45 - GALVANIZED STEEL AND TIMBER

Uncoated steel nails used in hardwood not only corrode themselves by the corrosion products attach the surrounding timber

INTRODUCTION
Metal fasteners have been used in timber structures for thousands of years, and while other methods and materials of construction have been developed, timber remains an important light structural building material.

With the declining availability of native hardwoods in Australia, much of the timber construction now takes place using graded plantation softwoods or engineered timber products based on softwood forest products.

In addition to changes in timber availability, there has also been a major shift in pre-fabricated construction, where frames and trusses are assembled off-site, leaving traditional ‘stick’ construction becoming a relative rarity.

Nail guns have largely replaced the carpenter’s hammer and self-drilling fasteners have replaced conventional nails in many applications.

The basic reality remains with all this engineered timber construction of the need to ensure that the fasteners used are durable enough to match the design life of the structure.

WHAT FASTENERS FOR WHAT PURPOSE?
Nails.
There are three basic types of nailing systems commonly used. These are conventional nails, collated nails and gang nails. While all have spe¬cific design functions, the nature of each type of nailing systems has a significant impact on its durability.

Conventional nails.
There are many types of nails designed for gen¬eral and specific purposes. Head shape and shank design determine the performance while the nail gauge (diameter) and metallurgy will determine the strength of the nail. Nails are designed to con¬nect timber to timber (softwood and hardwood), sheeting (plasterboard, hardboard, wallboard, particle board, underlay and roofing) to timber and for other special fastening operations such as fas¬tening timber to aerated concrete blocks. The head size is determined by the material which is being fastened so that the nail head will not pull through the material.

The nail shan
ks may be plain, ring shanked (radially grooved) or twisted shank with the shank design determined by the nature of the material to which the attachment is being made. Assemblies subject to vibration or movement are best served by twisted shank or ring shank nails, especially in softwood.
Roofing nails have an integral cap and washer and have long been the standard fastener for corrugated roofing. These are also available in vari¬ous shank designs including those for cyclone rated areas and for use in softwood. This type of fastener has been most affected by the introduc¬tion of self-drilling Type 17 fasteners yet is a su¬perior performer in terms of durability, which is discussed later in this article.

Collated nails
Collated nails are used in nail guns and are con¬nected in strips or coils for use through nail gun magazines. Collated nails often have notched heads to allow the nails to nest with parallel shanks. Some collated nails are connected with paper strips while others are spot welded to a set of thin connecting wires.

Poor performance of the single electroplated fastener in this external hanger bracket, compared to the galvanized nails after 5 years in trated pine.

Gang nails

Gang nails are manufactured from pre-galvanized or black steel sheet and are better described as nail plates. The strip has a series of points punched out at right angles to the plate. Gang nails are widely used for butt jointing timber, particularly trusses and wall framing. Special gang nail fas¬teners such as the National Dek Lok, designed for invisible attachment of timber decking oper¬ate on the same principle.

Self-drilling fasteners

Self-drilling fasteners are now used almost universally in many facets of timber construction. While much of this activity is inside the structure (e.g. plasterboard fixing), the most critical applications involve the fixing of external cladding.

While much of the attention has been focused on the performance of these fasteners in attaching metal cladding, and having compatible life with the cladding, they are also largely used to fasten the cladding to timber frames and trusses, hence their mention in this context.

Most metal roof and wall cladding used in Australia today is fixed to either steel or timber framework with self-drilling, self-drilling screws. The concept of this type of fastening is relatively new and was introduced by I.T.W. in the USA in the 1960's as a labour saving device in the automotive industry.

The use of fasteners rapidly expanded into the building industry for fixing plasterboard lining and metal cladding. ITW Buildex commenced manufacture of TEKS and Type 17 fasteners in Australia in the late 1960's and now produces approximately 2 million fasteners per day in plants in Melbourne and Sydney. The early self-drilling screws were electroplated with zinc or cadmium to a minimum thickness of 8 microns and passivated. At this time, it was more common to clad building in more severe corrosive environments with asbestos cement, aluminium or protected metal claddings, most of which were fastened with stainless steel self tapping screws or wood screws.

The situation began to change dramatically in the late 1970's due to:

1. The introduction of BlueScope Steel ZINCALUME™ and COLORBOND™ cladding with increased corrosion resistance.
2. The health risks associated with asbestos cement sheeting
3. The flood of cheap, low-quality imported fasteners from Asia following the expiration of the TEKS patent.

Many of these had only 2-3 microns of electroplated zinc with a corrosion resistance 25% that of the original ITW Buildex product.

The result was that ZINCALUME™ and COLORBOND™ were being used in more widely and being fixed with fasteners with inferior corrosion resistance. As a result, BlueScope steel approached fastener manufacturers in 1981, requesting that self-drilling screws have minimum of 1000 hours salt spray resistance.

The Fastener Institute of Australia formed a technical committee to produce a draft standard that eventually became AS 3566 - Self Drilling Screws fin- the Building and Construction Industry which was released in 1988 and revised in 1990 and again in 2003. It is unusual in being a performance based standard rather than a materials based standard and its aim is to ensure that fasteners have a similar life to the materials they are required to fix.

Hot dip galvanized twisted shank nails are recommended by the treated pine industry for use in their structural sections.

Class 3 - Screws for External Use
The Standard AS 3566 requires minimum corrosion resistance levels under accelerated testing to the following levels:
1. 1000 hours salt spray testing
2. 15 cycles Kesternich (acid rain) testing
3. 2000 hours QUV testing (for organic coatings)
4. 1000 hours humidity testing.

Screws with an average zinc coating thickness of 40 microns applied either by hot dip galvanizing or mechanical plating are exempt from these tests provided they have a minimum spot thickness of 35 microns.

The testing of new types of coatings and fasteners which have appeared since the introduction of AS 3566 in conjunction with ZINCALUME™ and COLORBOND™ have taught the industry many valuable lessons.

1. Bi-Metallic Corrosion
Stainless steel fasteners were long believed to be the answer to all fixing problems in severe environments. Stainless steel has now been shown to be incompatible with COLORBOND™ and can cause premature corrosion of the roofing sheet.

2. Shank Corrosion
Corrosion of the shank of a roofing screw can occur under the roof to an advanced stage before any sighs of external corrosion appear. This is believed to be the result of pure water corrosion arising from condensation on the underside of the cladding.In studying the possible causes of this type of corrosion, Buildex realised that a self drilling screw cut a neat sized hole in the roof sheet, causing a sharp edge of the hole to rub off a significant amount of the coating or plating that had been applied to the shank. A special feature called `Shankguard' was added to all crest fixing screws that causes a slightly oversized hole to be created in the sheet before the shank passes through, preventing damage to the corrosion resistant coating. This feature increases the corrosion resistance of the shank by 60%.

3. Sheet Movement after Fixing
Hi Grip is another feature that has been added to Buildex roofing screws since the introduction of AS 3566. This system incorporates differently pitched threads under the fastener head that grips the roof sheet against the head of the fastener which eliminates vertical vibration of the sheet against the shank of the fastener and further enhances the durability of the shank.

4. Sealing Washers
The fastener industry has worked closely with BlueScope Steel in testing many facets of corrosion resistance of fastening systems and their compatibility with cladding materials. It has been found that corrosion of the cladding in severe marine environments can he accelerated using sealing washers containing carbon black, causing galvanic corrosion of the roof sheeting.
As a result, Buildex have altered the formulation of sealing washers from black EDPM to a gray formulation containing virtually no carbon black.

5.Severe Marine Environments
With cladding products being used in severe marine environments, and stainless steel screws being considered incompatible, the latest revision of AS 3566 has included a Class 4 durability level for heavy

duty (marine and industrial) applications.

The need continues for architects and roofing manufacturers to actively specify that fasteners must at least meet AS 3566 Class 3 if the basic objective of having fasteners and cladding of compatible life spans is to be met.

The majority of metal cladding and roofing in Australia is installed in ‘moderate’ environments and by simply ensuring that the minimum standards of AS 3566 Class 3 are specified and met, the benefits to be obtained both commercially and aesthetically from products such as ZINCALUME and COLORBOND will be enjoyed by the whole community.

CCA treated pine is very aggressive on both zinc and steel when its moisture content exceeds 20%. These electroplated bolts have almost totally corroded in pergola structure after 10 years.

MATERIALS OF MANUFACTURE

The vast majority of nails are made from low carbon steel. The drawing, cold heading and point¬ing operations increase the tensile strength of the wire and this is also a factor in the design and performance of the wire. Nails that are too soft are difficult to drive without bending and nails that are required to be driven into resistant materials such as masonry also require an additional degree of stiffness.

Nails for marine applications (boat nails) are manufactured from silicon bronze or similar alloy. Stainless steel nails are also available from specialised manufacturers but in the final analy¬sis, most fastening applications depend on steel fasteners with varying degrees of protective coat¬ing from none, in the case of ‘bright’ nails to heavy hot dip galvanized coatings.

Gang nails or nail plates are almost always manu¬factured from pre-galvanized sheet. The durabil¬ity requirements in more aggressive environments have required hot dip galvanized nail plates to be specified.

STEEL AND TIMBER

Non-threaded fasteners are inevitably subject to very severe treatment during their installation, and few assembly operations are more severe than being hammered, with the resultant very high impact energy of the hammer-head being trans¬ferred to the very small surface area of the nail head. There is also a degree of abrasion on the nail shank as it is driven into the timber.

For the first 150 years of Australian colonisation, the country’s abundant hardwood supplies were used universally for building and construction in the absence of significant native softwoods. Also, the availability of the so-called royal grades of Australian hardwood such as mahogany, tallowood and turpentine, with their superior du¬rability did not require the use or timber preserva¬tives.
With the increasing dependence of plantation tim¬ber and the need to use less durable hardwood timber, the use of preservative treatments has become almost universal.

The permeability of pine means it can be treated with a wide range of preservative treatments when being used in exposed situations, in contact with the ground or in any area it may be subjected to moisture such as indoor swimming pools and greenhouses. Once treated, it can withstand conditions in which insects and/or fungal decay would quickly destroy untreated timber.

Treated pine is used both for structural and non-structural purposes in a range of dressed and sawn products. Indeed, it has extensive applications both above and below ground. Preservative treatments are usually either:

• Water-borne
  – Copper Chrome Arsenic (CCA)
  – Alkaline Copper Quaternary (ACQ)
  – Copper Azole (CuAz)
• Solvent-borne
  – Light Organic Solvent Preservative (LOSP), or
• Oil-borne
  – Creosote
  – Pigmented Emulsified Creosote (PEC)

Treatments may not always be absorbed into every part of the timber, so when treated timber has been cut, an appropriate re-sealing treatment should be applied to the cut surface.

When finishing treated timber with paint, stains or clear coatings consult with the producer/supplier as to the best method of application, as the treatments may have an adverse affect if a compatible coating is not applied.

The Australian Standards requires that each piece of treated timber, claimed to conform with the standard, must be labeled on one end with the treatment plant number, the preservative code number and the hazard class.
Hazard class

The hazard class according to AS1604 is determined by a number of factors including insect attack, temperature, moisture and the geographical location of the exposure environment. There are six hazard classes:

- H1 – is used in dry, inside above ground exposure situations for furniture, flooring and interior joinery subject to attack from insects other than termites.
- H2 – is used in dry, inside above ground exposure situations for framing, trusses and flooring subject to attack from termites and borers.
- H3 – is used in outside, above ground exposure situations for pergolas (above ground), decking, fencing, cladding, fascias, joinery and any structural timber subject to moderate fungal decay, borers and termites.
- H4 – is used in outside in the ground exposure situations for fence posts, greenhouses, landscaping and pergolas (in ground) subject to severe fungal decay, borers and termites.
- H5 – is used in outside in the ground or in fresh water exposure situations for retaining walls, house stumps, building poles, pilings, cooling tower fill and any critical structural applications subject to
very severe fungal decay, borers and termites.
- H6 or H6SW– is used in marine water exposure situations for piles, jetty cross bracing, landings, steps, sea walls and boat hulls subject to marine borers and decay.

Fasteners In all exposed situations, hot-dipped galvanised or other corrosive-resistant fastenings should be used to secure preservative treated timber. Stainless steel fasteners may be required in severe environments in close proximity to coastal areas.

Further, all nails used with treated pine should be twist-shank or ribbed, to avoid their withdrawal as moisture conditions in the wood change

Copper chrome arsenic (CCA) treatment is the most widely used timber treatment and the pres¬ence of treatment chemicals in the timber can have a significant and sometimes dramatic effect on the durability of the fasteners used.

Another factor in fastener performance in timber is the nature of the timber itself. Although timber degradation is not electrochemical in nature, it can be treated as a special form of corrosion. Timber is a classic biodegradable material subject to ‘corro¬sion’ by numerous agents ranging from insect and fungus to ultraviolet degradation and chemical at-tack.

The durability of the connection between timber and metals determines the durability of the com-posite material formed by the attachment of the timber to steel or other medium. The designer must determine the critical factors in a wood-metal system. Is it the corrosion of the fastener that will cause the system to fail or is it decay of the timber around the fastener that will cause failure of the joint?

Anyone who has had to maintain timber fence palings will have asked these questions. Has the paling fallen off because the nail has rusted off or because the wood around the nail has degraded and the hole is bigger than the nail?

WHY DO FASTENERS CORRODE IN TIMBER?

Corrosion of fasteners in timber is due to the for¬mation of an electrochemical cell. Metal fasten¬ers are not usually electrically connected although with metal roof cladding it is a possibility. The electrochemical cell formed with metal fasteners in timber can thus be likened to a crevice corro¬sion or waterline corrosion situation. The head of the fasteners (bolt, nail. screw or gangnail plate) becomes the cathode and the embedded part of the fastener becomes the anode because of its oxy¬gen deficient environment. In then presence of an electrolyte, corrosion will proceed because of the current flow that occurs between the anodic and ca¬thodic sites.

The likelihood of corrosion of metal fasteners in timber is influenced by the following factors:

- moisture content
- wood species
- preservative treatment
- presence of decay (micro-organisms)

Moisture in timber

The naturally occurring inorganic salts, wood acids, atmospheric contaminants and timber pre-servatives will contribute to the ionisation of any moisture that comes in contact with the timber. Fortunately. there is a critical moisture level in tim¬ber below which the corrosion reaction is signifi-cantly reduced. This moisture content is about 16-18%. Moisture content alone is the main factor controlling corrosion of metal fasteners in timber.

While seasoned timber will have moisture levels below the critical levels, it should be remembered that rain and condensation on the surface is suffi¬cient to stimulate corrosion at the interface. Short cycles of wetting and drying and the resulting expansion and contraction of the timber will re¬sult in cracking and splitting of the wood, espe¬cially around fasteners which allow end grain in¬gress of moisture into the timber. It is for this rea¬son that paint systems for timber are designed to fill the pores in the timber and seal and preserve the surface.

The ubiquitous pink primer applied to exterior woodwork prior to priming and painting contains various extenders, UV and fungicide additives such as zinc oxide to assist in maintaining a sta¬ble environment for the timber in service.

Fungal decay

Fungal activity. and moisture levels around 20% are deemed to be sufficient to promote fungal decay. Corrosion products from fasteners may di¬rectly stimulate the development of wood-destroying fungi through the release of nutrients or by alter¬ing the pH of the micro-environment. Alkali hydroly¬sis and oxidation of the wood can also occur causing the wood around the corroding fastener to become soft and absorbent, which in turn retains moisture longer and absorbs it easier, thus propagating the corrosion of the fastener.

Wood species

The acidity of timber varies depending on spe¬cies and the location of the wood within the tree, as pH can vary from heartwood to sapwood. A number of studies have been done worldwide that have fitted various species of timber into an ap¬proximate corrosivity series. While pH is an ob¬vious factor, the presence of other components such as aromatic phenols in the timber and its per¬meability to moisture are also important in deter-mining the corrosive effects of wood on metal fasteners.

The following table lists some common Austral¬ian timbers with their typical pH and polyphenol contents.

Timber Species	**pH (heartwood)**	**Polyphenols (tannic acid equivalent)** %
Common Name		
Blackbutt	3.12 - 3.25	6 - 13.5
Peppermint	3.15	11.0
Turpentine	32 1	152
White Mahogany	3.24	8.72
Coastal Grey Box	3.42	15.8
Tallowood	3.55 - 3.56	17.0 - 17.3
Banealay	3.56	4.37
Mountain Grey Gum	3.57	12.1
Yellow Stringybark	3.62	1 1.6
Sydney Blue Gum	3.65 - 3.80	5.78 - 10.3
Red Ironbark	3.66	10.4 - 11.0
Flooded Gum	3.84	5.24
Spotted Gum	4.25 - 4.68	4.46 - 6.05
Brush Box	4.55	1.23
Grey Ironbark	4.88	6.92

Table: Acidity and polyphenol content in a range of commer¬cial hardwoods. From Krilov and Gref (1986)

While the effect of timber species is important in the durability of fasteners, the Australian saw milling industry is acutely aware of the corro¬sive effects of green Australian hardwoods through the corrosive effects steel saw blades. Corrosion losses in the order of 3-8 g/m2/hour have been recorded with the stringybark species ex¬hibiting much higher levels of corrosion damage.
Preservative treatments and fastener corrosion

Copper chrome arsenic (CCA) preservatives are the most widely used timber preservatives. Tim¬ber which has been freshly treated with CCA has a high moisture content, a high acidity and a high electrical conductivity. All of these conditions are ideal for the electrochemical corrosion of metal. Much test work has been done, particularly by the Queensland Department of Primary Industries Forest Service, to determine the corrosive effects of timber treatment on various metals and coat-ings used in fasteners.

There is a dramatic increase in corrosion in both steel and galvanized coatings, and with silicon bronze and copper fasteners with freshly treated timber with high moisture content. Bare steel nails corrode almost 10 times faster in newly treated timber at 80% moisture content compared with seasoned timber at moisture levels typically un¬der 15%. The Queensland DPI Forest Service rec-ommends that treated timber be withheld from sale for a 'cure' period to avoid the environmen¬tal consequences of unfixed CCA salts leaching from the timber and to minimise fastener corro¬sion.

Other preservative treatments such as ammoniacal preservatives, boron preservatives, light organic solvent preservatives (LOSP) and oil type preserva¬tives are now more widely used in Australia, but like CCA treatments, are not considered to present significant corrosion problems for fasteners in cured condition.

Other factors

I. Effect of rusting iron on wood: Iron acts as a catalyst in the deterioration of wood tissue and rusting iron in contact with wood causes a decrease in tensile strength of the timber due to the decom¬position of hemicellullose by alkaline corrosion products.

2. Chloride ions: Wood usually contains natural chloride and as in most corrosive environments, the presence of chloride is particularly relevant. Chloride levels in eucalypts generally range be¬tween 10-100 ppm in heartwood and 100-2000 ppm in sapwood, with bark having higher levels. Pinus radiata typically contains 10-200 ppm in its sapwood.

Fastener materials and coatings

The vast majority of fasteners are manufactured from mild steel. Stainless steel, copper, monel and brass are also used for specialised fastener appli¬cations such as boat building and other heavy duty applications where steel is inappropriate.

While a large number of nails are used in `bright' (uncoated) condition, most exterior exposure ap-plications require some type of protective coat¬ing to be used on the nails if long term perform¬ance is required.

This can be zinc plating, hot dip galvanizing or polymer coating with varnish or other paint coat¬ing for specific purposes.

Hot dip galvanizing is the most commonly used economical method of improving the durability of nails in timber, as the hot dip galvanizing proc¬ess applies a very heavy coating to the fastener compared to zinc plating . In addition, the alloy¬ing of the zinc to the steel in the hot dip galvaniz¬ing process provides an extremely hard and dura¬ble coating that is able to withstand the rigors of being hammered. The thickness of the hot dip galvanized coating is generally in excess of 40 microns and is typically 6-8 times the thickness of zinc plating used on fasteners.

Hot dip galvanized nails are recommended without exception for use with CCA treated pine, and most treated pine suppliers carry only hot dip galva¬nized steel accessories. Durability problems can occur with gang nails used for exterior applica¬tions if they are manufactured from pre-coated steel sheet, as the zinc coating is relatively thin (around 20 microns) but more significantly, there is a large area of exposed steel on the cut edges of the nail plates that places additional demands on the zinc to cathodically protect the cut edges and accelerates failure of the coating in these ar¬eas.
Some manufacturers have gone to hot dip galvanizing nail plates to improve their durability.
Designing to minimise wood/metal corrosion

Like all corrosion problems, one of the best ways to minimise corrosion risk is through good anti-corrosion design. The metal/wood connection is no exception.

There is a hazard level classification under the Timber Utilisation and Marketing Act (1987) where environments for timber use are classified from HI (off the ground, well ventilated and com¬pletely protected from the weather) to H6 (fully exposed, high decay hazard, ground contact) and this is a useful guide to fastener selection and treat¬ment.
Timber structures need to be assessed for durabil¬ity in the same way as steel structures, using appropriate parameters and be designed with an awareness of the particular characteristics of tim¬ber in mind. Important considerations include:

- Exposure condition of site
- Moisture content of timber in service should be below 20%
- Selection of type of timber
- Protective coating systems to seal timber (primers, paint, varnish)
- Keep timber off the ground
- Recess fasteners and seal or plug holes
- Avoid coupling timbers of dissimilar porosity
- Avoid wood/metal interfaces near water line - full immersion may be better than intermittent immersion.
- Avoid puddling of rain and condensation at connections.
- Ensure adequate ventilation
- Use fasteners with equivalent durability to the design life of the structure.

CONCLUSION
The management of corrosion in fasteners used in conjunction with timber is an important issue and one which has a direct impact right down to the home owner. The selection of inferior fasten¬ers in domestic construction: paling fences, decks, pergolas and other home hardware can dramati¬cally reduce their maintenance free lives and the small premium associated with using the best available fasteners is a good example of short term savings adding up to long term problems.

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INDUSTRIAL GALVANIZERS

INGAL
SPECIFIERS MANUAL

01 - SPECIFIERS MANUAL — THIRD EDITION

Industrial Galvanizers Australian Galvanizing Division (IGAG) operates nine galvanizing plants around Australia, ranging in size from large structural galvanizing facilities to specialised small plants designed to process small parts.

The Australian Galvanizing Division has galvanized in excess of 2 million tonnes of steel products in Australia since its first plant was commissioned in 1965 and is recognized for its ability to handle complex and difficult projects, as well as routine contracts.

This experience has been collated in the Specifiers Design Manual, to assist those involved in the design of steel products and projects to better understanding the galvanizing process and allow the most durable and cost-effective solutions to be delivered to these products and projects. All sections of this Third Edition have been completely updated and additional sections have been included to provide additional technical information related to the use of hot dip galvanized steel.

In addition to its Australian Galvanizing operations, Industrial Galvanizers Corporation has a network of manufacturing operations in Australia, as well as galvanizing and manufacturing businesses throughout Asia and in the USA.

The company's staff in all these locations will be pleased to assist with advice on design and performance of hot dip galvanized coatings and products. Contact details for each of these locations are located elsewhere in this manual.

This edition of the Industrial Galvanizers Specifiers Manual has been produced in both html and .pdf formats for ease of access and distribution and all documents in the Manual are in .pdf format and can be printed if paper documents are required.

The Specifiers Manual is also accessible in its entirety on the company's web site at www.ingal.com.au.

Additional copies of the Specifiers Manual are available on CD on request.

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