ADVISORY NOTE 49

BEST PRACTICE FOR ABCB HOUSING PROVISIONS

Issue 3: May 2023

TABLE OF CONTENTS

Contents

Changes from Issue 2

The changes from issue 2 are significant. The NCC 2019 Volume Two was superseded in September 2022 and corrosion protection moved from Clause 3.4.4.4 in Volume 2 to Clause 6.3.9 in the ABCB Housing Provisions. Corrosion protection requirements are now aligned to AS 4312 and AS/NZS 2312.2 zones of atmospheric corrosivity and there is no differentiation between interior and exterior exposure. Options are given for galvanizing, duplex and paint coatings which must conform to the requirements of AS/NZS 2312.2 and AS 2312.1. Corrosion protection must be reinstated to the original condition for all cut-ends, welds, and other damage. The ABCB Housing Provisions became active on May 1, 2023, although this change becomes active on October 1, 2023.

This Advisory Note is not suitable for use in New Zealand.

Please check https://gaa.com.au/technical-publications/ to ensure you have the latest edition.

ADVISORY NOTE 49

BEST PRACTICE FOR ABCB HOUSING PROVISIONS

INTRODUCTION

This Advisory Note provides additional advice to the Building Code of Australia, also known as the National Construction Code, for the corrosion protection of structural steel in housing and related applications. It deals with some common issues but cannot describe all situations and independent professional advice must be sought if there is any doubt.

All structural steel used in housing is now required to be protected from corrosion and the *deemed-to-satisfy provisions* for corrosion protection are now the same for internal and external structural steel. The minimum level of corrosion protection is now aligned to the macro-environment. This means that there is a wider scope of materials considered suitable. Batch hot dip galvanized structural steel can be used as a *deemed-to-satisfy* solution in all environments, although there are some environments where a duplex coating will be required. Continuously galvanized structural steel (typically used as hollow sections) only meets the minimum *deemed-to-satisfy* requirements in low (C2) environments. Additionally, when the structural steel is cut or welded on-site or where the coating is otherwise damaged the protective coating must repaired to the original corrosion protection condition.

BACKGROUND

NCC 2022 Volume Two – Building Code of Australia primarily covers the design and construction of smaller scale buildings including houses, small sheds, carports, and some associated structures. The **ABCB Housing Provisions** contains ***Deemed-to-Satisfy Provisions*** that are acceptable forms of construction. There is no obligation to adopt any option contained in the ABCB Housing Provisions if it is preferred to meet the ***Performance Requirements*** some other way. However, if the *Deemed-to-Satisfy Provisions* are not followed, then there is an obligation to satisfy the appropriate authority the design meets the *Performance Requirements* of the ABCB Housing Provisions with a ***Performance Solution***.

The National Construction Code 2022 Building Code of Australia – Housing Provisions Standard 2022 (Australian Building Codes Board, 2022) sets out the requirements for corrosion protection of certain structural steel members such as:

- Bearers supporting a timber floor or non-loadbearing stud wall,
- Strutting beams supporting roof and ceiling loads,
- Lintels supporting a roof, ceiling, frame, and timber floor, and
- Columns, piers, stumps, posts, and piles

Clause 6.3.9 covers the corrosion protection for all structural steel ***except for structural steel elements built into masonry (for example, lintels), which are covered in Clause 5.6.7***. The minimum corrosion protection is aligned to the environment and location provisions in Clause 7.2.2, *Corrosion protection and compatibility requirements for roofing* although the designation for metallic coated roofing is not the same as for batch hot dip galvanized (HDG) structural steel. For example, HDG225 is approximately equivalent to Z450 roofing when considering the protective life of the galvanized coating. The information on environments shown in Clause 7.2.2 are identical to those shown in AS 4312 (Standards Australia, 2019) for corrosion rates of steel, AS/NZS 2312.2 (Standards Australia & New Zealand Standards, 2014) for batch HDG and duplex coatings and AS 2312.1 (Standards Australia, 2017) for paint. This means specifiers can use one set of corrosion rates for design, considerably simplifying the process.

The commercially available batch HDG coatings such as those conforming to AS/NZS 4680 (Standards Australia & New Zealand Standards, 2006) often exceed the minimum requirements for galvanizing in the ABCB Housing Provisions and, in most cases, ***the cost of corrosion protection should not increase*** where corrosion protection utilising batch HDG was used previously. Table 3 is provided in this Advisory Note to assist specifiers and galvanizers alike understand the new provisions.

There are multiple types of zinc coatings sold in Australia that are a form of galvanizing but some of these are not always suitable for long term protection of structural steel in corrosive environments. For example, structural hollow sections galvanized to AS/NZS 4792 ZB100/100 (Standards Australia and Standards New Zealand, 2006) will meet the *deemed-to-satisfy* provisions of the ABCB Housing Provisions only in Low (C2) environments, while electrogalvanized hollow sections to AS 4750 (Standards Australia, 2003) do not meet the *deemed-to-satisfy* provisions for any environment. Batch HDG coatings on steel produced to AS/NZS 4680 vary with steel section thickness and all batch HDG coatings on steel sections greater than 3 mm will meet the minimum requirements of the ABCB Housing Provisions for structural steel members up to High (C4) environments. Environments that are Very High (C5) will require HDG900 or a listed duplex coating. It is important that the correct coating specification is selected and supplied to ensure the coating meets both the *deemed-to-satisfy* provisions and provides adequate performance.

Note: Clause 6.3.9 of the ABCB Housing Provisions covers the corrosion protection of structural steel members used in masonry construction, but it does not cover corrosion protection of structural steel built into a masonry wall such as lintels. For lintels and other structural steel elements built into masonry, specifiers must refer to Clause 5.6.7 of the ABCB Housing Provisions, AS 3700 (Standards Australia, 2018)*, and AS 2699* (Standards Australia, 2020)*.*

NATIONAL CONSTRUCTION CODE

The National Construction Code (NCC) is Australia's primary set of technical design and construction provisions for buildings. It is a self-described performance-based code which primarily applies to the design and construction of new buildings and is used by architects, builders, building surveyors, engineers and other building related professions and trades. The NCC is given legal effect through relevant State and Territory legislation and the applicability of the NCC for a particular situation should be assessed against the relevant local legislation.

The Building Code of Australia (BCA) makes up 3 volumes of the NCC along with the ABCB Housing Provisions which are the subject of this Advisory Note. The ABCB Housing Provisions primarily cover the design and construction of houses, small sheds, carports, and extensions to existing structures. The NCC allows either a *Performance Solution* or a *Deemed-to-Satisfy Solution* to meet the requirements of the BCA. The differences can be complex, and these are described in Part A2 of Volume 2 of the BCA.

Clause 6.3.9 of ABCB Housing Provisions deals with the minimum acceptable corrosion protection for structural steel for *Deemed-to-Satisfy Provisions*. It is this aspect that is clarified in this Advisory Note. The guidelines in this Advisory Note are not a *Performance Solution* but do provide more information that will assist professionals in the development of a suitable corrosion protection system for structural steel in some common applications.

ADVISORY NOTE 49

Structural steel members in the ABCB Housing Provisions

A range of structural steel members are included in the Acceptable Construction Practice section of Clause 6.3.9. of the ABCB Housing Provisions. Hot formed sections included are a range of taper flange beams, universal beams, parallel flange channels, taper flange channels, equal angles, and unequal angles. Cold formed sections covered include a range of standard tubular sections (rectangular, square, and round hollow sections). Structural steel members covered vary in thickness from 1.6 mm for a limited selection of tubular sections to well over 6 mm thickness on various hot formed sections. The steel thickness is important as it affects the galvanized coating thickness formed on batch hot dip galvanized sections which, in turn, directly influences the durability of the structural steel and the service life of the structure.

Corrosion protection of structural steel members in the ABCB Housing Provisions

The ABCB Housing Provisions detail mandatory corrosion protection of structural steel members in Clause 6.3.9 where four atmospheric environments (*low, medium, high,* and very high) are described (Table 1 of this document). In addition, the concept of *breaking surf* and a definition of *heavy industrial areas* is provided. The ABCB Housing Provisions do not provide any mandatory requirements related to micro-environments, although they do provide some *deemed-to-satisfy* provisions for piers or stumps and ventilation of the sub-floor. Table 7.2.2a relating to roofing and walling provides descriptions of the common environments seen in Australia and these are equivalent to the information contained in AS/NZS 2312.2 where the Corrosivity Categories are denoted C2, C3, C4, and C5. This information is reproduced below.

A ***low*** environment (C2) is defined as being remote inland areas (more than 10km from breaking surf) or more than 1km from a sheltered bay, including dry rural areas remote from the coast or sources of pollution. Many areas of Australia beyond at least 50 km from the sea are in this category, including most cities and towns such as Canberra, Ballarat, Toowoomba, Alice Springs, and some suburbs of cities on sheltered bays such as Melbourne, Hobart, Brisbane, and Adelaide that are more than 1 km from the sea. However, each of these have many exceptions which are in more corrosive categories.

A ***medium*** environment (C3) is defined as being more than 1 km from breaking surf or heavy industrial areas or more than 50 m from salt water not subject to breaking surf, typically around sheltered bays, such as Port Phillip Bay. This extends from about 50 m from the shoreline to a distance of about 1 km inland but seasonally or in semi-sheltered bays extends 3 km to 6 km inland. Along ocean front areas with breaking surf and significant salt spray, it extends from 1 km inland to about 10 to 50 km depending on wind direction and topography. Much of the metropolitan areas of Wollongong, Sydney, Newcastle, Perth, and the Gold Coast are in this category. This can extend to 30 km to 70 km inland in South Australia while on some evidence, other southern Australian coastal zones are in this, or a more severe category. This also includes urban and industrial areas with low pollution and for several kilometres around large industries such as steel works and smelters.

A ***high*** environment (C4) is defined as being more than 200 m from breaking surf or 50 m from sheltered bays. In areas of rough seas and surf it extends from several hundred metres to about 1 km inland. As with other categories the extent depends on wind, wave action and topography. The category will also be found inside industrial plants and can influence a distance of 1.5 km down wind of the plant.

A *very high* environment (C5) is defined as being within 200 m of breaking surf or a heavy industrial area. It is also found in aggressive industrial areas with a pH of less than 5.

Figure 1. A high environment located within 1km of breaking surf.

Breaking surf is defined in the NCC as any area of salt water where waves break on an average of four days per week but does not include white caps or choppy water. This normally occurs in open seas and would usually preclude sheltered locations in the vicinity of Port Philip Bay, Sydney Harbour and near coastal rivers such as Derwent, Swan, and Brisbane Rivers.

Heavy industrial areas are defined as the industrial environments around major industrial complexes. Corrosion of steel from industrial effects is no longer an important factor as heavy industrial areas are relatively few in Australia and are known from surveys to be restricted to the areas nearby to the processing plants at Mt Isa and Port Pirie (see AS 4312 for more information).

Table 1 ABCB Housing Provisions Table 6.3.9a Minimum protective coatings for structural steel members *(edited)*

Environment	Location	Minimum protective coating		
		Option 1 (HDG)	Option 2 (Duplex)	Option 3 (Paint)
Low (C2)	Typically, remote inland areas more than 1km from sheltered bays	HDG75	-	ACL2, ACC2, IZS1, PUR2A
Medium (C3)	Typically, more than 1km from breaking surf or aggressive industrial areas or more than 50m from sheltered bays	HDG225	-	ACL3, ACC4, ACC5, IZS1, PUR3, PUR4
High (C4)	Typically, more than 200m from breaking surf or aggressive industrial areas or within 50m from sheltered bays	HDG450	HDG150 & 4D OR HDG300 & 2D	ACC6, IZS3, PUR5
Very High (C5)	Typically, within 200m from breaking surf or aggressive industrial areas	HDG900	HDG300 & 5D OR HDG600 &4D	ACC6, PUR5

Notes

1. *HDG and duplex systems to AS/NZS 2312.2 (see over)*
2. *Paint systems to AS 2312.1 (see over)*

Duplex coatings in the ABCB Housing Provisions

Duplex coatings use a batch HDG coating as a base plus a paint coating applied in several layers to provide additional protection in corrosive environments. The designations used in the ABCB Housing Provisions are further detailed in Table 6.3.9b and are drawn from AS/NZS 2312.2. The GAA publishes several free technical documents relating to the selection and application of duplex coatings, available from https://gaa.com.au/technical-publications/. These documents should be referenced if more information is required, however a basic description is provided here.

2D Degrease, wash, and dry the batch HDG steel, then sweep blast it and paint with 2-pack inhibitive epoxy primer to 75 µm DFT plus polyurethane or 2-pack acrylic gloss to 100 µm DFT.

4D Degrease, wash, and dry the batch HDG steel, then sweep blast it and paint with 2-pack high build epoxy to 250 µm DFT plus polyurethane or 2-pack acrylic gloss to 100 µm DFT.

5D Degrease, wash, and dry the batch HDG steel, then sweep blast it and paint with 2-pack epoxy primer (inhibitive) to 75 µm DFT plus 2-pack high-build epoxy to 225 µm DFT plus polyurethane or 2-pack acrylic gloss to 100 µm DFT.

Notes:

1. *Surface preparation is critical to long life performance of painted surfaces and sweep blasting must be carried out by an expert.*
2. *DFT = dry film thickness. This means the thickness of each paint layer measured after it has dried.*
3. *The sweep blasting procedure used for surface preparation of galvanized steel for painting described in AS/NZS 2312.2 will remove nearly all the galvanized coating from continuously galvanized hollow sections. A performance solution will be required for any necessary additional corrosion protection using paint for these products. This procedure is only suitable for batch HDG coatings.*
4. *All major paint suppliers can provide paints to these specifications. Paint manufacturer instructions must be followed to ensure adequate corrosion protection.*
5. *Options for duplex coatings exist in Table 6.3.9a. For example, HDG150 & 4D or HDG300 & 2D are alternative deemed-to-satisfy solutions for a High (C4) environment (see Table 1 above) although the thinnest commercially available batch HDG coating is HDG320. The GAA solutions in this Advisory Note assume the least expensive paint coating available for the thinnest commercially available batch HDG product meeting the requirements of AS/NZS 4680. Table 3 shows the likely most economical solution for each environment.*

Paint systems in the ABCB Housing Provisions

Table 6.3.9c of the ABCB Housing Provisions provides details on the paint systems used in the deemed-to-satisfy provisions. These are drawn from the solutions provided in AS 2312.1 and more information on these products is available from major paint manufacturers and professional painters.

The GAA does not provide advice on the application and selection of paint systems for corrosion protection.

ADVISORY NOTE 49

HOT DIP GALVANIZING

Batch hot dip galvanizing is the process of dipping a structural steel member or fabrication into molten zinc. The process forms a metallurgical bond between the zinc and the steel to create a long lasting and abrasion resistant coating that protects against corrosion in atmospheric conditions. More detail on the batch HDG process can be found at the GAA's website (www.gaa.com.au).

For all hot formed structural steel members (taper flange beams, universal beams, parallel flange channels, taper flange channels, equal angles, and unequal angles), galvanizing can only be applied by the batch HDG process governed by Australian Standard AS/NZS 4680 (Table 2). The batch hot dip galvanizing of hollow sections (tube and pipe) is also covered by AS/NZS 4680. Although other galvanized coating solutions are available in Australia, none of the continuous galvanized coatings applied over SHS or RHS hollow sections meet the coating mass and thickness requirements of the ABCB Housing Provisions in environments other than *Low* (C2).

Table 2 Batch hot dip galvanized coating thickness requirements for AS/NZS 4680

Steel thickness (mm)	HDG coating thickness average minimum (µm)	HDG coating mass average minimum (g/m²)
> 6	85	600
> 3 to ≤ 6	70	500
≥ 1.5 to ≤ 3	55	390
< 1.5	45	320

Note: The HDG coating thickness is the usual method of checking compliance of HDG coating application and can be converted to mass by multiplying by 7.14. The HDG coating mass is rounded for convenience of description.

The steel thickness normally controls the batch HDG coating thickness and coating mass commercially available in Australia to AS/NZS 4680. Only the steel thickness is required to be provided to the galvanizer to prepare structural steel to the requirements of AS/NZS 4680 as the ABCB Housing Provisions have special requirements for galvanized coating mass and thickness which are less than what is commercially available (except for HDG900).

To check the coating thickness supplied, a simple non-destructive test is available. If a test report is required, this must be included on the order and will usually incur a cost, otherwise a certificate of conformance can be supplied by all members of the Galvanizers Association of Australia on request.

The requirements of the ABCB Housing Provisions differ from the normally used terms in the galvanizing industry, however the requirements of AS/NZS 4680 are such that the batch HDG coating on all steel sections greater than 3 mm in thickness will exceed the requirements of Table 6.3.9a of the ABCB Housing Provisions for Low (C2), Medium (C3) and High (C4) environments, and in most cases the actual thickness received will provide for a batch HDG coating service life significantly more than envisaged in the ABCB Housing Provisions. HDG900 or Duplex coating solutions are required for Very High environments (C5).

Table 3 of this Advisory Note provides a direct comparison of the commercially available batch HDG structural steel options and the deemed-to-satisfy provisions of the ABCB Housing Provisions.

HDG900 is normally only available where the steel thickness is more than 10 mm, and the steel contains more than 0.01% silicon. The chemistry of the steel can be found by reference to the Test Certificate of the actual product supplied.

Other types of galvanized coatings are readily available for hollow sections. Most of these will not meet the minimum requirements for batch HDG coated steel in the ABCB Housing Provisions except for areas with Low corrosivity (C2). In addition, most of these coatings are too thin to be prepared by sweep blasting for the Duplex coating options given in Table 6.3.9a of the ABCB Housing Provisions. It is critical that the designer specifies the correct material and the builder orders and receives the correct material to ensure long term durability of the coating.

Figure 2 The batch HDG structural steel members (verandah posts and edge members) have good access and would be expected to provide structural support with regular maintenance of the galvanized coating for 50 years in moderate locations. Regular maintenance, plus repairs to the galvanized coating should be expected to be carried out during the life of the building in severe environments.

Table 3. Compliance of batch galvanized coatings to the ABCB Housing Provisions Table 6.3.9a

		Batch Hot Dip Galvanizing Specification	Standard batch HDG (AS/NZS 4680)				Special HDG
		Steel thickness range (mm)	≤ 1.5	> 1.5 to ≤ 3	> 3 to ≤ 6	> 6	*See key*
		Coating thickness, μm (minimum average)	45	55	70	85	125
		Coating mass g/m^2 (minimum average)	320	390	500	600	900
Environment and Description		*Deemed-to-satisfy* (*see key*)					
Low	Typically, remote inland areas more than 1km from sheltered bays	HDG75					
Medium	Typically, more than 1km from breaking surf or aggressive industrial areas or more than 50m from sheltered bays	HDG225					
High	Typically, more than 200m from breaking surf or aggressive industrial areas or within 50m from sheltered bays	HDG450	HDG300 + 2D	HDG300 + 2D			
Very High	Typically, within 200m from breaking surf or aggressive industrial areas	HDG900	HDG300 + 5D	HDG300 + 5D	HDG300 + 5D	HDG600 + 4D	

Key
- (green) All batch HDG to AS/NZS 4680 is ***deemed-to-satisfy*** in the nominated steel thickness range.
- (yellow) All batch HDG to AS/NZS 4680 is ***deemed-to-satisfy*** in the nominated steel thickness range when duplex coated as indicated.
- (orange) A HDG900 coating is always ***deemed-to-satisfy*** although this can only occur if the steel is suitable to form a HDG900 coating which requires the **steel thickness and steel chemistry** to be suitable and **normally** occurs when the steel thickness is more than 10 mm, **and** the silicon content of the steel is more than 0.01%.

Notes

1. *The batch HDG coating thickness and mass is determined by the steel thickness, as shown in AS/NZS 4680. See also notes 2 and 3 for additional information. Additional durability information and design requirements for batch hot dip galvanizing are shown in AS/NZS 2312.2.*
2. *For some applications and certain steel chemistries, the steel may also need to be blasted before batch hot dip galvanizing but do not specify this without reference to your galvanizer. See also AS/NZS 2312.2 for more information.*
3. *For a coating mass of 900 g/m^2 (HDG900), the internal batch hot dip galvanized coating thickness of hollow sections will be the Standard HDG thickness relevant to the steel thickness and will therefore require a **performance solution** in most cases.*

ENVIRONMENTAL CONDITIONS FOR CORROSION OF STEEL

Corrosion of steel in housing applications

The corrosion of steel in housing is generally related to the atmospheric corrosivity experienced by steel, known as the *macro-environment*, plus any localised effects, known as the *micro-environment*, such as sheltering of unwashed surfaces in corrosive locations, defects in the corrosion protection from steel fabrication or installation, and design defects.

The macro-environment

The general atmospheric condition in an area is usually the main driver affecting the corrosion rate of steel and this is known as the macro-environment. Australian Standards AS 4312 and AS/NZS 2312.2 provide excellent guidance on the macro-environment in Australia.

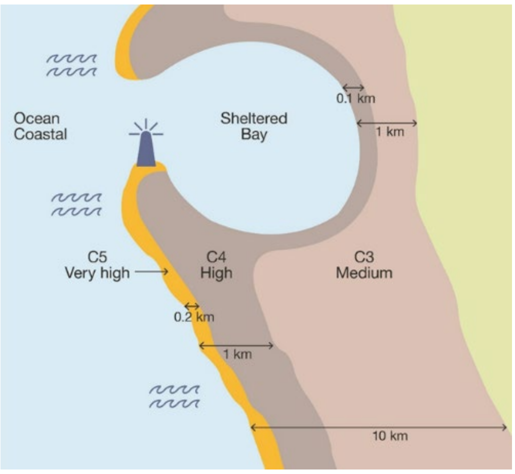

Figure 3 Corrosivity Categories as shown in AS 4312 and AS/NZS 2312.2

For ease of design, the macro-environment is generally broken up into Corrosivity Zones. The zones are generally related to the distance from the coast and the type of coast, where the corrosion rate of steel increases dramatically as the distance to the coast decreases (see Figure 3 and Table 4). The type of coast is important, where the conditions around sheltered bays are usually less corrosive, while exposure to surf increases the corrosion rate of steel. Category CX, as described in Table 4, mainly occurs at the shoreline of severe surf conditions and is therefore not generally applicable for domestic housing and is not covered in the ABCB Housing Provisions.

Figure 4 Batch HDG structural steel posts in combination with a continuous HDG sub-floor located in a Low (C2) environment (more than 10km from breaking surf).

Table 4 Corrosivity in Australia as described in AS 4312 and AS/NZS 2312.2

Category		Generic examples	Specific examples
CX	Severe surf shoreline	Surf beach shoreline regions with very high salt deposition.	Some Newcastle beaches
C5	Surf Seashore	Within 200 m of rough seas & surf beaches. May be extended inland by prevailing winds & local conditions.	More than 500 m from the coast in some areas of Newcastle
C4	Calm Seashore	From 200 m to 1 km inland in areas with rough seas & surf. May be extended inland by prevailing winds & local conditions.	All coasts
		From the shoreline to 50 m inland around sheltered bays. In the immediate vicinity of calm salt water such as harbour foreshores.	
C3	Coastal	From 1 km to 10 km inland along ocean front areas with breaking surf & significant salt spray. May be extended inland to 50 km by prevailing winds & local conditions.	Metro areas of Perth, Wollongong, Sydney, Brisbane, Newcastle, & the Gold Coast
		From 100 m to 3 – 6 km inland for a less sheltered bay or gulf.	Adelaide & environs
		From 50 m to 1 km inland around sheltered bays.	Port Philip Bay & in urban & industrial areas with low pollution levels
C2	Arid/Urban Inland	Most areas of Australia at least 50 km from the coast.	Canberra, Ballarat, Toowoomba & Alice Springs
		Inland 3 – 6 km for a less sheltered bay or gulf.	Adelaide & environs
		Can extend to within 1 km from quiet, sheltered seas.	Suburbs of Brisbane, Melbourne, Hobart
C1	Dry indoors	Inside heated or air-conditioned buildings with clean atmospheres.	Commercial buildings

The distance of C2 and C3 zones from the coast vary around Australia, and this can influence the best solution for corrosion protection. The GAA recommends that designers take the time to understand the distance of the house or structure from corrosive influences before deciding on the protective coating solution. This is discussed further in the next section.

Corrosion rate of steel and HDG coatings in the macro-environment

The rate of corrosion for uncoated structural steel members and HDG coatings is provided by AS 4312 and AS/NZS 2312.2 as shown in Table 5. The corrosion rates shown in each Corrosivity Category are provided as a range where, for normal Australian washed atmospheric exposures, the distance from the coast is the driving force. Although it is known the long-term steady state corrosion rate of metals reduces over time, the Australian Standards use the first year of corrosion as a conservative estimate.

The ABCB Housing Provisions provide the deemed-to-satisfy provisions based on a calculated time to first maintenance of each coating of a minimum 15 years, so most applications should provide at least this level of protection in the macro-environment.

The corrosion rate can be compared to standard batch HDG coating thicknesses to determine the estimated service life of the coating. Using this information and the options available in Table 6.3.9a of the ABCB Housing Provisions, the estimated service life of each option can be determined.

When completely covered by a batch HDG coating the steel will not commence rusting, so the steel corrosion rates are only important if the batch HDG coating has been fully consumed by the environment to which it is exposed.

Table 5 Rate of corrosion of structural steel and HDG coatings

AS 4312 & AS/NZS 2312.2 Corrosivity category, description & typical environment			Typical corrosion rate for the first year (µm/y)	
			Structural steel	HDG coatings
CX	Extreme	Ocean/Offshore	>200 to ≤700	>8.4 to ≤25
C5	Very High	Surf seashore	>80 to ≤200	>4.2 to ≤8.4
C4	High	Calm seashore	>50 to ≤80	>2.1 to ≤4.2
C3	Medium	Coastal	>25 to ≤50	>0.7 to ≤2.1
C2	Low	Arid/Urban inland	>1.3 to ≤25	>0.1 to ≤0.7
C1	Very low	Dry indoors	≤1.3	≤0.1

Table 6 shows the same information in the form of life to first maintenance of the galvanized coating. For batch HDG coatings this should be considered the time at which major maintenance of the item is required to reinstate corrosion protection to the steel.

CX is excluded from Table 6 as it is unlikely that many buildings for domestic purposes would exist in such an environment and all galvanized coatings on steel are unlikely to be suitable, even with a duplex coating.

ADVISORY NOTE 49

Table 6. Expected range of life to first maintenance of HDG coatings in the macro-environment for commonly available corrosion protection methods according to AS/NZS 2312.2

Product and type		Steel thickness	HDG coating mass & thickness		Environment & estimated life of HDG coating (min-max, years)			
		mm	g/m^2	µm	Very high C5	High C4	Medium C3	Low C2
AS/NZS 4680	HDG900[1]	See note 1	900	125	15-30	30-60	60->100	>100
	HDG600	>6.0	600	85	10-20	20-40	40->100	>100
	HDG500	>3.0-≤6.0	500	70	8-16	16-33	33-100	>100
	HDG390	>1.5-≤3.0	390	55	6-13	13-26	26-78	78->100
	HDG320	<1.5	320	45	5-10	10-21	21-64	64->100
AS/NZS 4792[2]	ZB100/100	All	100	14	1-3	3-6	6-20	20->100
	ZB135/135	All	135	19	2-4	4-9	9-27	27->100
AS 4750[3]	ZE50/50	All	50	7	0-1	1-3	3-10	10-70

Notes:

1. *HDG900 is special batch HDG coating and should be specified as "AS/NZS 4680, except minimum average coating thickness to be 125 µm (900 g/m^2) and local average coating thickness to be 100 µm". It is normally only available when the steel thickness is more than 10 mm,* ***and where the silicon content of the steel is more than 0.01%****. For some applications and certain steel chemistries, the steel may also need to be blasted before galvanizing but do not specify this without reference to your galvanizer. For hollow sections that have been blasted, the internal galvanized coating thickness will be the Standard batch HDG thickness relevant to the steel thickness and will therefore require a performance solution in most cases. See also AS/NZS 2312.2 for more information.*

2. *AS/NZS 4792 galvanized coatings are only available for cold formed tubular sections and use pre-galvanized strip which is then formed into a welded tube. The welded area is repaired by the tube manufacturer to restore corrosion protection to the AS/NZS 4792 Standard. These products meet the deemed-to-satisfy requirements of the ABCB Housing Provisions for Low (C2) environments when any damage from fabrication or handling (for example, after cutting or welding) is repaired.*

3. *AS 4750 is the Australian Standard for electrogalvanized tubular sections commonly available in Australia. The coating mass (50 g/m^2) does not meet the minimum deemed-to-satisfy provisions of the ABCB Housing Provisions for HDG. Electrogalvanized coatings are also not strictly hot dip galvanized as the coating is mechanically bonded to the underlying steel and does not form the hard, abrasion resistant zinc-iron alloy layers formed by other galvanized methods. These coatings would generally be only suitable for internal applications.*

The micro-environment

Buildings are known to offer a significant shielding effect when the steel is fully enclosed (figure 5) within the building envelope, such as an enclosed roof, wall, or intermediate floor.

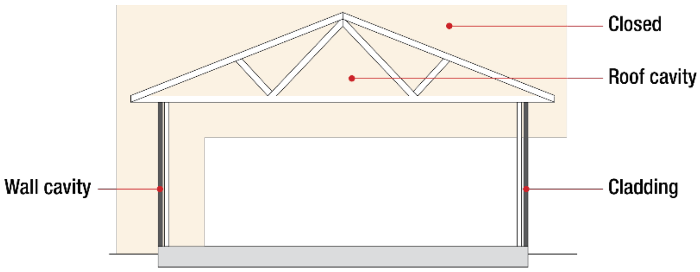

Figure 5 Enclosed spaces in a building are usually those in the roof space, wall cavity and intermediate floor structural members.

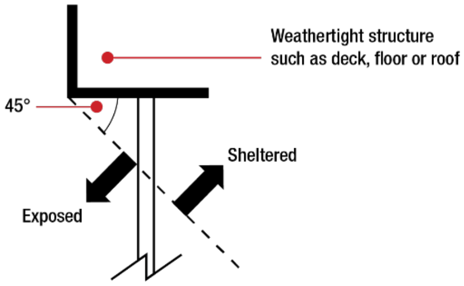

Figure 6 Most designs assume that structural steel and other elements is sheltered from rain once it is less than a 45° angle from the protected edge.

If the steel is not fully enclosed in the building and is exposed to wind-driven salt in an area which is not exposed to cleansing rain (for example, an open subfloor, carport, and veranda), the location is described as sheltered (figure 6) and the corrosivity of the micro-environment can be significantly higher than the overall, or macro-environment. This aspect is critical for estimating the design life of structural steel. When a subfloor is open to the environment, it can be partly exposed and partly sheltered, as shown in figure 7.

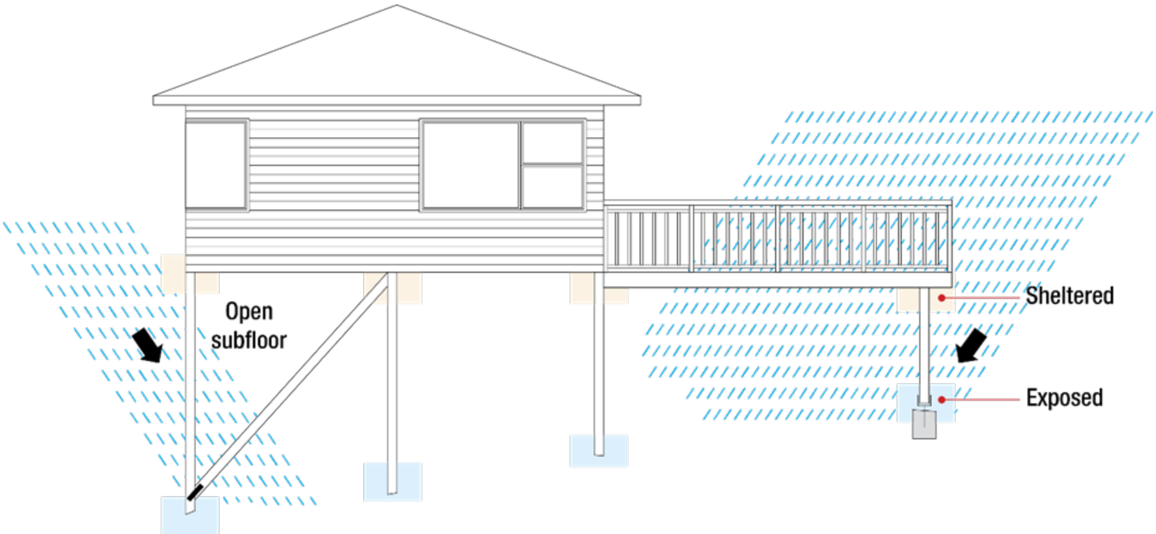

Figure 7 An example showing that a house can have a combination of enclosed, exposed, and sheltered spaces in the one design which exhibit micro-environments that need to be fully assessed for maximum durability.

Steel that is fully exposed and rain washed can normally be assumed to be affected only by the macro-environment, although the fittings and connections still need to be assessed to ensure their service life is like the overall structure or that they can be easily replaced or maintained. Structural elements can include decks, pergolas, and subfloor framing although the angle of any overhang can be critical.

Damaged coatings: a special micro-environment

All coatings on structural steel can be damaged by rough handling, welding, cutting, or drilling, exposing bare steel to the environment which will corrode rapidly if large enough. Therefore, all damaged areas need to be repaired, as required in Clause 6.3.9 of the ABCB Housing Provisions.

For batch HDG coatings, the repair is relatively straightforward. In most cases the steel can be cleaned of damage and rust, and a zinc rich paint applied to 100 µm coating thickness. These products are readily available from most hardware stores and professional paint stockists. The GAA has an Advisory Note (Galvanizers Association of Australia, 2022) with more detailed information on options where the steel has aesthetic requirements. For damage to duplex coatings, the paint manufacturer can provide repair options which will vary depending on the product used.

CORROSION OF STRUCTURAL STEEL - DESIGN CONSIDERATIONS

The design life of the structural member is not usually the same as the service life of the batch HDG or duplex coating. When a coating has been fully consumed by its environment, the structural steel will always support the building until enough steel has corroded to cause failure. In some cases, while a structural steel member might be able to be maintained, the evidence of corrosion may not be apparent to a reasonable person.

The main questions relating to corrosion protection of structural steel in housing design are:

1. What is the acceptable life for both the protective coating and the structural steel member?
2. What maintenance of both the protective coating and structural steel member can be reasonably expected by the homeowner?

To answer these questions, we usually need to understand whether the member is enclosed or exposed, the accessibility of the member for maintenance, the difficulty in providing the required maintenance and/or the cost of simply replacing the member (figures 5-7).

Enclosed members include:

- ceiling battens, roof framing (e.g., strutting beams),
- wall framing (e.g., lintels and columns), and
- floor bearers and joists, including intermediate floors.

Exposed members that are accessible for maintenance include:

- stumps and piers supporting the main building which are bolted to a base plate or attached to, but not embedded in, a concrete footing.
- verandah beams, rafters, columns, and stumps,
- carport rafters, beams, and posts,
- pergola rafters, beams, and posts,
- decks and balconies independent of the main structure, and
- roof battens and lower storey unlined eaves.

Exposed members that are difficult or inaccessible for maintenance include:

- floor piers/stumps embedded in concrete,
- floor bearers and joists,
- integrated decking and
- balcony structures (e.g., cantilever)).

Design of the ground/steel interface

Design of the ground/steel interface is also critical as ponding of moisture can significantly accelerate the corrosion of the coating and the structural steel. This effect is known as *ring barking* or *collar corrosion* and is common where water or moisture can pond at the base and in areas where water can seep into gaps around concrete, paved, or tiled joints (figure 8) or the steel post and soil (figure 9). The ground/steel interface is an example of a micro-environment.

In the example of the verandah post embedded into a tiled or paved verandah (figure 8), corrosion has occurred due to a micro-environment and out of sight of the homeowner and structural failure could occur relatively early in the design life.

Figure 8 A verandah post embedded into a tiled floor in a wet area. Water has seeped into the gap between the tile and the steel through capillary action, leading to accelerated corrosion and early failure. This is a design defect where separation of the water from the steel was not considered.

Figure 9 This large post bolted to a concrete pad will finish below the ground level and will be at risk of collar corrosion reducing the durability of the structure unless additional protection is added.

Numerous steps can be taken to help a galvanized steel member embedded in concrete and soil reach the desired service life. Some or all the following measures may be required depending on the corrosivity of atmospheric environment and potential issues identified during the design process.

If water can pool at the interface between the galvanized steel and concrete or soil, a localised corrosion cell forms which results in higher-than-expected corrosion rates. Ponding can be minimised by building up concrete or soil around the interface to promote a natural water run-off, and by preventing water from running down the member to the interface. If ponding cannot be avoided through a design change, additional barrier protection is recommended at the interface. Figure 10 and figure 11 show examples of the range from best to worst protection of the galvanized coating in soil and concrete, respectively.

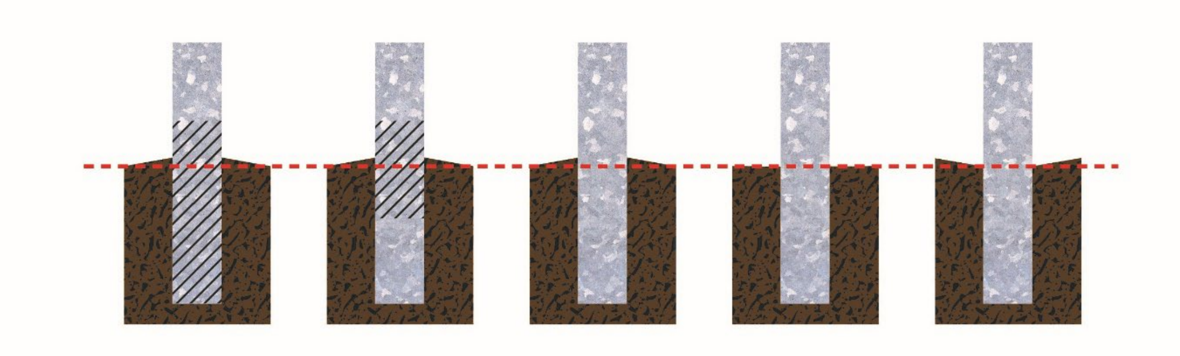

Figure 10 Showing the best design (left) to worst design (right) for galvanized steel embedded in soil.

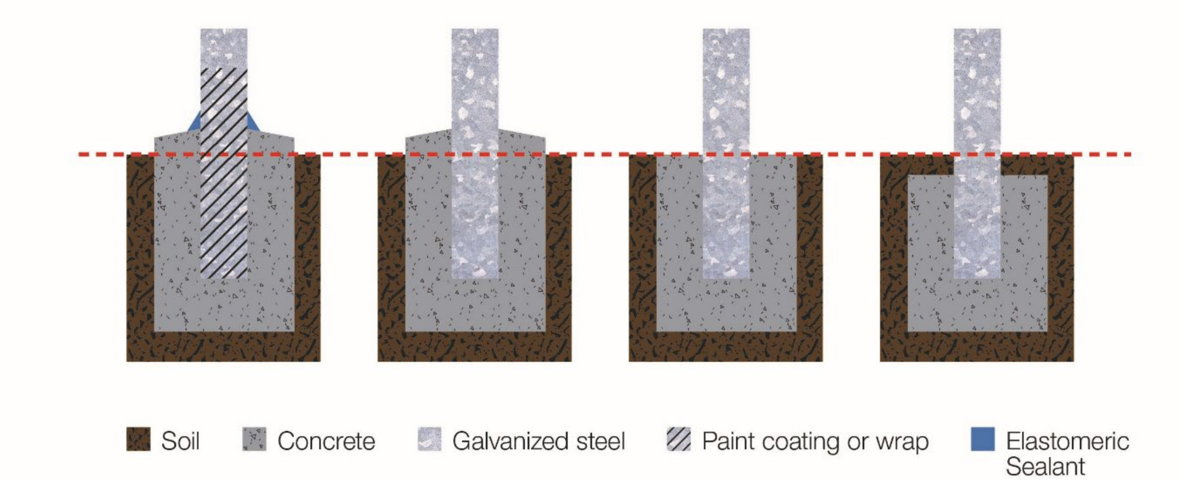

Figure 11 Showing the best design (left) to worst design (right) for galvanized steel embedded in concrete.

Figure 12 Batch HDG coated posts being used in combination with a traditional timber frame and subfloor.

Additional barrier protection

Batch HDG structural steel members are embedded in concrete footings to extend life and provide a higher tolerance to the overturning moment. For this design to be effective the concrete/steel/air interfaces must be designed and built correctly. This includes extending the concrete below the bottom of the pier, according to the Engineers specification, ensuring the concrete extends above the natural ground level and slopes away from the steel by at least 10° to prevent ponding, and providing additional barrier protection when the exposed atmospheric corrosivity category is C3 or above (Figure 13). This method is especially useful when long-term corrosion protection is required in a corrosive atmosphere and for posts, piers or stumps which are at the perimeter of a sub-floor.

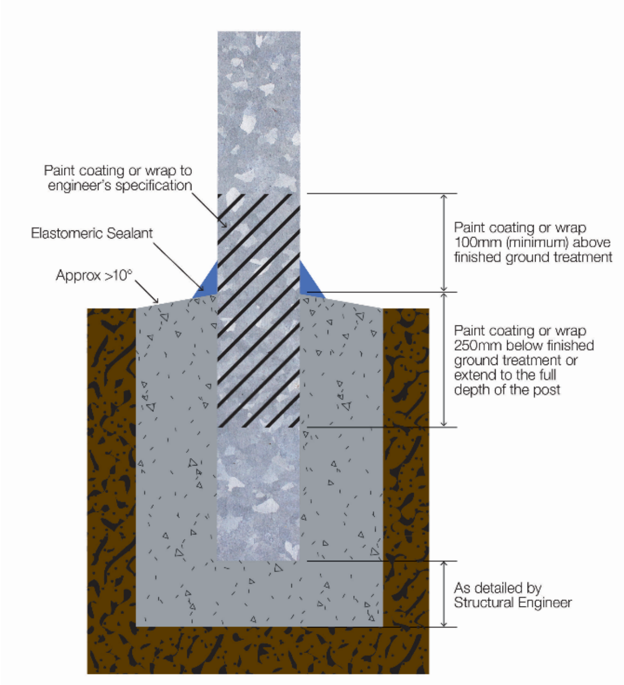

Figure 13 Recommended design for protection of steel to concrete interfaces for long-term durability.

There are several options for protecting the galvanized steel with an additional barrier at the galvanized steel and concrete or soil interface. The normal methods are by using a suitably thick paint or tape wrapping, such as Denso "Ultraseal" cold applied bituminous tape (Denso) (Figure 14). Tapes and paint allow the concrete base to end at or below the interface to the atmosphere, but it will be necessary to consider the corrosivity of the soil in these designs. The barriers are also more susceptible to accidental damage in use. For this application, while probably more expensive than a paint coating, the Denso

Figure 14 Denso Ultraseal tape wrapped around the base of a newly embedded post.

Figure 15 A galvanized post without additional protection at the steel and concrete interface showing accelerated corrosion which has reduced the overall durability of the structure. The galvanized coating above the ground. remains in excellent condition.

Ultraseal is easier to apply in the field than other tapes, faster to apply than paint coatings with little to no curing time and has the additional benefit of being able to be selectively overcoated where required.

The best solution will vary depending on the exposure environment, aesthetic requirements, and availability of materials. If the micro-environment is medium (C3) or higher, including an aggressive internal location, the GAA recommend embedding the steel in concrete and:

1. Apply to at least 100mm above the finished height of the concrete or soil and at least 250mm below the concrete:
    a. a non-conductive abrasion resistant high build epoxy paint layer at approximately 350µm dry film thickness (DFT) without zinc or aluminium pigment (AS/NZS 3750.14 (Standards Australia and Standards New Zealand, 1997 (R 2013))), or
    b. Denso Ultraseal tape wrapped around the structural steel section.
2. Slope the concrete surface away from the steelwork to facilitate drainage of water away from the steel to concrete interface.
3. Once the concrete has cured apply an elastomeric sealant around the interface of the concrete to seal any existing shrinkage cracks.

Concrete, bricks, and mortar are susceptible to corrosion in acid sulfate soils and will not provide significant protection in these circumstances unless the concrete is designed for these soils. The best solution is to modify the fill and/or increase the cover if concrete use is required (see also GAA Advisory Note AN 42 (Galvanizers Association of Australia, 2021)). If the concrete footing finishes below the finished ground level, then the protection of the galvanized steel to soil interface with a barrier coating is always recommended to increase the durability of the steel structure.

Installing posts on elevated concrete pads

An alternative to embedding structural steel into concrete footings is to bolt the steel to concrete pads. This means that there is no chance of collar corrosion but does introduce other corrosion design issues that need to be resolved.

The underside the base plate needs to be protected to ensure water is not drawn into the inevitable gap between the galvanized steel base plate and concrete pad. This can be done using a suitably thick epoxy paint coat on the underside of the base plate or a plastic spacer.

A base plate will be either welded or bolted to the upright steel section. In the welded case this should be done before galvanizing to ensure the best protection of the welded area, or the welded areas will need repair with a suitable zinc-rich paint. Almost certainly a post-galvanized welded area will require more regular maintenance, so this should not be done unless access to the repaired area is easy or the welded area is in a very low corrosion area (that is, internal to the building). For bolted connections, all swarf from drilled holes needs to be removed to avoid unsightly rust spots and any cut structural steel will also need to have bare steel repaired to avoid edge corrosion. For tubular sections exposed to rainwater it may also be necessary to seal the joint at the top and between the base plate and the tube with an elastomeric sealant to stop water entry.

Depending on the design, bolted connections may be a *performance solution* to meet the requirements of the ABCB Housing Provisions.

Figure 16 A pre-galvanized steel subfloor (with inbuilt ant caps) in a Low (C2) environment with the batch HDG posts bolted down onto elevated concrete pads.

Subfloors in flood prone areas

The subfloor area on any building will have a unique micro-environment that differs to the macro-environment due to the sheltering effects of the building design from prevailing winds, rain, and sunlight. Subfloors exposed to flood events are subject to additional corrosivity due to the following influences:

1. Flood waters can contain corrosive contaminants.
2. Subfloor areas can take weeks to dry out resulting in prolonged levels of high humidity.
3. Long duration flooding can last for days. Corrosion rates of zinc are higher in immersed conditions compared to atmospheric exposure and galvanized steel may be subject to damage after prolonged immersion. Uncoated steel is subject to permanent damage after short periods of wetness.
4. Silt and flood debris remaining on the surface of materials increases the time-of-wetness and the corrosion rate.
5. If the flood water is high enough, both hollow and open sections with a lip can trap silt, water, salt, and other contaminants, increasing the drying time and promoting corrosion.

Elevating the house and provision of good subfloor ventilation is a prerequisite to minimizing the impact of flood events on subfloor durability although elevated designs with open subfloors in coastal environments may also create a sheltered microenvironment with increased corrosivity as the subfloor members will be exposed to increased airborne salt deposition and reduced rain washing. Part 6.2 of the Housing Provisions deals with the minimum requirements for subfloor ventilation in flood-prone areas.

ADVISORY NOTE 49

The ABCB Standard: *Construction of buildings in flood hazard areas* (Australian Building Codes Board, 2019), says that materials used for structural purposes and located below the flood hazard level must be capable of resisting damage, deterioration, corrosion, or decay considering the likely time the material would be in contact with flood water and the likely time it would take for the material to subsequently dry out. Materials used for structural purposes include loadbearing columns, bracing members, structural connections, fasteners, wall framing members and the like.

Batch HDG has a series of hard abrasion resistant layers under the usual pure zinc outer layer and, along with the naturally thicker coating than other galvanized materials, batch HDG will better resist damage to the coating from the debris and detritus carried with flood waters than all other coatings. However, long-term exposure to pooled water or contaminated materials must be avoided.

The GAA recommends increasing the minimum corrosion protection of structural steel in flood prone microenvironments above the requirements of the ABCB Housing Provisions to at least AS/NZS 4680 requirements (as shown in Table 2) and pay specific attention to the Design Considerations at the ground/steel interface. Due to the risk of hollow sections and open lipped sections trapping detritus including silt, water, salt and other contaminants, paint coating systems are not recommended unless hollow sections are fully sealed or there is ready access for cleaning and maintenance of all surfaces of all structural steel section.

If there is any doubt about the corrosivity of a microenvironment, the GAA recommends the designer seeks professional advice.

HDG coated steel in contact with timber

In structural applications in atmospheric or embedded conditions, galvanized steel may be required to be isolated from timber through suitable paints, wraps or other isolating barriers to increase the durability. A common application here is as I-beam or channel retaining wall posts with timber sleepers, where the timber facing elements are painted with an isolating paint.

Most galvanized fasteners used for joining timber (nails, screws, bolts, washers, nuts, etc) have a part exposed to the atmosphere and a part embedded in the timber. Galvanized fasteners are often suitable, but some fasteners will need additional protection from specially formulated paints when the timber has been preserved with a copper-based preservative.

Most timbers are slightly acidic (pH 3.5 to 5.5) therefore, when moisture is present and the metal is in contact with the timber, unprotected steel will have a low resistance to corrosion causing chemical reactions that result in a strength loss in the surrounding timber and leading to dark staining around steel fasteners.

Corrosion of the embedded part of the fastener will be influenced by the moisture content of the timber, the timber's natural 'pH,' the availability of oxygen and other influences such as a preservative treatment of the timber, for example, a copper-based preservative treatment. In the presence of moisture, copper-based timber preservatives such as CCA, ACQ and copper azole can cause accelerated corrosion of galvanized steel where the copper component of the chemical preservative is the cathode (protected end), and the zinc is the anode (corroded end). See AS/NZS 2312.2 and Timber Service Life Design (Wood Solutions, 2020) for more information.

Corrosion of the exposed part of the fastener is usually controlled by the macro- and micro-environments in a similar manner to that described for structural steel.

Batch HDG steel is not recommended for use to support decks in the wet zones around saltwater pools due to the high risk of salt saturated wet timber resulting in accelerated corrosion of the galvanized coating, connectors, and structural steel unless additional protective coatings are applied.

SUMMARY

The ABCB Housing Provisions set out the *deemed-to-satisfy* provisions for corrosion protection using protective coatings for structural steel members. The degree of corrosion protection required is determined by the environment and location and this is aligned to the zones of atmospheric corrosivity described in AS/NZS 2312.2*.* Batch hot dip galvanized steel coatings produced to AS/NZS 4680 vary with steel section thickness and all batch HDG coatings on steel sections greater than 3 mm will always meet the minimum requirements of the ABCB Housing Provisions for structural steel members in High (C4) environments. Environments that are Very High (C5) will require HDG900 or a duplex solution. Structural hollow sections galvanized to AS/NZS 4792 will not meet the *deemed-to-satisfy* provisions of the ABCB Housing Provisions, except in Low (C2) environments.

The requirements for internal steel are as per external steel and when any coated steel is cut or welded on-site or where the coating is otherwise damaged the protective coating must repaired to the original corrosion protection condition.

Maintenance of the batch HDG coating will be required in some environments to maintain structural performance. Additional protection may be required when accessibility for maintenance is impossible or difficult and the local environment is also severe. For house piers and other structural steel embedded in the ground, additional barrier protection of the galvanized coating will normally be required at the concrete interface, extending 100mm above and 250mm below the concrete surface. In addition, the bottom of the pier should be fully encased in concrete according to the engineer's specification, and the top of the concrete sloped to prevent ponding.

REFERENCES

Australian Building Codes Board. (2019). ABCB Standard: Construction of buildings in flood hazard areas. (3.0 (2012.3)). Canberra: Australian Building Codes Board.

Australian Building Codes Board. (2022). *ABCB Housing Provisions.* Canberra, ACT, Australia: Australian Building Codes Board.

Denso. (n.d.). *Denso Ultraseal Tape.* Retrieved January 21, 2021, from http://densoaustralia.com.au/pdfs/DensoBitumenButylTapes/Denso-Ultraseal-Tape.pdf

Galvanizers Association of Australia. (2021, September). *Technical Publications.* Retrieved April 2023, from Galvanizers Association of Australia: https://gaa.com.au/technical-publications/

Galvanizers Association of Australia. (2022, March). *Technical Publications.* Retrieved April 2023, from Galvanizers of Australia: https://gaa.com.au/technical-publications/

Standards Australia & New Zealand Standards. (2006). *Hot dip galvanized (zinc) coatings on fabricated ferrous articles.* Sydney & Wellington: Standards Australia & New Zealand Standards.

Standards Australia & New Zealand Standards. (2014). *Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings, Part 2: Hot dip galvanizing.* Sydney & Wellington: Standards Australia & New Zealand Standards.

Standards Australia. (2003). *Electrogalvanized (zinc) coatings on ferrous hollow and open sections.* Sydney: Standards Australia.

Standards Australia. (2017). *Guide to the protection of structural steel against atmosheric corrosion by the use of protective coatings - Part 1: Paint coatings.* Sydney: Standards Australia.

Standards Australia. (2018). *Masonry Structures.* Sydney: Standards Australia.

Standards Australia. (2019). *Atmospheric corrosivity zones in Australia.* Sydney: Standards Australia.

Standards Australia. (2020). *Built-in components for masonry construction (3 parts).* Sydney: Standards Australia.

Standards Australia and Standards New Zealand. (1997 (R 2013)). *Paints for steel structures High-build epoxy (two-pack).* Sydney & Wellington: Standards Australia and Standards New Zealand.

Standards Australia and Standards New Zealand. (2006). *Hot-dip galvanized (zinc) coatings on ferrous hollow sections, applied by a continuous or a specialized process.* Sydney & Wellington: Standards Australia and Standards New Zealand.

Wood Solutions. (2020). *Timber service life design - Design Guide for Durability.* Forest and Wood Products Australia.

WE'RE HERE TO HELP

Are you looking for more information or advice on the application, design, process, bolting, welding or painting of galvanized steel? Want advice on a specific situation or issue? You're in the right place! We would love to hear from you.

Galvanizers Design Manual

GAA main website - Find a galvanizer, bath size & technical support
gaa@gaa.com.au
+61 3 9654 1266
Level 5/124 Exhibition Street Melbourne VIC 3000 Australia

galvanizers ASSOCIATION OF AUSTRALIA

GANZ main website - Find a galvanizer, bath size & technical support
enquiry@galvanizing.org.nz

GALVANIZING ASSOCIATION