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# BULLETIN

# Fasteners selection

February 2010

- Metal fasteners used in building must be chosen to comply with Building Code clauses B1 *Structure* and B2 *Durability*.
- Select fasteners for the appropriate corrosion zone and exposure conditions to ensure they will perform over their service life.
- This Bulletin replaces Bulletin 453 of the same name.

# 1.0 INTRODUCTION

**1.0.1** Metal fasteners used in building must be chosen with care to ensure they comply with Building Code clauses B1 *Structure* and B2 *Durability*.

**1.0.2** Acceptable Solutions for fasteners and fixings for timber-framed buildings are contained in NZS 3604 *Timber framed buildings* Section 4 and E2/AS1 Tables 20–22. Select fasteners for the appropriate corrosion zone and exposure conditions to ensure they will perform over their service life.

**1.0.3** A wide range of high-performance fasteners are readily available in New Zealand, which are able to cope with the high copper content in timbers treated to H3.2 and above and the corrosive environments in many parts of New Zealand.

**1.0.4** This Bulletin highlights those areas and applications where care is required and to encourage the correct specification of fasteners.

# 2.0 MATERIALS FOR FASTENERS

**2.0.1** Nails, screws, straps, plates and bolts are commonly manufactured from mild steel, galvanised steel, aluminium, brass, copper, Monel, nickel, silicon bronze and stainless steel. Plastics are used in a small number of instances (for example, staples).

**2.0.2** Mild steel is the most commonly used fastener material. Its popularity stems from its high degree of formability, good tensile strength and low cost. Mild steel fasteners may not always be durable enough, and they are frequently supplied with a zinc or chrome coating to improve corrosion performance.

**2.0.3** Zinc coatings on metallic fasteners are commonly produced by hot-dipping, electroplating or mechanical coating. The structural and functional properties of zinc coatings depend greatly on the coating process used:

- A hot-dip galvanised (HDG) coating is integral with the steel through zinc-iron alloy interfacial layers that are overcoated with zinc. It has excellent continuity and uniformity. Thick coatings (50–125 μm) are easily attainable, but this depends on the thickness of the material being coated.
- Electroplating deposits a layer of zinc on a steel surface through electrochemical reduction. The coating thickness is usually less than 15 μm. Electroplated zinc is not alloyed with the steel, nor does it have the iron-zinc alloy layers of hot-dip galvanised coatings.
- Mechanical plating involves the agitating of parts with a mixture of impactors, zinc powder, chemical promoter and water. The coating is not alloyed with the steel, nor does it have the iron-zinc alloy layers of hot-dip galvanised coatings. The adhesion of the coating is only good when compared with the electroplated coating. Coating thickness typically ranges from 5–70 μm.

**2.0.4** Silicon bronze is an alloy of copper and tin, with a small amount of silicon. Its superior corrosion resistance makes it suitable for marine environment applications. The main drawback is its high cost.

**2.0.5** Brass is an alloy of copper and zinc. It has lower tensile strength and is a relatively soft metal so its use as a fastener is primarily for its appearance.

**2.0.6** Aluminium and its alloys have high corrosion resistance. Surface treatment such as anodising or epoxy powder coating can be applied after manufacture to further improve the atmospheric corrosion performance. Aluminium alloy fasteners are used for decorative appearance.

**2.0.7** Stainless steel is a large group of alloys containing chromium (Cr), which gives them a high degree of corrosion resistance:

- Austenitic stainless steels (300 series) are non-hardenable, non-magnetic and offer the best corrosion resistance. AISI 304 works well in most atmospheres. AISI 316 is better still, especially in marine environments.
- Common ferritic stainless steels for fasteners are AISI 410, 416 and 431.
- AISI 430 and 430F are the best martensitic alloys for fasteners.
- Ferritic and martensitic steels are mainly used for economic reasons and where corrosion resistance requirements are not too severe.

**TABLE 1. TYPES OF FASTENERS**

| FASTENERS | DESCRIPTION | APPLICATION |
|---|---|---|
| Bolts | Hexagon head and smooth shoulder (also known as hexagonal cap screws or machine bolts) | General structural purposes |
| | Carriage bolt (domed top and a square under the head) | Timber use only |
| | Hexagonal lag bolt or lag screw, coach screw | Fastening in timber to replace bolts where nut is inaccessible or to improve appearance |
| | Threaded rod | Where it is difficult to specify bolt length |
| Nails | Round wire nail, brad, panel pin, veneer pin | General works with softwoods and thin timber |
| | Flat, bullet, rose and jolt head nail | Framing and general finishing |
| | Oval wire nail | Joinery work where appearance is important |
| | Hardboard nail with a diamond-shaped head | Hardboard fixing |
| | Spring-head roofing nail | Fixing corrugated sheeting to timber |
| | Clout head nail | Fixing of thin sheets |
| | Decking spike | Timber deck fixing |
| | Fibre-cement sheet nail | Fixing cement sheeting to timber framing |
| | Masonry nail | Fixing timber to brick or concrete |
| | U-shaped round wire nail (staple) | Fixing fencing, flex or cable |
| Screws | Flat/oval head, tapered shank; cross-recessed drive, smooth upper stem | Pulling two pieces of timber together for a tight joint |
| | Hexagon washer head; external hexagon drive | Fixing roofing steel sheets |
| | Bugle head, cross-recessed and hexagonal recessed head, posi or square drive | Fixing of internal sheet linings<br>General fixing in timber to timber connections and where uplift may be severe |

**2.0.8** Pure nickel fasteners are ideal for applications involving contamination and strength retention at high and low temperatures but are not common in building.

**2.0.9** Copper is a relatively soft, malleable corrosion-resistant material commonly used in the manufacture of wall and roof cladding, cladding accessories (gutters, soakers) as well as nails and screws for cladding and roofing where the fixing is part of the architectural design.

**2.0.10** Demand is growing for plastic fasteners, typically nylon. They have low strength characteristics but are suitable where lightness or electrical non-conductivity is important. Nylon is corrosion-resistant and has high electrical and thermal insulating properties. However, nylon is subject to severe deterioration under elevated temperatures and may weaken in low temperatures.

## 3.0 TYPES OF FASTENERS

**3.0.1** Nails, screws, straps, brackets and plates (nail or nail-on) are the most common fasteners used. Bolts with brackets are the fasteners of choice for heavy members, such as beams and posts.

**3.0.2** Fasteners can be categorised according to their purpose. Table 1 provides a brief summary of fasteners and their typical applications.

## 4.0 CORROSION

**4.0.1** Corrosion is a primary cause of metal fastener failure. Corrosion resistance is provided by the properties of the metal or alloy or a protective coating. A fastener can be resistant to corrosion in one environment but corrode in another. The progressive degradation and loss of performance from corrosion may be caused by one or a combination of:
- moisture and temperature of the macro- and micro-environment
- aggressive chemicals such as airborne sea salt, gas and solid matter from geothermal/volcanic activities, soot and dust
- corrosive extractives leached out of construction materials
- preservation chemicals used for timber treatment, particularly soluble copper
- electrolytic action (when dissimilar metals are involved in the above situations in the presence of sufficient moisture to promote electrical activity).

**4.0.2** Corrosion severity depends on the level of contaminants, moisture and temperature. In general, corrosion is highest in a hot, wet, contaminated environment and lowest in a cold, dry, uncontaminated environment.

## 5.0 JOINING METALS TO METALS

**5.0.1** Fastener material and coating selection is not the only consideration when designing joints to resist corrosion. Materials must be suitable for the environment and be compatible with each other.

**5.0.2** When two dissimilar metals are in electrical contact while moisture (or any conducting corrosive electrolyte) is present, enhanced and aggressive corrosion of one metal occurs at the joint area, with partial or complete protection of the other metal. This is called galvanic corrosion, bimetallic corrosion or dissimilar metal corrosion.

**TABLE 2. GALVANIC SERIES OF COMMON METALS AND ALLOYS IN SEAWATER – NOBLE (LEAST ACTIVE) AT THE TOP**

| |
|---|
| Graphite (0.2→0.29V) |
| Platinum (Pt) (0.22→0.25V) |
| AISI 316 (Passive) (-0.1→0V) |
| AISI 304 (Passive) (-0.1→-0.05V) |
| Lead (Pb) (-0.25→-0.19V) |
| AISI 430 (Passive) (-0.28→-0.2V) |
| AISI 410 (Passive) (-0.35→-0.26V) |
| Silicon bronze (-0.29→-0.26V) |
| Copper (-0.37→-0.3V) |
| Brass (-0.4→-0.3V) |
| Mild steel (-0.63→-0.57V) |
| Aluminium (Al) (-1.0→-0.76V) |
| Zinc (Zn) (-1.03→-0.98V) |
| Magnesium (Mg) (-1.63→-1.6V) |

**Notes:**
- The use of lead-edged flashings over galvanised steel is acceptable because the small areas of lead involved and the patina on the lead provides protection.
- Lead edging is not suitable for zinc/aluminium alloy-coated steel.
- Stainless steel will not noticeably corrode aluminium when the aluminium (anode) is large in relation to the stainless steel (cathode), as in using stainless steel fixings in aluminium window frames.

**5.0.3** Different metals have different electrical potentials. In the presence of an electrolyte, such as a wet atmosphere, an electrochemical cell can be established between two metals if the difference in potential between them is sufficient to drive an electric current flow from one material to another.

**5.0.4** Electrons will transfer from the metal with a negative potential (less noble or anode) to the metal with a positive potential (noble or cathode). The less noble metal will corrode. The galvanic series (where metals are listed according to their corrosion potentials in seawater) is used to predict the galvanic effect of coupling two metals in service. The further apart the metals are in the galvanic series, the greater the galvanic corrosion effect. Table 2 is a short list of the galvanic series used to rank the corrosive potential.

**5.0.5** Galvanic corrosion intensity is also related to the ratio of areas of the metals in electrical contact. When a noble metal with a large area is coupled to a less noble metal with a small area, corrosion of the less noble metal will be more severe. The reverse occurs where the noble metal has a very small area and produces little galvanic current. In practice, less noble metal should be designed to have a larger area than the noble metal to decrease corrosion risk.

**5.0.6** Simple procedures to reduce or eliminate the risk of galvanic corrosion between fasteners and other widely used dissimilar metals in a particular environment are as follows:
- In some moderate environments, avoiding corrosion of dissimilar metals by ensuring that the anode in the corrosion cell is much larger than the cathode, for example, aluminium window (anode) fixed with stainless steel screws (cathode).

**TABLE 3. FIXINGS AND FASTENERS, BRANZ GOOD PRACTICE RECOMMENDATIONS**

| ITEM FIXED | FIXED TO | ENVIRONMENT | FASTENER TYPE | COMMENTS | DURABILITY (YRS) |
|---|---|---|---|---|---|
| **Timber wetted in service** | | | | | |
| H5 piles | H3.2, H4 timber | All | Stainless steel, silicon bronze | | 50 |
| H4, H3.2 joists, bearers, posts, jackstuds | H3.2, H4, H5 timber | All | Stainless steel, silicon bronze | | 50 |
| H3.2 decking | H3.2 timber | B, C, D | Hot-dip galvanised steel:<br>- bolts and washers in accordance with Table 4.2 of NZS 3604:1999<br>- screws in accordance with AS 3566<br>- nails with a minimum 310 g/m²<br>Stainless steel nail plates | Stainless steel recommended for lower maintenance and for ACQ or CuAz treated timber | 15 |
| | | G | Stainless steel | | 15 |
| | H4, H5 timber | All | Stainless steel, silicon bronze | | 15 |
| Plywood H3 (acting as structural diaphragm) | H3.2, H4 timber | All | Stainless steel, silicon bronze | | 50 |
| Compressed fibre-cement sheet | H3.1, H3.2 timber | B, C, D | Hot-dip galvanised steel | | 15 |
| | | G | Stainless steel, silicon bronze | | 15 |
| | H4 timber | All | Stainless steel, silicon bronze | | 15 |
| **Subfloor structural elements open to airborne salts, but not subject to rain wetting or excessive levels of subfloor moisture** | | | | | |
| H1.2, H3.1 timber bearers, braces and plates within 600 mm of ground | H5 timber piles | All | Stainless steel | H1.2, H3.1 timber must remain dry in service<br>Provide a DPC between H5 and other timbers | 50 |
| | Concrete | All | Stainless steel | H1.2, H3.1 timber must remain dry in service<br>Provide a DPC between materials | 50 |
| H1.2, H3.1 subfloor bracing more than 600 mm from ground | H5 timber piles | B, C, D | Hot-dip galvanised steel:<br>- bolts and washers in accordance with Table 4.2 of NZS 3604:1999<br>- screws in accordance with AS 3566<br>- nails with a minimum 310 g/m²<br>Stainless steel nail plates | H1.2, H3.1 timber must remain dry in service<br>Stainless steel recommended for lower maintenance | 50 |
| | | G | Stainless steel | Proprietary systems with appraised durability may use hot-dip galvanised components | 50 |
| | H1.2 | B, C, D | Hot-dip galvanised steel:<br>- bolts and washers in accordance with Table 4.2 of NZS 3604:1999<br>- screws in accordance with AS 3566<br>- nails with a minimum 310 g/m² | H1.2 timber must remain dry in service<br>Stainless steel recommended for lower maintenance<br>Floor space must be accessible | 50 |
| | | G | Stainless steel | H1.2 timber must remain dry in service | 50 |
| H3.2 subfloor bracing – pole house | H5 timber | All | Stainless steel | Likely to be wetted in service | 50 |
| H3.2 | H5, H3.2 timber | All | Stainless steel | Assumed that H3.2 timber will be damp at some time | 50 |
| H1.2 bearers, floor joists and jack framing | H1.2 timber | B, C, D | Hot-dip galvanised steel:<br>- bolts and washers in accordance with Table 4.2 of NZS 3604:1999<br>- screws in accordance with AS 3566<br>- nails with a minimum 310 g/m² | H1.2 timber must remain dry in service | 50 |

| ITEM FIXED | FIXED TO | ENVIRONMENT | FASTENER TYPE | COMMENTS | DURABILITY (YRS) |
|---|---|---|---|---|---|
| H1.2 bearers, floor joists and jack framing (continued) | H1.2 timber (continued) | G | Hot-dip galvanised steel:<br>- bolts and washers in accordance with Table 4.2 of NZS 3604:1999<br>- screws in accordance with AS 3566<br>- nails with a minimum 310 g/m²<br>Stainless steel nail plates | Use stainless steel for higher durability and less maintenance<br>H1.2 timber must remain dry in service | 50 |
| | H3.2 timber | B, C, D | Hot-dip galvanised steel:<br>- bolts and washers in accordance with Table 4.2 of NZS 3604:1999<br>- screws in accordance with AS 3566<br>- nails with a minimum 310 g/m²<br>Stainless steel nail plates | Assumes H3.2 remains dry in service<br>Use stainless steel for higher durability and less maintenance and where timber may be wetted in service | 50 |
| | | G | Stainless steel | | 50 |
| Above-floor structural elements – enclosed (clad and lined) and dry | | | | | |
| H1.1 timber framing, H1.2 | H1.1, H1.2 timber | All | Bright steel | Timber moisture content below 20% | 50/15/0 (1) |
| | Concrete | All | Bright steel | Provide a DPC between materials, retighten bolts when timber dry | 50/15/0 (1) |
| H3.1 framing | Concrete | All | Bright steel | Provide a DPC between materials | 50 |
| | H3.1 framing | All | Bright steel | | 50 |
| H3.2 framing | Concrete | All | Bright steel | Provide a DPC between materials | 50 |
| | H3.1, H3.2 framing | All | Bright steel | | 50 |
| Light-weight steel framing (studs, beams, ceiling battens etc.) | Concrete | All | Bright steel | Provide a DPC between materials | 50/15/0 (1) |
| | H1.1, H1.2 timber | All | Bright steel | Fixings must remain dry in service | 50/15/0 (1) |
| | Light-weight steel | All | Bright steel | Fixings must remain dry in service | 50/15/0 (1) |
| Pre-galvanised steel bracing strap | H1.1, H1.2 timber | All | Bright steel | Fixings must remain dry in service | 50 |
| HDG brackets | H1.1, H1.2 timber | All | Bright steel | Fixings must remain dry in service | 50 |
| | H3.1 timber | All | Bright steel | Fixings must remain dry in service | 50 |
| Steel roof trusses | H1.1, H1.2 timber | All | Bright steel | Fixings must remain dry in service | 50 |
| | Light-weight steel | All | Bright steel | Fixings must remain dry in service | 50 |
| Timber roof trusses | H1.1 and H1.2 timber | All | Bright steel | Fixings must remain dry in service | 50 |
| Structural ceiling suspension systems | Concrete | All | Bright steel | Fixings must remain dry in service | 15 |
| | Light-weight steel | All | Bright steel | Fixings must remain dry in service | 15 |
| Flooring (acting as structural diaphragm) | | | | | |
| Particleboard flooring (prelaid) | H1.1, H1.2 timber | All | Hot-dip galvanised steel | Do not use staples; stop all fixing holes | 50 |
| | H3.1 timber | All | Hot-dip galvanised steel | | 50 |
| Timber flooring | H1.1, H1.2 timber | All | Bright steel | Stop all fixing holes | 15/50 |
| | H3.1 timber | All | Bright steel | Stop all fixing holes | 15/50 |
| Plywood flooring | H1.1, H1.2 timber | All | Bright steel | Class 4 screws and H3 CCA treated plywood recommended in wet areas | 15/50 |
| Wall claddings (non-structural with battened cavity or direct fix) | | | | | |
| H3.1 painted weatherboard | H1.2, H3.1, H3.2 timber | All | Hot-dip galvanised steel | Stop and paint fixing points | 15 |
| | HDG steel | All | Hot-dip galvanised steel | | 15 |

**TABLE 3. FIXINGS AND FASTENERS, BRANZ GOOD PRACTICE RECOMMENDATIONS (continued)**

| ITEM FIXED | FIXED TO | ENVIRONMENT | FASTENER TYPE | COMMENTS | DURABILITY (YRS) |
|---|---|---|---|---|---|
| Wall claddings (non-structural with battened cavity or direct fix) (continued) | | | | | |
| Unpainted H3.2 external timber | H1.2, H3.1, H3.2 timber | All | Hot-dip galvanised steel or stainless steel | Use stainless steel for less maintenance and with ACQ and CuAz treated material | 15 |
| | Light-weight steel studs | All | Hot-dip galvanised steel or stainless steel | Use stainless steel for less maintenance and with ACQ and CuAz treated material | 15 |
| Cedar/redwood unpainted | H1.2, H3.1, H3.2 timber | All | Stainless steel, silicon bronze, aluminium, copper | Copper fixings will stain the boards | 15 |
| Fibre-cement | H1.2, H3.1, H3.2 timber | All | Manufacturers recommend stainless steel in most situations | | 15 |
| | Light-weight steel | All | Manufacturers recommend stainless steel in most situations | | 15 |
| Aluminium siding | H1.2, H3.1 timber | All | Check manufacturer's specific requirements | Proprietary systems may use galvanised fixings | 15 |
| | HDG steel | All | Check manufacturer's specific requirements | Proprietary systems may use galvanised fixings | 15 |
| Plastic/vinyl claddings | H1.2, H3.1 timber | All | Check manufacturer's specific requirements | Proprietary systems may use galvanised fixings | 15 |
| | Light-weight steel | All | Check manufacturer's specific requirements | Proprietary systems may use galvanised fixings | 15 |
| Polystyrene board | H3.1 timber | All | Check manufacturer's specific requirements | Proprietary systems may use galvanised fixings | 15 |
| | HDG steel | All | Check manufacturer's specific requirements | Proprietary systems may use galvanised fixings | 15 |
| | Concrete | All | Check manufacturer's specific requirements | Proprietary systems may use galvanised fixings | 15 |
| Galvanised steel cladding | H1.2, H3.1 timber | B, C, D, G | Class 4 coated steel | Grade of cladding must be suitable for environment<br>Do not use copper-based or stainless steel fixings | 15 |
| | Light-weight steel | B, C, D, G | Class 4 coated steel | Grade of cladding must be suitable for environment<br>Do not use copper-based or stainless steel fixings | 15 |
| Roof claddings | | | | | |
| Plywood flat roof sarking (H3 CCA plywood) | All timber | All | Stainless steel | Timber must remain dry in service | 15 |
| | Light-weight steel | All | Stainless steel | Steel must remain dry in service | 15 |
| Plywood pitched roof sarking | All timber | All | Hot-dip galvanised steel | | 15 |
| | Light-weight steel | All | Hot-dip galvanised steel | | 15 |
| Steel roof tiles | All roof framing timber | B, C, D | Hot-dip galvanised steel painted | Grade of roofing must be suitable for environment | 15 |
| | | G | Hot-dip galvanised steel, insulating washer | Grade of roofing must be suitable for environment | 15 |
| Aluminium roofing | All roof framing timber | All | Class 4 coated steel, slotted hole and washer or proprietary clip | Do not use copper-based fixings<br>Grade of roofing must be suitable for environment | 15 |
| | Light-weight steel | All | Class 4 coated steel, slotted hole and washer or proprietary clip | Do not use copper-based fixings<br>Grade of roofing must be suitable for environment | 15 |
| Treated pine roofing shingles | All roof framing timber | All | Stainless steel, silicon bronze, copper | | 15 |
| Untreated cedar roofing shingles | All roof framing timber | All | Stainless steel, silicon bronze, copper | | 15 |
| Unpainted galvanised steel | All roof framing timber | See comments | Class 4 coated steel or proprietary hot-dip galvanised factory painted steel (2) | Grade of roofing must be suitable for environment<br>Do not use copper-based fixings<br>Uncoated cladding may not last 15 years | 15 |
| | Light-weight steel | See comments | Class 4 coated steel or proprietary hot-dip galvanised factory painted steel (2) | Grade of roofing must be suitable for environment<br>Do not use copper-based fixings | 15 |

| ITEM FIXED | FIXED TO | ENVIRONMENT | FASTENER TYPE | COMMENTS | DURABILITY (YRS) |
|---|---|---|---|---|---|
| Roof claddings (continued) | | | | | |
| Coil-coated steel roofing | All roof framing timber | See comments | Class 4 coated steel or proprietary hot-dip galvanised factory painted steel (2) | Grade of roofing must be suitable for environment<br>Do not use copper-based fixings | 15 |
| | Light-weight steel | See comments | Class 4 coated steel or proprietary hot-dip galvanised factory painted steel (2) | Grade of roofing must be suitable for environment<br>Do not use copper-based fixings | 15 |
| Factory painted zinc/aluminium alloy | All roof framing timber | See comments | Class 4 coated steel or proprietary hot-dip galvanised factory painted steel (2) | Grade of roofing must be suitable for environment<br>Do not use uncoated stainless steel or copper-based fixings | 15 |
| | Light-weight steel | B, C, D, G | Class 4 coated steel or proprietary hot-dip galvanised factory painted steel (2) | Grade of roofing must be suitable for environment | 15 |
| Zinc/aluminium alloy unpainted | All roof framing timber | B, C, D, G | Class 4 coated steel, proprietary hot-dip galvanised steel factory painted, aluminium | Grade of roofing must be suitable for environment<br>Do not use copper-based fixings or uncoated stainless steel | 15 |
| | Light-weight steel | B, C, D, G | Class 4 coated steel, proprietary hot-dip galvanised steel, factory painted, aluminium | Grade of roofing must be suitable for environment<br>Do not use copper-based fixings or uncoated stainless steel | 15 |
| Translucent sheet material | H1.1, H1.2, H3.1 timber | All | Hot-dip galvanised steel, stainless steel, aluminium | | 15 (3) |
| | H3.2 timber | All | Stainless steel, aluminium | Stainless steel recommended for ACQ or CuAz treated material | 15 |
| Galvanised steel spouting/galvanised brackets | H3.1 timber painted, H3.2 | All | Hot-dip galvanised steel, stainless steel | Stainless steel recommended for H3.2 | 15 |
| Plastic spouting and brackets | H3.1 timber painted, H3.2 | All | Hot-dip galvanised steel, stainless steel | Stainless steel recommended for H3.2 | 15 |
| Joinery | | | | | |
| Aluminium window reveals | H1.2, H3.1 timber | All | Bright steel | Timber must remain dry in service | 15 |
| | Concrete | All | Bright steel | Provide a DPC between materials | 15 |
| | Light-weight steel | All | Hot-dip galvanised steel | Steel must remain dry in service | 15 |
| Internal door jambs | H1.2, H3.1 timber | All | Bright steel | Timber must remain dry in service | 15 (4) |
| | Light-weight steel | All | Hot-dip galvanised steel | Steel must remain dry in service | 15 (4) |
| External door jambs | H1.2, H3.1 timber | All | Bright steel | Timber must be painted and remain dry in service | 15 |
| | H3.2 timber | All | Stainless steel | | 15 |
| | Light-weight steel | All | Hot-dip galvanised steel | Steel must remain dry in service | 15 |
| Internal linings and finishing | | | | | |
| Gypsum plasterboard | All framing timber | Not applicable | Plated or hot-dip galvanised steel | Framing to be less than 20% moisture content | 15 (5) |
| | Light-weight steel | Not applicable | Zinc plated steel | | 15 (5) |
| Fibrous plaster | All framing timber | Not applicable | Hot-dip galvanised steel | | 15 (5) |
| | Light-weight steel | Not applicable | Hot-dip galvanised steel | | 15 (5) |
| RWB | All framing timber | Not applicable | Plated steel | | 15 (5) |
| | Light-weight steel | Not applicable | Zinc plated or hot-dip galvanised steel | | 15 (5) |
| Finishing timber | All framing timber | Not applicable | Bright steel | | NA |
| | Light-weight steel | Not applicable | Plated steel | | NA |
| Wet area linings | All framing timber | Not applicable | Plated steel or adhesive | | 15 |
| | Light-weight steel | Not applicable | Plated steel or adhesive | | 15 |

**TABLE 3. FIXINGS AND FASTENERS, BRANZ GOOD PRACTICE RECOMMENDATIONS (continued)**

| ITEM FIXED | FIXED TO | ENVIRONMENT | FASTENER TYPE | COMMENTS | DURABILITY (YRS) |
|---|---|---|---|---|---|
| Miscellaneous | | | | | |
| Water pipe clips (plastic or galvanised) | H1.1, H1.2 timber | All | Bright steel | Timber must remain dry in service | 15/50 (6) |
| | HDG steel | All | Plated steel | Steel must remain dry in service | 15/50 (6) |
| Interior wet area shelving | H1.1, H1.2 timber | Not applicable | Hot-dip galvanised steel, stainless steel | | NA |
| | Plasterboard | Not applicable | Hot-dip galvanised steel, stainless steel | | NA |
| Interior dry area shelving | All | Not applicable | Plated steel | | NA |
| Fencing | | | | | |
| Gate hinges | H4 timber | B | Hot-dip galvanised steel | Stainless steel recommended for lower maintenance and for ACQ or CuAz treated timber | NA |
| | | C, D, G | Stainless steel | | NA |
| H4 exterior timber | H4 timber | All | Hot-dip galvanised steel | Stainless steel recommended for lower maintenance and for ACQ or CuAz treated timber | NA |
| H3.2 exterior timber | H3.2, H4 timber | All | Hot-dip galvanised steel | Stainless steel recommended for lower maintenance and for ACQ or CuAz treated timber | NA |
| Fibre-cement | H4 timber | All | Hot-dip galvanised steel | Stainless steel recommended for lower maintenance and for ACQ or CuAz treated timber | NA |

**Notes:**

Corrosion zones are those classified by AS/NZS 2312:

- Category A (very low–mild under AS/NZS 2312:1994): Environments most commonly found inside heated or air-conditioned buildings with clean atmospheres such as commercial buildings but may also be found in semi-sheltered locations remote from marine or industrial influence and in unheated or non-air conditioned buildings. The only external environments in New Zealand are some alpine regions although generally these environments extend into category B. (Category A not used for New Zealand.)
- Category B (low–moderate under AS/NZS 2312:1994): Environments in this category include dry rural areas remote from the coast or sources of pollution. Most areas within New Zealand that are beyond 50 km from the sea are in this category, for example, Hamilton, which can, however, extend as close as 1 km from seas that are relatively sheltered and quiet. Unheated or non-air conditioned buildings where some condensation may occur (such as warehouses and sports halls) can be in this category. (This zone corresponds to zones 2 and 3 of NZS 3604:1999.)
- Category C (medium–marine under AS/NZS 2312:1994): This category mainly covers coastal areas with low salinity. The extent of the affected area varies significantly with factors such as winds, topography and vegetation. Around sheltered areas, category C extends beyond 50 m from the shoreline to a distance of about 1 km inland. For a sheltered bay or gulf, this category extends about 3–6 km inland. Along the ocean from areas of breaking surf and significant salt spray, it extends from about 1 km inland to between 10–15 km inland depending on the strength of prevailing winds and topography, for example, much of Wellington. Category C corrosivity can also occur in humid production rooms such as food processing plants, laundries, breweries, printing works and dairies. (This zone corresponds to zone 1 of NZS 3604:1999.)
- Category D (high–severe marine under AS/NZS 2312:1994): This category occurs mainly on the coast. Around sheltered bays, category D extends up to 50 m inland from the shoreline. In areas with rough seas and surf, it extends from about several hundred metres inland to about 1 km inland. As with categories B and C, the extent depends on winds, wave action and topography. Industrial regions may be within this category, but in New Zealand, these are only likely to be found within 1.5 kilometres of the plant. This category extends inside the plant where it is best considered as a micro-environment. Damp, contaminated interior environments (such as those that occur within swimming pools, dye works, paper manufacturers, foundries, smelters and chemical plants) may also extend into this category. (This zone corresponds to the sea spray zone of NZS 3604:1999.)
- Category E (very high–E-I Industrial, E-M Marine): This category is common offshore and on the beachfront in regions of rough seas and surf beaches. The region can extend inland for several hundred metres. This category may also be found in aggressive industrial areas, where the environment may be acidic with a pH of less than 5. Some of the damp and/or contaminated interior environments in category D may occasionally extend into this category. (BRANZ note: This zone is a very aggressive environment and is not usually found in New Zealand.)
- G (Geothermal): Corrosive conditions may exist within the central North Island geothermal zone bounded by Te Puke, Kawerau, Ohakune and Waiouru. (Under the revision of NZS 3604, it is proposed that geothermal areas be subject to specific design – currently, they are zone 4 under NZS 3604:1999.)

(1) Framing that does not provide support to secondary elements and is not associated with a NZBC requirement or is non-structural and has no NZBC durability requirement and is shown as 0 years.
(2) Proprietary factory-applied paint system to electroplated fasteners.
(3) No durability requirement when use does not form part of the building envelope.
(4) Durability only applies to doors required to be provided by the NZBC.
(5) Durability only applies to linings required to be provided by the NZBC.
(6) Durability depends on the pipe's location within the structure.

- In marine, industrial and geothermal zones, ensuring that the fastener is the same material as or has a proven compatibility with the base metals.
- Protecting the metal most likely to corrode with a sacrificial coating such as coating steel with zinc (galvanising).
- The application of a paint or other isolating system between all the metals involved (assuming that it is not damaged by differential movement). If only one metal can be painted, coat the noble metal.
- Using insulating washers to prevent electrical contact between dissimilar metals.
- Allowing for movement of the fastened metals as they expand and contract with heat. Slotting the fastener holes in aluminium roofing (ensuring that the holes are sealed with watertight washers) or using proprietary hidden (protected) sliding clips will allow the metal claddings to move without damaging the corrosion-resistant coatings.

**5.0.7** Table 3 outlines fastener/material compatibility based on the galvanic series and gives the BRANZ recommended minimum acceptable level of fastener corrosion protection for the given installation conditions. Greater corrosion protection can be provided by using higher specification fasteners, such as substituting stainless steel for HDG, but be wary of dissimilar metals. This list is not exhaustive, and a number of possible fastener, material or environment conditions may not be covered.

# 6.0 FASTENERS INTO TIMBER

**6.0.1** Timber and metal are compatible in most construction; however, if there is sufficient moisture at the timber-metal interface, corrosion can be expected.

## 6.1 CONTACT CORROSION

**6.1.1** When the moisture content of timber is higher than 20%, breakdown of acetylated polysaccharides in the timber by water will make the timber acidic. The timber can then attack the metallic components through direct contact. Timber naturally contains varying levels of mineral salts – sulphate (1–10%) and chloride (0.1–5%) increase the corrosion hazard of acids.

**6.1.2** Some timbers emit acidic leachate, which can corrode metals. Western red cedar used as weatherboards and shingles has emissions that are aggressive to metals in the immediate vicinity. Vapours from new oak can damage metal fittings.

**6.1.3** Timber used at elevated temperatures (over 100°C) might be risky. This process can accelerate hydrolysis and increase the expelling of acid from the timber.

**6.1.4** In general, harder timbers are more acidic and therefore more corrosive (see Table 4). Some timbers contain aromatic phenols, which may increase corrosion risk of adjacent steel components.

**TABLE 4. CORRELATION BETWEEN PH VALUE AND CORROSIVITY OF SOME COMMON TIMBERS**

| TIMBER | TYPICAL PH VALUES | CORROSIVITY |
|---|---|---|
| Oak | 3.4–3.9 | Very corrosive |
| Sweet chestnut | 3.4–3.7 | Very corrosive |
| Red cedar | 3.5 | Very corrosive |
| Douglas fir | 3.5–4.2 | Moderately corrosive |
| Walnut | 4.4–5.2 | Least corrosive |

## 6.2 CONTRIBUTION OF CHEMICALS FROM PRESERVATION TREATMENT

**6.2.1** Organic solvent-based timber preservatives do not cause corrosion as the heavy oils used tend to inhibit corrosion. Water-based chemicals, used for drying certain hardwoods (for example, maple), flame-retardant salt treatments (for example, ammonium phosphate/sulphate and boric acid/borax) and copper-containing preservatives can be a corrosion hazard.

**6.2.2** Waterborne timber preservatives may increase corrosion for metals embedded in or in contact with timber because of the metallic ions, in particular, chemically active cupric ions, in these preservatives. They act synergistically with chemicals in timber to create a unique corrosive environment. Corrosion risk is negligible if the timber is dry and the preservative components were thoroughly fixed and dried before the fastening components were installed. When the moisture content of the treated timber rises above 18–20%, corrosion can occur and deteriorate metals and timbers.

**6.2.3** The increase of copper content in the preservative is always associated with an increased corrosion rate. Alkaline copper quaternary (ACQ) and copper azole (CuAz), developed as an alternative to chromated copper arsenate (CCA), have a much higher copper concentration at the same treatment retention level. BRANZ tests have shown that ACQ and CuAz are approximately three times more corrosive than CCA under identical conditions.

## 6.3 ELECTROCHEMICAL CORROSION

**6.3.1** Oxygen plays an important role in corrosion. Differential oxygen concentration cells could be set up along metallic bolts or nails embedded in timber. The oxygen starved area (the shank) is anodic and corroded, while the area with free access to oxygen (the head) is cathodic. This corrosion mechanism is also related to the nature of the timber

## 6.4 OTHER CHARACTERISTICS

**6.4.1** When timber (except naturally corrosive species like cedar and redwood) is dry in service, bright steel fasteners are not a corrosion risk. When timber is wetted, the risk of corrosion is significant, and bright steel will corrode and may fail rapidly. The moisture content threshold for corrosion beginning is related to the species and treatment of timber. For untreated, boric or LOSP treated radiata pine, the threshold is 18–20%. For western red cedar, the threshold can be as low as 16%. For CCA treated timber, the threshold will be around 18%. For higher treatment levels, such as H4 or H5, where the corrosion risk is higher, the critical moisture content figure may be lower, depending on the level of dissimilar metal in the preservative treatment and how well the preservative is chemically 'fixed' in the timber (see BRANZ Bulletin 493 *Timber treatment*).

**6.4.2** The first evidence of corrosion is usually where the fastener enters the timber. Corrosion of steel fasteners in timber causes a loss of joint strength. The fastener loses metal and is physically weakened, and migration of the dissolved iron into the timber causes the timber cellular structure to breakdown ('nail sickness'). This seriously reduces the effectiveness of the fastener (see Figure 1).

**6.4.3** Metals most susceptible to corrosion by timber are cadmium, lead, mild steel, magnesium and zinc, while aluminium, brass, copper, stainless steel and tin are relatively resistant.

Figure 1: Nail sickness.

# 7.0 CORROSION PERFORMANCE OF GALVANISED STEEL FASTENERS

**7.0.1** Galvanised steel fasteners have a zinc coating applied to the steel using techniques that may show different responses to environmental attack in service. Mechanically plated nails are commonly inferior to hot-dip galvanised nails under identical conditions because:

- the mechanically plated coating does not have iron-zinc coating layers, which have a much higher corrosion resistance than solid zinc in most aggressive environments
- the mechanically plated materials usually have a relatively high porosity – without any post production sealing, the coating is unlikely to provide enough protection when exposed to the most aggressive environments
- the mechanically plated coating has a lower thickness.

**7.0.2** Fasteners with electroplated zinc coatings are not expected to show high resistance to corrosion due to the inherent drawbacks of lower coating thickness and poorer coating adhesion.

**7.0.3** Hot-dip galvanised nails are usually produced by manufacturing the nail from galvanised wire that is stamped to form the shape of the head or by galvanising the fabricated nail to achieve a uniform coating. The nail head is prone to corrosion compared to the shank due to coating defects in the head area, particularly with the first production method. Applying metallic or polymeric coatings to the nail head area can minimise the negative effects of production imperfections, but these cannot be relied upon because:

- the service life of the polymeric coatings is not predictable and they are prone to damage during construction
- any additional metallic coating might not be compatible with the zinc coating, and other corrosion problems can then be induced – any premature failure in these coatings will degrade the performance of the coating on other areas.

**7.0.4** The life of the zinc coating may increase in proportion to thickness. Any structural defect (formed during fabrication or installation) present in the coating can cause localised failure, which quickly damages the integrity and protection of the coating system. A longer service with a thicker coating does not always happen, even when the coating is exposed to the open atmosphere.

# 8.0 FASTENER SPECIFICATION

**8.0.1** Fasteners will generally perform better when:

- the moisture content of the timber does not exceed 20%
- the metal of the fastener is compatible with any metals it is in contact with (see Table 2).

## 8.1 MINIMUM FASTENER REQUIREMENTS

**8.1.1** For exterior non-structural applications and claddings requiring not less than 15-year durability in all corrosion zones, use hot-dip galvanised fasteners for fastening into timber or steel. For greater durability and less maintenance, use stainless steel in marine environments.

**8.1.2** When exposed to severe marine environments, fasteners made of 304 or 316 stainless steel may stain. Surface damage during installation sometimes leads to the formation of rust since the passive film formed on the surface was breached, but this will not normally affect the integrity and stability of the structure.

**8.1.3** In CCA, CuAz or ACQ treated timber subjected to wetting and drying (fence palings, unpainted treated radiata pine cladding), the micro-environment in the timber can be very corrosive, and the performance of hot-dip galvanised fasteners will depend on the timber moisture content. Copper may be a satisfactory fastening material in these applications. The most favoured material for nails is austenitic stainless steel, especially when a long service life is required.

**8.1.4** Aluminium is corrosion-resistant in most environments but is not compatible with any copper-based preservative used for timber treatment.

## 8.2 CLADDINGS THAT ACT AS STRUCTURAL BRACING

**8.2.1** Structural claddings requiring not less than 50-year durability or corrosive timber such as western red cedar and redwood require very corrosion-resistant fasteners such as stainless steel, silicon bronze, copper or aluminium.

**8.2.2** Stainless steel fasteners are available in a wide range of shapes and sizes in 304 and 316 alloys. Fasteners of ferritic and martensitic steels may be lower in cost, but they have a lower corrosion resistance.

## 8.3 INTERNAL FASTENERS ENCLOSED AND PROTECTED FROM AIRBORNE SALTS OR RAIN WETTING

**8.3.1** The minimum specification for internal fasteners should be:

- bright steel fasteners where timber has less than 20% moisture content at all times
- zinc plated or hot-dip galvanised fixings where spaces may be poorly vented and in damp spaces (showers or saunas)
- hot-dip galvanised for plasterboard that will be stopped with gypsum compounds that are corrosive when wet. (The rough texture of hot-dip galvanising also improves withdrawal resistance from timber.)

## 8.4 FASTENING TIMBERS TREATED WITH COPPER-BASED CHEMICALS

**8.4.1** When fastening copper-based treated timber that will be above 20% moisture content in service, the following precautions should be taken:

- Allow time for the copper preservative salts to fix in the timber before fastening – this may take 2 months in summer or up to 3 months in winter.
- For timbers subjected to wetting and subsequent drying (such as fence palings or unpainted treated radiata pine cladding), use hot-dip galvanised fasteners. Copper or stainless steel will provide a much higher durability with less maintenance.

- For treated timber that is continually wet or damp, in marine environments or where greater protection from corrosion is required in periodically wetted timber, use copper, silicon bronze (staining may occur with copper fasteners) or stainless steel.
- Never use aluminium with any copper-based preservative treated timber.

## 8.5 FASTENERS IN MARINE ENVIRONMENTS

**8.5.1** In marine environments, type 304 stainless steel will meet the requirements of NZS 3604 but staining or surface rusting may occur.

**8.5.2** Type 316 stainless steel or silicon bronze fasteners should be used where staining would not be acceptable.

**8.5.3** Where stainless steel nail fixings are to be used, specify that the nails are to be annularly grooved to provide holding resistance similar to hot-dip galvanised fixings.

## 8.6 SUBFLOOR CONNECTIONS AND FASTENERS

**8.6.1** Subfloor bolts and nail fixings to timber in which the copper treatment salts are fixed and that will not be damp in service may be hot-dip galvanised.

**8.6.2** When fixing to H5 treated timber within 600 mm of the ground or when the timber moisture content is over 20%, bolts and other fixings such as nail plates must be stainless steel. Refer to Table 3.

## 8.7 NAIL PLATES AND CONNECTORS

**8.7.1** Nail plates manufactured from zinc plated steel present a special case when used for subfloor structural applications in exposed or highly corrosive situations. Because of their thin gauge and small anode-to-cathode area ratio at cut edges, corrosion may result in significant loss of strength. Stainless steel nail plates should be used in areas subjected to windblown salt or on timber that may be above 20% moisture content. They should also be used on H4 or H5 treated timber piles within 600 mm of the ground.

**8.7.2** Nail plates manufactured from zinc plated steel may be used (with caution) in sheltered moderate environments provided that:
- the subfloor area is well ventilated but not exposed enough to encourage salt deposition (see NZS 3604 Table 4.1)
- they are not fixed to piles within 600 mm of the ground
- copper-based treated timber has been allowed to fix for 2–3 months before fixings are installed
- the building is not within a localised severe environment.

**8.7.3** Subfloor fastenings that are hot-dip galvanised after manufacture may be used with caution in up to marine environments provided that:
- the subfloor area is well ventilated (to NZS 3604)
- the risk from salt accumulation is low
- they are not fixed to timber piles within 600 mm of the ground
- the timber moisture content in service is less than 20%
- copper-based treated timber has been allowed to fix for 2–3 months before fixings are installed
- the building is not within a localised severe corrosion environment.

**8.7.4** AISI 304 stainless steel is recommended for not less than 50 years durability in corrosion zones D and E as defined by AS/NZS 2312:2002. AISI 316 stainless steel performs better in cases where salt may accumulate on the fixing. It offers a higher level of corrosion resistance with less risk of staining. Many other specialist stainless steel specifications are available for specifically designed alternative solutions.

## 8.8 METAL FIXINGS AND PLASTICS

**8.8.1** Plastics generally do not cause problems with fastener durability, with one exception. When PVC is exposed to sunlight (and fire), it begins to break down, giving off small amounts of a solution that is corrosive to many metals, especially zinc, steel, brass and aluminium. Fasteners on low-pitched PVC-U roofs should be installed with PVC-U encapsulation caps to protect them from acidic run-off.

**8.8.2** Most plastics have high thermal expansion rates in comparison with metals, and allowance should be made for this when fastening sheets.

## 8.9 METAL FIXINGS INTO CONCRETE

**8.9.1** Aluminium should be separated from fresh cement or cement-based products because they are very alkaline until fully cured. Care should also be taken to prevent water flowing over concrete or other cement-based products on to uncoated aluminium or zinc. Zinc reacts quite vigorously with wet cement.

**8.9.2** Steel fasteners in concrete are usually protected against corrosion by passivation of the steel arising from the high alkalinity within concrete that is correctly placed, compacted and cured. Loss of durability occurs due to the ingress of chlorides to the steel-concrete interface or carbonation of the concrete reducing the alkalinity. Rust formation on the fasteners can cause spalling of the concrete and fastener pull-out. Steel fasteners should not be used in concrete that will be exposed to moisture.

**8.9.3** Most austenitic, ferritic and ferritic-austenitic steels show very high corrosion resistance when embedded in or in contact with concrete structures.

**8.9.4** Fasteners embedded in concrete will first corrode immediately adjacent to the concrete surface.

## 8.10 METAL FIXINGS AND FIBRE-CEMENT-BASED PRODUCTS

**8.10.1** Hot-dip galvanised fixings can be satisfactorily used to fix fibre-cement-based products that will be painted and kept dry, but stainless steel is a safer alternative and is required by some manufacturers to validate their warranties. Aluminium fixings should not be used.

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