive environment as defined under ISO9223 and AS4312 with the rate of zinc loss at the flange outer surface given the reduced environmental exposure resulting from the protective coating, fibre cement and adhesive.

The Galvanisers Association of Australia [(#1)] provides data for the predicted rate of zinc loss. The benchmark exposed galvanised element in the ISO 9223 category in category C5 is predicted to have a rate of zinc loss of 8.4 microns pa.

Given the permeability of the facade system is 0.6g/m2/24hrs at 1kPa it can be expected that a 2 metre pa rainfall at the surface will result in the permeation of only 12 grams/m2/24hours at the façade stud flange surface. This is equivalent to an exposure of 4.4 kg/m2 pa. A 2 metre rainfall assumed of a C5 environment results in an exposure of 2000kg/m2 pa. The relative exposure and therefore expected zinc loss will be 4.4/2000 times that expected of a category C5 exposure i.e. 0.18 microns pa.

This rate of zinc loss predicts a service life of 111 years for a 20 micron coating

Internal Lining Elements of the Logicwall® System

The exposure of the stud flanges at the surfaces of internal walls and to the internal surface of external walls will be at a benign level C1 according to ISO 9223. Internal surfaces where condensation could occur for short periods in bathrooms and kitchens should be appropriately treated prior to final finish coat. This short duration condensation will be limited to the exposed surface and not elements internal to Logicwall®.

A benign C1 level environment will deliver a service life of 200 years

Third Party Accreditation

The British Board of Agrement has undertaken a certification analysis of the AFS Logicwall® system for use in the UK. The analysis details the structural performance, thermal performance, behaviour in relation to fire, sound insulation and durability as assessed by the BBA. They conclude the system is fit for its intended use provided it is installed, used and maintained as set out in the certificate. The BBA Approval Inspection Testing Certification Certificate Number for the AFS Logicwall® system is 14/5119.

The certification report states in the section ALL MAP 16 Durability:
"*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."*

Historic Performance

Similar systems providing stay in place formwork made from galvanised steel channel sections and fibre cement sheet have been used in many projects commencing in the 1980's. To our knowledge there have not been any corrosion issues.

AFS Logicwall® has been supplying the Logicwall® system since 1996. Over many thousands of projects AFS have had no corrosion issues with stay in place formwork manufactured with fibre cement board and galvanised steel channel sections and where the project was detailed, installed and maintained to AFS specifications. (#3)

Conclusions

The analysis of exposure conditions associated with the AFS Logicwall® systems for internal and external applications shows that the life expectancy will be equal or better to that which can be expected of a concrete structure designed in accordance with AS3600.

The structural core of the Logicwall system comprises the concrete with the embedded corrosion resistant webs of the Logicwall galvanised steel channel sections. The reduction in exposure resulting from the façade elements of the system and the embedment of the galvanised studs results in a predicted life in excess of that expected of a comparable conventional concrete structure.

The embedded Logicwall studs are corrosion protected through surface galvanizing. The alkaline rich concrete environment in which the studs are embedded is protected from alkalinity reduction through the action of the FC sheeting and coatings. This system would provide a life expectancy greater than 50 years.

The façade elements of the Logicwall system consist of the stud flanges, the adhesive layer to fibre cement sheets with a Dulux Acratex system maintained in accordance with Dulux recommendations. The protection afforded by the façade surface elements results in a very low predicted rate of zinc loss and hence a life expectancy of the stud flanges well in excess of 100 years.

Where Logicwall surfaces present to internal building areas it is expected the exposure categories applicable under ISO 9223 will be C1 which will deliver a life expectancy of 200 years.

References

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#2. . *Corrosion of the zinc alloy coating in galvanised reinforced concrete, Prof S.R. Yeomans, University of NSW ADFA 1994.*

#3. . *AFS Designer and Certificates, AFS Walling Solutions.*

#4. . *Moisture in Concrete and Moisture-sensitive Finishes and Coatings, APR 2007 .*

#5. . *Service Life of Galvanized Steel Articles in Soil Applications, American Galvaizers Association 2011.*

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