JAMES COOK CYCLONE STRUCTURAL TESTING STATION

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A SURVEY OF THE CORROSION OF BUILDING COMPONENTS

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G. F. REARDON
and
G. DOULL

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A SURVEY OF THE CORROSION OF BUILDING COMPONENTS

G. F. Reardon and G. Doull

SUMMARY

Evidence of the corrosion of some building materials was drawn to the attention of the Cyclone Testing Station. In particular, some roofing screws only a few years old were corroded completely through their shanks. As the location of the buildings containing the screws was well away from the seaside a survey was initiated to determine the extent of the corrosion. The area surveyed included 18 coastal shires and cities from Mackay to Cairns in North Queensland. Buildings within 1 km of the coastline were excluded from the survey.

Some 200 buildings were surveyed in detail, almost half of which were shed type buildings because of their easy access. Roofing screws were the most common building elements showing corrosion. The state of the screw head proved to be no real indication of the soundness of the shank. Screws nearest the windward edge of buildings seemed to be at the greatest risk. Galvanised roofing nails were less affected by corrosion but older ones were often loose from rotting of the timber around the shank. Other building components and structural elements were less affected by corrosion. Although the actual percentage of screws that were corroded is quite low, the fact that they occurred in groups at a highly loaded part of the roof is a cause for concern. It is unlikely that the findings of the survey would be restricted to North Queensland.

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1. BACKGROUND

In a report on damage to buildings in far North Queensland by cyclone Winifred (Reardon, Walker and Jancauskas, 1986), there was mention of corrosion of metal components. In one particular instance, severe corrosion had sufficiently weakened some RHS steel support columns that a carport was destroyed during the storm. Evidence was also given of severe corrosion of roofing screws. In Western Australia similar observations were made by Boughton (1987) while inspecting damage caused by cyclone Connie in the Pilbara area. Boughton noted failure of corroded elements at stresses of approximately 50% of design wind load, whereas sound elements would be expected to resist approximately 2.5 times design wind load.

FIGURE 1 Corroded screws sent to the Station

Some time after cyclone Winifred a number of severely corroded roofing screws were sent to the Cyclone Structural Testing Station at James Cook University from the Atherton Tablelands area. Figure 1 shows some of the screws. They had been taken from a three year old building in Atherton. The building in question is shown in Figure 2. The portion of the building

Figure 2 Building having corroded screws

to the right hand side of the downpipe was added early in 1986 after some roof sheeting had been lost during the cyclone. During that rebuilding programme all of the screws on the near slope of the roof had to be replaced. The corrosion in some of them was so bad that it had almost eaten through the 5.2 mm shank diameter of the 14 gauge screw. It had all occurred on the shank of the screw beneath the roof sheeting but above the roofing batten. However the heads of the screws were still in good condition, illustrating little evidence of their condition beneath the roofing. It was reported that the screws sent to the Station were representative of many of those taken from the building.

It should be noted that Atherton is the main township on the Atherton Tablelands which form part of the Great Dividing Range. It is about 50 km from the sea and has an elevation of approximately 750 m above sea level, therefore it should be totally unaffected by salt air corrosion. Its average annual rainfall is only 1425 mm.

A short time later some similarly corroded roofing screws were sent to the Station from Innisfail, taken from a house about five years old. Innisfail is in a very high rainfall (3650 mm per annum), high temperature and high humidity area. It is located on the Johnstone River and has some seaside suburbs. Therefore some areas of Innisfail would be at risk from salt air corrosion. They were not included in this survey.

The discovery of badly corroded screws from these two areas led to the question of how extensive was the problem. The potential problem was extremely large, as the average sheet roofed house requires in excess of 1,000 screws and industrial or commercial buildings use significantly more. One interesting point about the corroded screws sent to the Station is that neither group had any identification of the manufacturer on the heads. It is believed that all screws manufactured in Australia are stamped with the manufacturer's symbol, e.g. BX for Buildex, SC for Spurway Cook, B for Boustead, etc. As the screw heads were marked with only concentric circles, it was assumed that they were imported. Some of the obvious questions arising from this information were as follows:

(a) was corrosion restricted to this unbranded make of screw?

(b) if so would all screws of this make be affected or was there a batch of screws that had been poorly coated?

(c) could such a batch be traced?

(d) if the problem was not restricted to a bad batch or one type of screw, how widespread was it?

The final and most important question was:

What would be the consequences of this corrosion, especially in cyclone prone areas?

The Cyclone Structural Testing Station has therefore collaborated with the National Building Technology Centre to conduct a survey to determine the extent of corrosion of building components in cyclone prone areas. NBTC provided funding for the Station to conduct the survey and analyse the data collected. Funding constraints did not allow for detailed investigations into the cause of the problems nor into their solutions. In fact, the Cyclone Structural Testing Station does not currently have on its staff a person qualified to conduct a metallurgical investigation into the causes of corrosion in building materials.

2. OUTLINE OF INVESTIGATION

2.1 Initial Contact

The survey was conducted by Mr Gavan Doull, a qualified civil engineer who was appointed specifically for the task. As well as being an engineer, Mr Doull had ten years with the building industry including running his own business. He was therefore eminently suited for the task.

The survey was initiated by writing to various associations and authorities explaining the problem and enquiring if they had observed any serious corrosion of building components. Letters were sent to the following groups:

Master Builders' Association,
Master Plumbers' Association,
Council building surveyors,
Council health surveyors,
Government departments,
Demolition contractors,
Manufacturers and distributors of roofing,
Manufacturers and distributors of roofing screws,
Renovations specialists.

The Queensland Master Builders' Association co-operated by including an article in their monthly journal. One Brisbane newspaper and a number of local newspapers also included small articles on the survey. The letters were followed up by a telephone call and, in most cases, a visit was made to discuss the matter in detail.

2.2 Response from the Building Community

In general the immediate response from the building community was poor. This was not unexpected as most unsolicited requests for information receive a poor response. Further it is acknowledged that most tradesmen do not frequently have contact with older buildings. However it was hoped to obtain feedback from builders making renovations or additions or from plumbers repairing or completely re-roofing buildings. Despite a concerted effort by the Station staff in contacting tradesmen involved in this work and interviewing them, little quantifiable information was obtained. Where corrosion was present (and the tradesman being interviewed usually remembered seeing some) the tradesman considered the problem to be isolated to his particular job and was concerned only with its immediate rectification.

The sub-contracting system further exacerbated the problem of obtaining reliable information, as it provides less feedback to the builder than would come from a team in his employment.

By far the best response came from the local government authorities. Not only were the building surveyors themselves very co-operative, but in many instances the authorities undertook to provide the Station with a monthly statement of the building activity. This has enabled Station staff to make contact with people renovating buildings and seek their assistance. The other method of obtaining information was merely by word of mouth. James Cook University maintenance staff were very helpful in that respect.

It was anticipated that demolition contractors may be a useful source of information, as they are very conscious of the quality of the materials they redeem. Likewise relocation contractors were thought to be a potential source of information. Unfortunately, neither group was able to supply much detailed or confirmable information.

As a result of the generally disappointing response from the groups contacted, the Station relied mainly on the building surveyors for its information and also on independent observations made by its own staff.

2.3 Extent of the Survey

The survey nominally covered the coastal shires with offices from Miriam Vale in the south to Cooktown in the north, a distance in the order of 1500 km but representing an estimated population of about 430,000. The area represented by the shires contacted is shown as the shaded portion on the map given as Figure 3. As a follow up to the initial letter from the Station, building surveyors in the included shires were interviewed by telephone. If the building surveyor indicated that he was aware of some serious corrosion of building components a visit was made to that area. A total of 18 shires and cities from Mackay to Cairns were visited. This represented an estimated population of about 350,000 people extending over a distance of approximately 750 km.

In an effort to eliminate an obvious source of corrosion, the decision was made to exclude from the survey all buildings within 1 km of the coastline. This distance describes the "Coastal" classification used in some definitions of exposure (SAA, 1988). This definition is meant to include large bodies of water but exclude small bays, estuaries and rivers. The intent of the survey was to investigate corrosion in "normal" atmospheric conditions rather than in those that may be defined as severe.

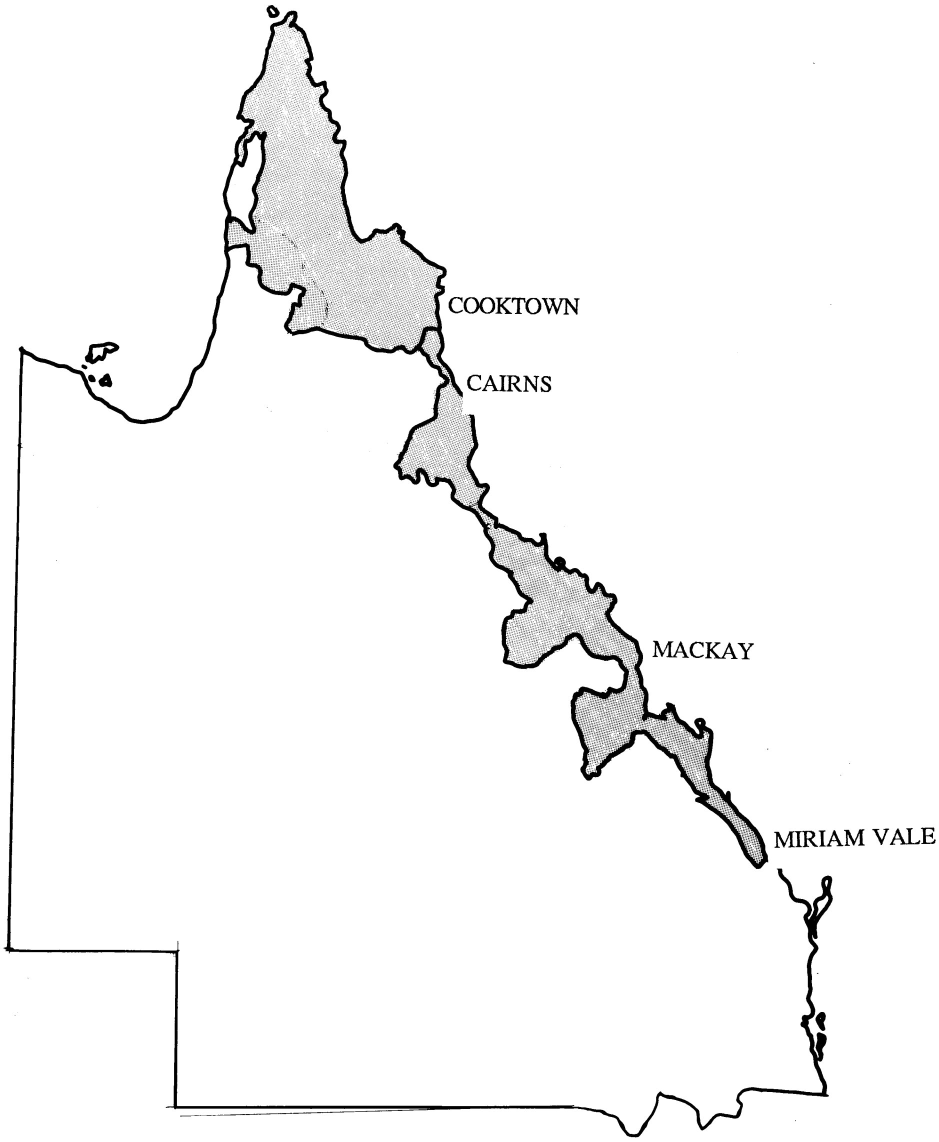


Figure 3 Area of Queensland included in survey

2.4 Type of Building Inspected

The survey was somewhat constrained by the type of building construction. Buildings such as houses, shops and commercial premises which were lined internally restricted the degree of inspection that could be made. In those cases the top surface of the roofing and the screw heads were usually the only components that could be inspected. Conversely, unlined buildings provided the best opportunity for inspection and therefore are the basis of the survey. Most information was obtainable from industrial buildings, sheds and open carports, all of which offered relatively easy access to their components. The building shown in Figure 2 is typical of the type included in this survey.

Obviously the co-operation of the owner and/or the occupier of the building was needed before it could be inspected. This aspect had to be handled carefully to ensure that the owner or occupier was not misled by the intentions of the survey. The staff had to be careful to explain that the buildings showing evidence of corrosion were not necessarily a hazard to life and limb, but that the corroded elements should be replaced at some time in the future. How far in the future would depend upon the extent of the corrosion.

The assistance given by building surveyors to gain permission to inspect buildings was invaluable. The survey would have been further restricted without that help.

Apart from gathering the verbal information provided by many interested parties, the Station's research officer inspected in detail some 200 individual buildings clad with metal roofing. Figure 4 illustrates a suitable grouping of the buildings, and the percentage of the total that each represents. The category "Houses, shops, etc." includes all of the buildings that were lined internally. The category "Farm buildings, sheds, etc" includes unlined buildings having external walls, whereas "Carports, etc." represents buildings without walls.

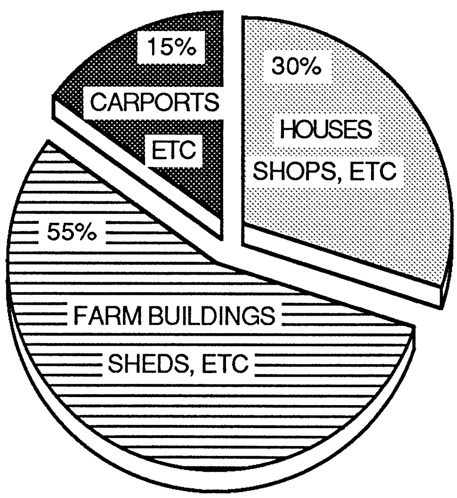


Figure 4 Buildings Inspected in Survey

2.5 Sampling Procedures

From the purely statistical viewpoint, the survey was purposely designed to be very biased in its sampling procedures. That is, buildings were not chosen at random from the approximately 120,000 buildings in the area. They were chosen because they were in some way suspect and because they offered easy access. Easy access usually meant that they were owned by the local shire or by somebody sympathetic to the aims of the survey. Time and financial constraints would not allow a random sampling approach. Further, it is debatable as to whether such an approach could have been successful.

3. OBSERVATIONS OF CORROSION

Most observations were made of the roofing and its fixings. Where possible they were inspected from both inside and outside. Because this survey was prompted by the evidence of screw corrosion, a particular emphasis was placed on observing the condition of roofing screws. It is estimated that approximately 350,000 screws would have been observed on the buildings. Of that number, approximately 1000 had either rusted through or were considered to have negligible strength because of corrosion. This latter figure does not include the badly corroded screws in the shed shown in Figure 1, which initiated this survey. Examples of badly corroded screws and others showing signs of corrosion are given in Figure 5.

The worst individual case in the survey was an industrial building at Atherton, illustrated as Figure 6. The 40 x 15 m building, about 10 years old, would have had approximately 6000 screws in its roof. In the bottom two purlins on the side nearest to the prevailing wind, 71 of the 500 screws were totally rusted through, 70 appeared to be in good condition and the remainder were in various states of corrosion. As can be seen from the photograph the building consists of an original section and extensions at the right end. The extensions were approximately two years old when the building was inspected. At least five screws in the second bottom purlin were considered to be in poor condition because of corrosion. Three of those five screws broke on being withdrawn from the steel purlin.

Some of the original screws in the ten year old part of the building had completely rusted through. Figure 7 shows a group of three screws driven through the roof decking and into a steel purlin. For clarity the screws are marked with an arrow. While the shank on the central screw is still reasonably sound, the shanks of the other two screws have rusted

Figure 5 Range of corroded screws

Figure 6 A building at Atherton containing the most corroded screws

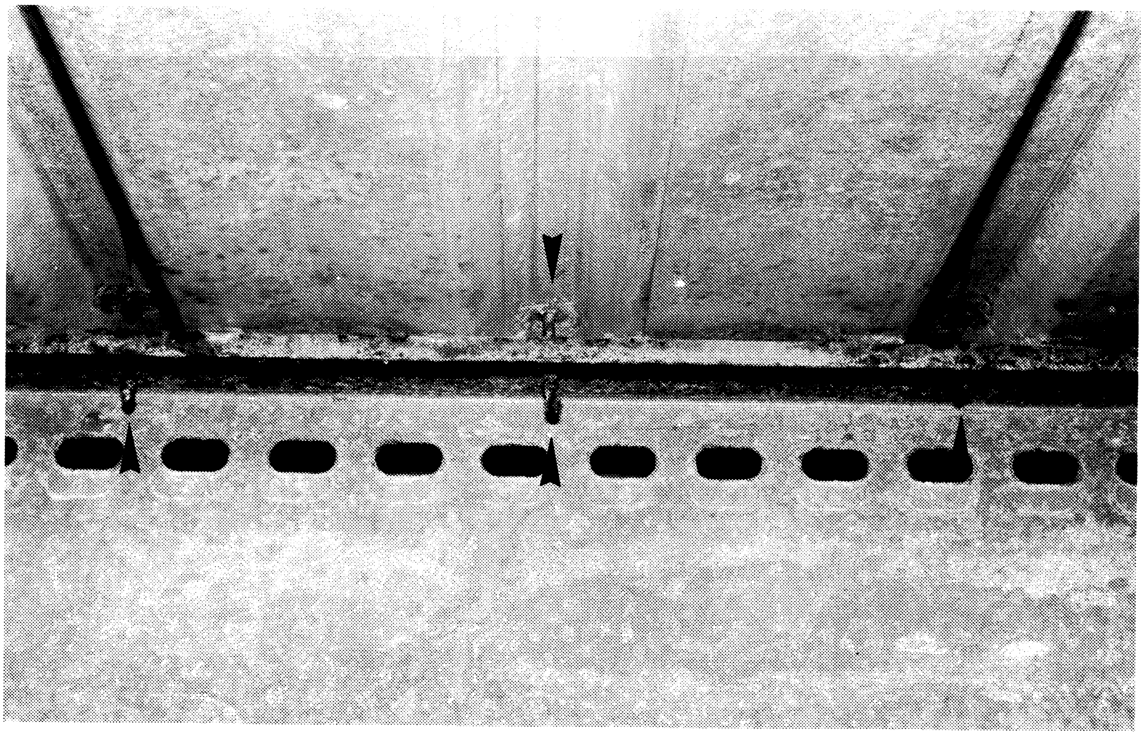


Figure 7 Two badly corroded screws in group of three

completely through. The purlin was the third one from the eaves of the building and therefore was virtually over the external wall.

The condition of various building components will now be discussed.

3.1 Roofing Screws

In this report the term "roofing screw" refers to a power driven screw that drills its own hole through the roofing and either penetrates a steel purlin or embeds itself into a timber purlin. The screws would be either 12 or 14 gauge and would be in general accordance with Draft Australian Standard DR 86107 "Screws - Self-Drilling - for the Building and Construction Industries". The survey noted only one occasion of corrosion of normal wood screws, which will be referred to later.

Clause 1.5.1 of that draft states in part that "Fasteners intended for external applications shall be finished with yellow iridescent chromate conversion coating, in accordance with AS 1791, Table 1, coating type C as a minimum requirement." It is probable that the screws inspected in this survey would be in accordance with that clause.

3.1.1 Screw heads

The overall observation was that on nearly all roofs some screw heads showed signs of corrosion. It was usually not serious. In those instances where screws could be withdrawn for inspection, it was noted that rusting generally stopped at the sealing washer. However there were some instances where severe rusting was observed and they will be discussed later. A total of 103 roofs were inspected specifically to estimate the extent of corrosion of the screw heads. A summary of the findings regarding screw heads is given in Table 1.

TABLE 1
EXTENT OF CORROSION OF SCREW HEADS

Percentage of screw heads corroded	Number of roofs
0 - 10	80
10 - 50	12
50 - 90	8
>90	3

3.1.2 Screw shanks

Because of difficulties regarding access, inspection of screw shanks was made in unlined buildings only. Of the 15 cases in the Innisfail and Atherton areas that were reported by the building surveyors as being serious, only 9 could be visited. In each of these nine buildings, severely corroded screw shanks were observed. The main location for rust was in the shank just above the purlin, that is, beneath the crest or rib in the roofing. In many instances the screw shanks were completely rusted through and their heads could be lifted off the roofing - albeit with some difficulty due to fusing of the sealing washer onto the roofing and the screw. Figure 8 shows a roofing screw with its shank having rusted through completely. It was located further along the purlin described in Figure 7. A point of interest is that the portion of the screw penetrating the purlin is showing virtually no evidence of rust. Both the cutting edge of the thread and the point of the screw are still quite sharp.

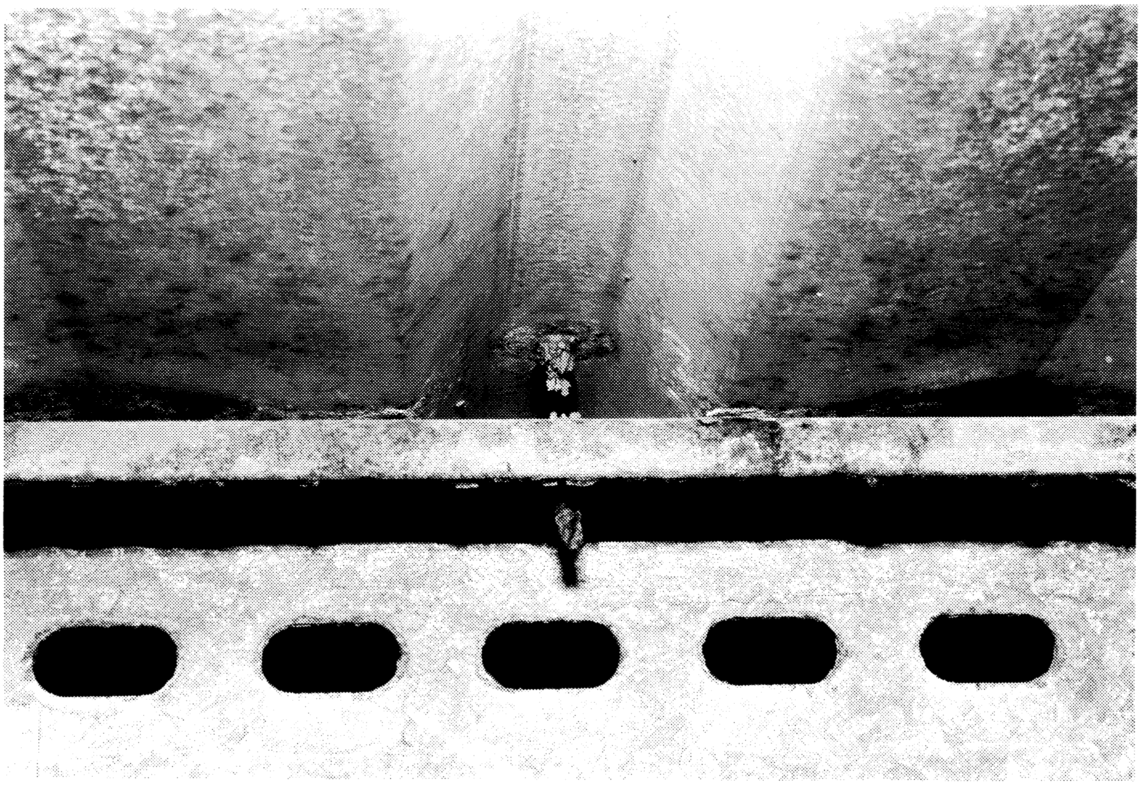


Figure 8 Screw shank rusted completely through

A disturbing aspect is that on most occasions where the shank had rusted through, the head showed little evidence of corrosion. The four screws shown in Figure 5 illustrate this point very well as all have sound heads despite the condition of their shanks. Figure 5 also illustrates the lack of corrosion of the threaded part of the screw or its point, a feature that has already been mentioned. As well as the head usually being being relatively free of corrosion the sealing washer was usually also in good condition. Thus the condition of the screw, and its effectiveness, cannot be accurately judged by the condition of its head.

Corrosion of the screw shank appeared to be unaffected by the type of purlin to which it was attached, whether it was timber or steel. Likewise the part of the screw embedded in the timber purlin showed virtually no effect of corrosion Most of the screws that were withdrawn from timber purlins were still sound along the length that had been embedded.

Figure 9 Screws taken from adjacent purlins

It was noted that in each of the nine buildings considered to have serious corrosion the problem area was confined to about 10-15% of the total roof area. This area was generally located at the eaves or edges and towards the direction of the prevailing winds. In the remainder of the roof the screws appeared less affected by corrosion. This is well demonstrated by Figure 9 which shows three screws extracted from the same rib of a sheet of roof decking, but from different purlins. The badly corroded screw was taken from the purlin virtually over the wall. The centre screw, showing corrosion at an obviously slower rate, was taken from the next purlin towards the ridge and the uncorroded screw came from the next purlin up the slope. This uncorroded screw would have been representative of the screws in the other purlins towards the ridge.

Some corrosion of screws was observed in buildings with non-metal sheet roofing. In a few instances, severe corrosion was noted. However as buildings with such roofs formed a low proportion of the total number inspected, an accurate assessment of their relative performance cannot be made.

3.1.3 Screw types

As the initial screws sent to the Station were unbranded, one of the tasks for this survey was to investigate whether the corrosion was affecting imported screws only. This certainly does not appear to be the case. As the screw heads were usually in good condition, it was easy to identify the various Australian brands. They were generally prominent among the corroded screws, as were the screws considered to be imported. The corrosion problem is therefore not restricted to a particular brand of screw, nor to imported screws. It appears to be a problem common to all types of screw.

A positive decision was made not to try to statistically categorise the brands or types of screw designated as seriously corroded. While such an analysis may be a useful exercise in a fully controlled experiment it would probably lead to incorrect conclusions from a limited survey such as this one. The results of such an analysis would more likely reflect the popularity of a particular brand rather than its susceptibility to corrosion.

3.1.4 Cyclone washers and sealing washers

Many of the buildings inspected included cyclone washers in their roof security systems. The presence of washers did not seem to influence the degree of corrosion of the screws. However the galvanised washers themselves showed very little evidence of corrosion. Figure 10 shows a cyclone assembly taken from the roof of a building at Ayr. The figure graphically illustrates the effects of the atmosphere on three different surfaces. The shank of the screw has virtually corroded through. The galvanised exposed surface of the cyclone washer has become dull, indicating that the galvanising is working to protect the steel. The underside of cyclone washer, which was protected from the atmosphere by its sealing washer, is still bright. While the age of the building was not determined, an upper limit can be estimated by the presence of cyclone assemblies. They were not used on steel roofing before cyclone Tracy hit Darwin in December 1984. The roof security system could therefore not have been more than 13 years old at the time of the survey.

In a verbal report from Darwin, the Station was informed of breakdown of "rubber" sealing washers. The report suggested that the failure was due to overheating. Although daily temperatures in Darwin are usually a little higher than those in North Queensland, it was anticipated that

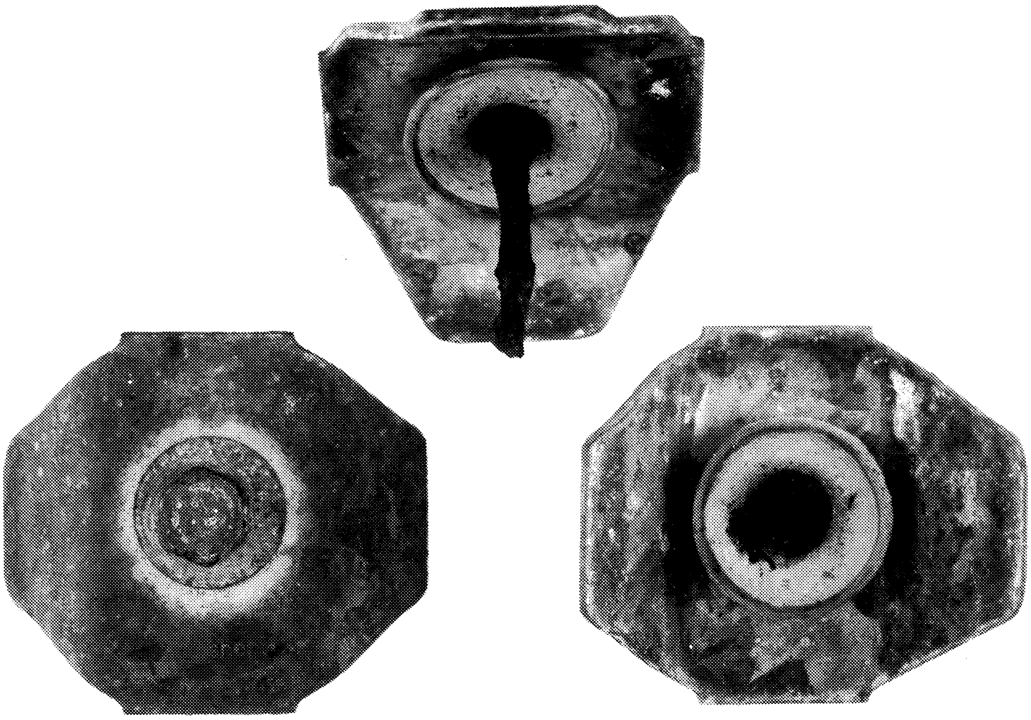
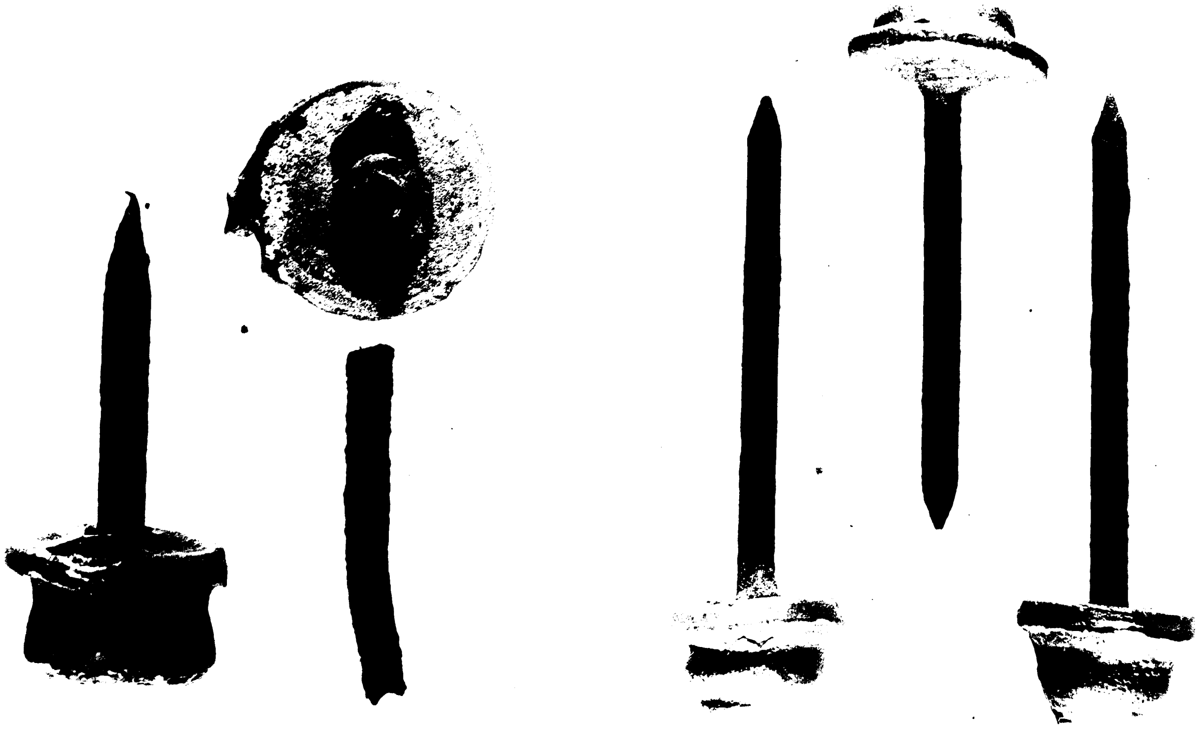


Figure 10 Cyclone assembly demonstrating the difference in corrosion protection

some evidence of breakdown of washers would be observed. This was not so. There were no obvious examples of cracking in sealing washers that had been well installed, although they had usually bonded onto the screw head and the roofing.

Enquiries have revealed that three different compounds have been developed over the years for use as sealing washers. The Station does not have the expertise to identify the different types, but accepts that those failing in Darwin may well be of a different compound than those observed in North Queensland.



(a) Corroded (b) Sound

Figure 11 Lead headed roofing nails

3.2 Roofing Nails

In general the problem of metal corrosion was significantly less for galvanized roofing nails than it was for roofing screws. The few examples of corrosion of roofing nails related to the old lead head type, and they came from buildings that must have been about 50 years old.

Figure 11(a) shows some corroded nails while Figure 11(b) shows relatively sound ones of similar age. Further, with the current trend away from the use of roofing nails in favour of screws, the average age of the nails would have been greater than that of the screws.

The perennial problem of nail popping was observed. Some nails at lap joints were as much as 15 mm proud of the roofing. In other cases nails had become so loose that they could be withdrawn by hand. This was usually associated with a very local rotting of the timber batten around the nail hole while the rest of it was still relatively sound. Possibly the same moisture conditions that were causing the screw shanks to corrode

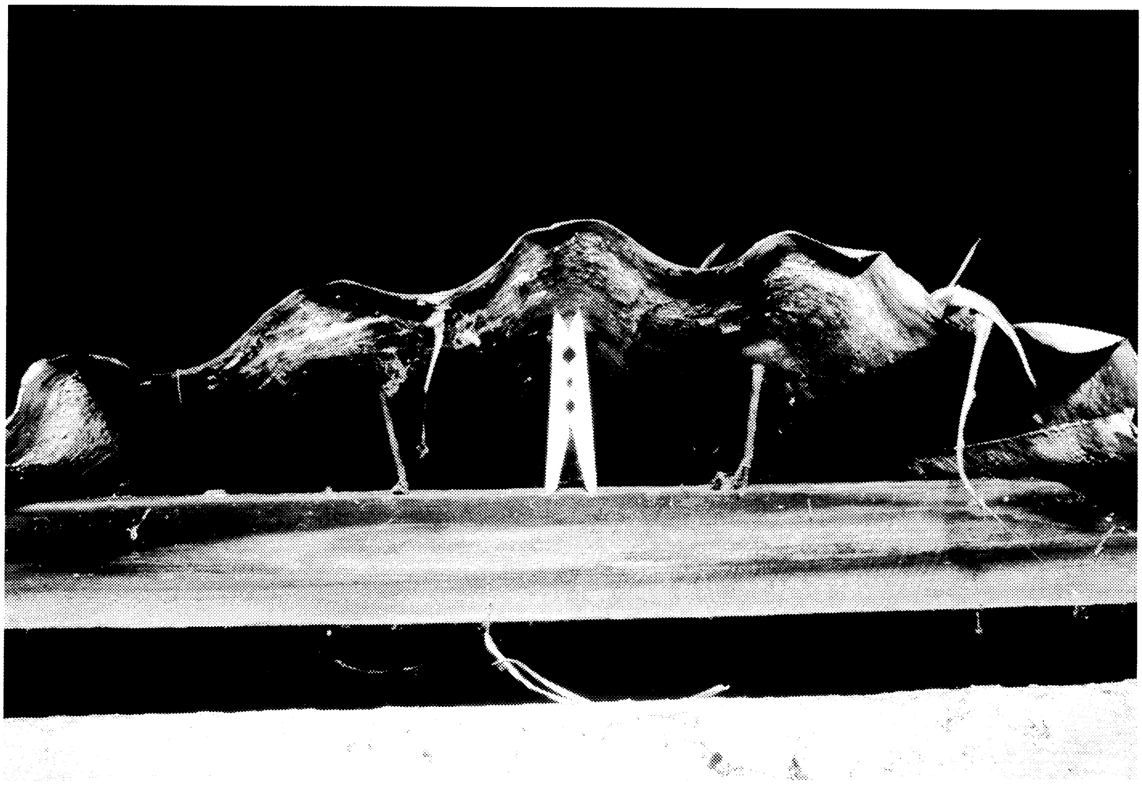


Figure 12 Roof of old shed showing loose nails

were causing this rot by having moisture run down the shank of the nail onto the timber. Figure 12 shows the roof of an old shed in Townsville where the nails, although hardly corroded, had totally lost their grip on the timber. Although this is quite a different problem from the corrosion of a fastener, it can leave a roof in an equally weakened state and susceptible to wind damage.

This comparative lack of corrosion of the galvanized nails must lead to the questioning of the effectiveness of the protective coating on the screws.

3.3 Cladding and Accessories

In general both roof and wall cladding showed little deterioration due to corrosion, although there were some instances of rusting of roof sheeting at the edge of low slope roofs. It was interesting to note that even in the locations where the screws had corroded right through, the steel roofing was usually still in good condition.

There was an interesting observation on a group of 20 year old buildings with galvanized (as opposed to zinc/aluminium coated) steel roofing. While the galvanized wood screws were still sound, the roofing was gradually rusting, with an acceleration of corrosion on the windward end of the buildings. There was a marked contrast in colour on top of the sheets between areas which had ceilings and those which did not. Corrosion was far less developed on the unceiled areas.

A common location for the start of corrosion of the sheeting was at a lap joint. There were many displays of zinc oxide on the underside of the lap. As has already been reported for roofing screws, there was a definite trend of corrosion occurring more readily on the windward slope of the roof than on the leeward slope. However, in the context of the total number of buildings inspected, corrosion of cladding cannot be considered a serious problem.

The well known corrosive action of "high purity rainwater" flowing from zinc/aluminium coated roof sheeting into galvanized gutters was observed on a few occasions. Also some flashing had rusted in similar circumstances.

3.4 Structures

Although the survey tended to concentrate on corrosion of fasteners, a cursory inspection of the structure was usually made. There was generally little evidence of corrosion of structural components, although on two separate occasions, one in the Atherton Shire and the other in the Johnstone Shire, severe corrosion of light gauge galvanized steel purlins was noted. In each case the building was about eight years old and only one of approximately 150 purlins was affected. It was one in the line of purlins directly above the wall facing the direction of the prevailing wind, where the screws attaching the roofing to those particular purlins were severely corroded, but the roofing appeared in good condition. The other purlins in that area had only traces of oxidation whereas the two rusted ones had corroded to a critical level. Figure 13 shows severe corrosion of the top lip of a purlin in the Atherton building.

There was a small amount of rusting at the knee of a portal frame in one of the nine buildings mentioned in Section 3.1.2. The degree of corrosion was not considered structurally serious but again its location on the windward side of the building reinforces earlier concern.

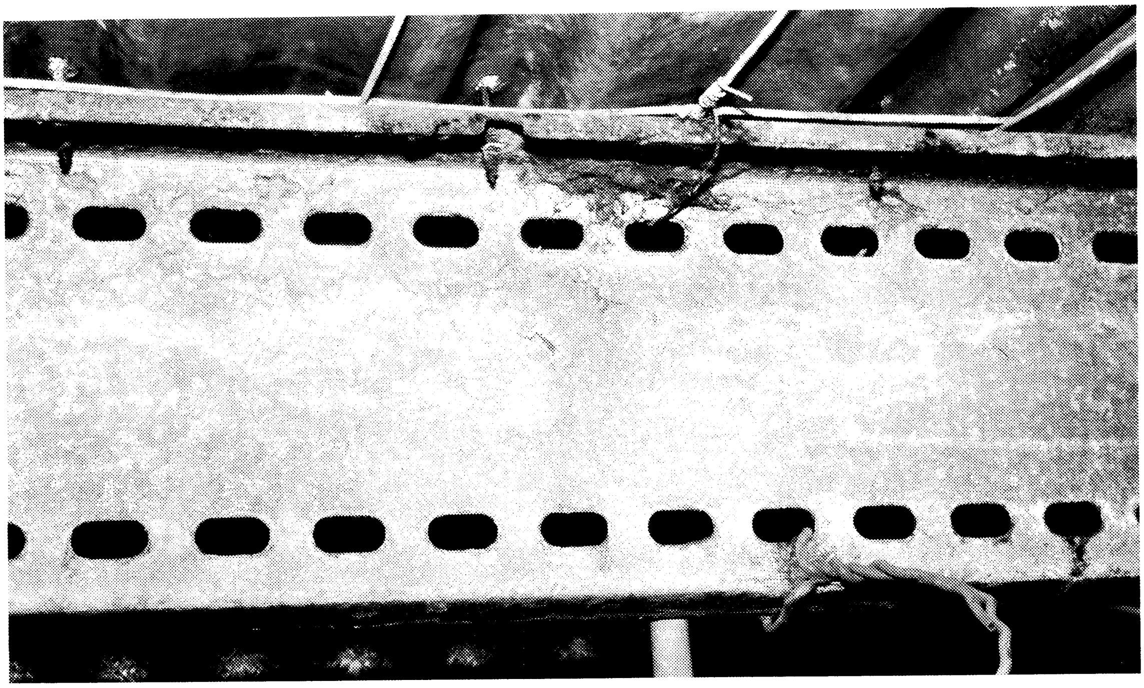


Figure 13 Corrosion of top lip of purlin

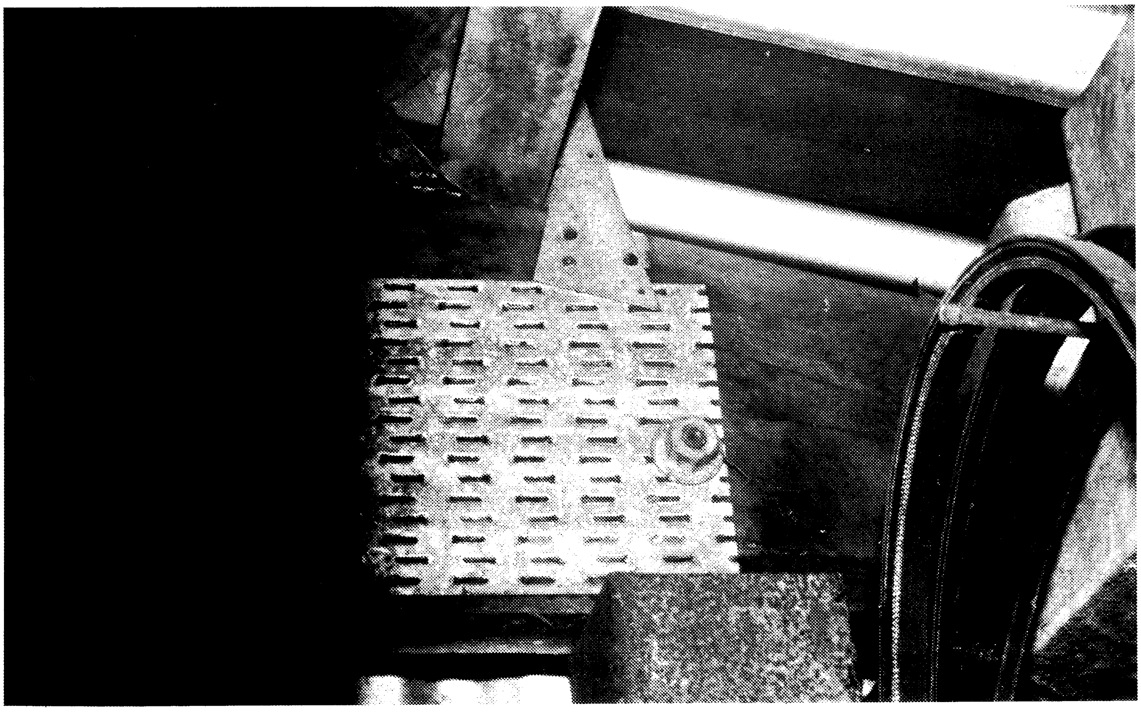


Figure 14 Toothed metal plate and framing anchor without corrosion

There appears to be no problems with corrosion of pressed nailing plates (Gang Nails and the like) used in truss construction. The plates exposed in unceiled buildings all appeared to be in good condition. There was no evidence of rusting at the cut edges of the metal where the teeth had been formed. Figure 14 shows a pressed metal plate in the heel of a truss in the building shown in Figure 2, where there was serious corrosion of the roofing screws in the purlin above the wall. Also shown in Figure 14 is a framing anchor with no evidence of corrosion.

Framing anchors (Trip-L-Grips etc) securing trusses to the structure also appeared to be in good condition. The only evidence of corrosion of a framing anchor was on the verandah of a beach hut about 8 years old. But that seaside location puts the example outside the guidelines of this investigation.

Detailed structural inspections were restricted to buildings. Bridges, towers, hoardings, fences and the like were not included in the survey. It is believed that the state electricity authority is monitoring the performance of its pylon structures in respect of corrosion, but it is not known whether the results will be made public.

4. CONCLUSIONS

Of the 350,000 screws that were observed in this survey of 194 buildings approximately 1,000 had ceased to function because of corrosion. As all of these badly corroded screws were less than 10 years old their performance in service is obviously unsatisfactory. Although only a very small percentage of the severely corroded screws were about three years old, the fact that any screws of that age were badly corroded is cause for serious concern.

The main concern about the severely corroded screws is not so much their total number, but that severe corrosion occurs to groups of screws in a highly loaded location on the building. When considering wind forces, roofing near the eaves is the most vulnerable part of a building. That roofing has to withstand the highest intensity of pressure trying to lift it from the structure. If the fixings securing that roofing to the structure have severely deteriorated, the roofing could blow off and be the instigation of major damage to the building and its contents. Further, the fact that condition of the head does not necessarily reflect the screw's integrity means that its effectiveness cannot readily be judged from above the roofing. This situation becomes worse where there is no access to inspect the shank of the screw.

As it is reasonable to expect that the yellow coloured screws that have been observed in this survey were coated in accordance with provisions of the relevant SAA code, AS 1791, those provisions need to be reviewed.

The following detailed conclusions can be drawn from this survey:

1. In buildings further than 1 km away from the sea, the component likely to corrode quickest is the roofing screw. Other metal components such as the cladding or parts of the structure corrode at a much slower rate.

2. Roofing and fastenings in the vicinity of the eaves on the side nearest the prevailing wind are more prone to corrosion than on the rest of the building. This indicates that the atmospheric conditions in such locations may be more severe than were considered when determining the industry standards for thickness of protective coating for screws.

3. Although the overall percentage of screws that were badly corroded is low, concern for the integrity of the building relates to the fact that corrosion occurs to groups of screws in a highly loaded part of the roof. There would be much less reason for concern if the corroded screws were randomly located over the roof surface.

4. The condition of the screw head is not a good indication of the condition of the shank, as there were a number of examples of screws with severely corroded shanks but relatively uncorroded heads.

5. Where the point and thread of the screw are visible below a purlin their condition does not necessarily reflect that of the shank above the purlin.

6. Corrosion is not restricted to imported screws or to screws from one particular manufacturer. This uniform performance is not unexpected if the screws are all manufactured to the same industry standards.

7. It appears that buildings without ceilings are more prone to corrosion than those with ceilings, although this could not be positively confirmed because of the limited number of ceiled buildings with access to view the fasteners.

8. Galvanized roofing nails corroded less than roofing screws.

9. Pressed nail plates and framing anchors generally showed little signs of corrosion.

10. With the exception of two light gauge metal purlins, structural members showed hardly any signs of corrosion.

11. It is unlikely that the results of this survey are unique to North Queensland. It is believed that climatic conditions in the region surveyed would occur at many other locations in Australia.

5. RECOMMENDATIONS

The Cyclone Testing Station does not have the appropriately qualified staff to continue this research into its second phase, that is, to determine why some roofing screws were found to be badly corroded after a relatively short period in service. It is anticipated that the National Building Technology Centre, the Station's partner in the project, will be able to continue with the metallurgical research now required to complete the total investigation. The following recommendations for continuing research are therefore made:

(a) Further investigations are needed to determine whether this problem is confined to the North Queensland or if it is a more widespread.

(b) The anticipated life of roofing screws should be established and compared with the life expectancy of other building components.

(c) The basic questions relating to the appropriate thickness and type of protective coating must be investigated. Possibly the parameters used for acceptance of a particular coating also need reviewing.

(d) More attention should be given to investigating buildings with ceilings as they were not well covered by this survey.

6. ACKNOWLEDGEMENTS

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It is also very grateful to those local government authorities in Queensland who co-operated in the survey, and in particular the Shires of Atherton and Innisfail. Co-operation from local representatives of roofing screw manufacturers is also acknowledged.

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