

Residential roof trusses: The financial implications – a case study

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Abstract

A review of the failure modes of nail plate timber trusses, the signs, the causes, the outcomes, a case study of the repair options, the repair works undertaken and their costs, some reflections on the failure and the repairs, the possible scale of the problem and the responsibilities of the professions and the industry for community safety.

Introduction

The problems associated with trussed roofs and the separation of nail plates from timber truss members (“Mechano-sorptive creep effect” or “nail plate delamination”) were first documented in about 2002, through studies undertaken by Mr John Goldfinch of FMG Consulting in Adelaide, South Australia. These studies resulted in the State Government department responsible for building, Planning SA, undertaking enquiries and issuing reports and warnings (Advisory Notice Building: Professional practice: Roof trusses- buildings at risk, December 2006; numbers 17/06 and 18/06 ex website (www.planning.sa.gov.au)) These buildings at risk were identified as follows -

“...Buildings having the following characteristics have been identified as being particularly vulnerable -

- Buildings constructed in the range 1970 – 1997; and*
- Roof framing consists of prefabricated timber trusses, and*
- Clear span buildings over large open public spaces such as community halls, libraries, churches, club/restaurant/hotel dining rooms, and*
- The roof covering is tiles.”*

This paper describes a case study of a domestic trussed roof that lay within the criteria above that failed and was repaired. The building was constructed in about 1972, is approximately 180 square metres in area, and is one of a pair of “Torrens Title (d) duplex” units. It has double brick walls with a tiled roof supported by timber nail plated trusses spanning about nine (9) metres. It has three bedrooms, two

bathrooms, a lounge, dining area, family room and two bathrooms. The building belongs to the writer and his wife.

This paper is in five parts, as follows, with appropriate reference being made to the case study.

Part one - A review of the signs, causes, and possible outcomes from the failure of trussed roofs

Part two - The options of roof replacement and/or repair

Part three - The repair option chosen, the precautions, the work done, the direct and indirect costs and other outcomes

Part four - Reflections on the failure and the repair

Part five - The potential future scale of the problem and the responsibilities of the professions and the industry for community safety

Content

Part one - A review of the signs, causes, and possible outcomes from the failure of trussed roofs

Signs: The external signs of a potential problem include excessive roof distortions, ceiling deflections, ceiling cracking, movement between ceilings, cornices and walls and nail head protrusions.

Causes: The fundamental causes include aspects of roof and truss design, nail plate design, the quality of the trusses and other components "as built", construction technology, including the presence, or otherwise, of sarking and associated site works including framing, anchorage and bracing and the effects of climate.

Outcomes: These range from minimal damage, to major component distortions and deflections to collapse.

General illustrations covering signs, causes and outcomes are available from the website www.prtfab.com.au and from the files of PRT Fabrication and Consulting P/L.

Case study: The building in 2007 showed no or minimal internal signs of distress, however, there were some distortions in the roof cladding profile. These distortions were not easily visible from the ground but, once observed, could be considered as being consistent with the movement expected in a thirty year old tiled roof. The roof had been inspected prior to purchase, in 1994, again in about 1998, where some construction irregularities were observed, but were not considered to be of concern. The roof was inspected again, (indirectly) in 2002 and 2004, when new building services were installed, however no irregularities were reported to the owners. The state of the roof was uncovered in March 2007, when an exposed timber beam deflected excessively, owing to a 40 mm diameter knot being close to the tensile

face of the beam. The owners had the area propped and in May 2007, commissioned a contractor to repair the beam.

The contractor removed some of the ceiling sheeting and found warped trusses and significant discontinuity(ies) between truss web and chord members. The contractor immediately further propped the area, drew the owner's attention to the situation and sought advice from an engineering consultant. The consultant warned the owners formally and recommended that rectification work be put in hand "without delay". The owners accepted the recommendations and rectification plans were prepared in June 2007.

During discussions the -

- consultant commented that the roof was potentially dangerous and "it could collapse soon or it could last a further fifteen years, no one can tell"; and
- contractor commented that repair work should, ideally, be done in the "spring", a period of minimal weather risk(s).

Insurance and legal advice was sought and the advice was that the circumstances were outside the current insurance policy conditions thus all costs would be at the owner's expense.

Part two - The options of roof replacement and or repair.

All trusses and joints were inspected and have to comply with AS 4440. The repair of this type of framing usually entails the re-plating with plywood, adhesive and screws of all truss connections affected plus the rectification of any other consequential damage. Replating involves the application of gusset plates to joints that are seriously affected and/or the re-screwing or replacement of other existing nail plates.

Case study: The consultant considered several options including the repair or replacement of the existing roof framing and the reuse or the replacement of the existing roof cladding. A design and specification for the work was prepared and estimates of the cost exceeded \$50,000.

Part three - The repair option chosen, the precautions, the work done the direct and indirect costs and other outcomes.

Case study: The option chosen for the repair involved the removal of the existing roof tiles, the realignment of the existing trusses, the re-plating / repair of affected truss joints, installation of further bracing, sarking and the reuse of the existing roof tiles. The design was completed in June 2007, but owing to weather risks, it was agreed that all works would be deferred until late August 2007. However, in the interim, it was recommended that the building be secured appropriately, all furniture from the 'long span' areas be removed and the roof be further propped from inside the building. These actions were undertaken, with the furniture being stored offsite.

Later, in early August 2007, further advice on the work was pursued and a design, specification and contract for the work were developed. The engineering design and some supervision was undertaken by FMG Consulting of Kent Town, South Australia. The construction was undertaken by PRT Fabrication and Consulting P/L of One Tree Hill, South Australia.

The final plans and scope of the work covered the following activities –

Scope of work:

- *Remove roof tiles for access*
- *Straighten and plumb all trusses as required*
- *Press and plywood plate all critical truss joints as per Koukourou Engineers standard repair schedule*
- *Screw all non-critical joints as per Koukourou Engineers standard repair schedule*
- *Add additional webs to cantilever trusses on the front of the carport*
- *Lift and pack between girder truss and lintel to lift back to original height*
- *Correctly brace all trusses as per code (AS 4440)*
- *Replace existing roof tiles and re point ridge caps*
- *Replace timber pitching beam on front of carport as per Koukourou Engineers calculations*
- *Replace timber posts to realign roof in carport*
- *Seal firewall between units as per building code requirements*
- *Remove all rubbish*
- *Replace linings in carport area removed previously*
- *All roof works to be carried out in accordance with AS 4440”*

In addition the scope was extended to include for sarking over the roof area.

The contract price and time was agreed and work started late in September 2007 and was completed late in October, 2007.

The internal propping was removed and the furniture was returned from storage. The work was completed to time, cost and quality, with little or no consequential damage to ceilings or other fittings from the works, or from the weather.

The all up cost, including all inspection and design fees, preliminary works such as the propping of the building during the period from May to October 2007, the sealing of the building during this time, the contract for repair and rectification work, the furniture handling and the interior propping, was about \$35,000.

Part four - Reflections on the failure and the repair.

Case study: The exercise has been a learning experience. The writer has had a lifetime's professional experience in the industry, however, the exercise generated

considerable anguish involving personal, professional and financial issues. The personal issues concerned the safety of the family and visitors; knowledge that the roof was potentially dangerous and that an accident could occur, at any time, was “simply untenable”.

The professional issues concerned the self questioning of personal competence: e.g.” How could an experienced professional allow the situation to occur ***under their own roof?*** “

The financial issues too were of concern, as the works had to be ‘self funded’. Now, it is worth remembering that in the case described -

- there was little or no external, visible evidence of the roof failure,
- the failure was uncovered through an unrelated matter and was discovered “by accident”, which, had it not occurred,
- the failure mechanism would have progressed, ending in partial or total collapse, which
- would have resulted in major, uninsured, property damage, and worse, may
- have resulted in the injury or death of some of the building occupants.

Now these and other aspects were canvassed amongst professional colleagues, most of who had never heard of roof trusses delaminating, and the dangerous situations that may follow. However, there were some “building control” colleagues who knew of the situation and the associated circumstances.

In the writers view, the major lessons are that the problems of trusses delaminating are -

- a real and an expanding issue, with potentially dangerous outcomes,
- not well known amongst general practising professionals,
- not well known amongst the property owners and general community, however, given the warnings from Planning SA,
- relatively well known amongst those professionals associated with building control.

Part five - The potential scale of the problem and the responsibilities of the professions and the industry for community safety.

The potential scale of the problem: The numbers of buildings that may be affected by the de-laminating of roof truss plates is unknown, however, the website of the contractor PRT Fabrication and Consulting P/L, www.prtfab.com.au, in describing a survey of units for a major client, comments as follows

“.....In 2003 PRT were commissioned to carry out random inspections of 140 units out of the total 1300 units owned by our client. The survey encompassed four states, 13 different sites, trusses from various fabricators and suppliers in

all types of climates and built over a period of the past 15 years using a range of softwoods and hardwood.

The results of the survey were staggering. Only 10% of roofs inspected had no plate movement less than the engineer's allowable tolerances.

Metal truss plates have teeth on average between 10 and 13 mm in length. During the survey some plates had the full length of the teeth exposed out of the timber and as a result some buildings were closed for further use. Several trusses had failed due to members that had slipped causing the roof to deflect with the ceilings and roofline verging on total collapse....."

Now, it is arguably "drawing a long bow", but if, say 10% of the buildings that were out of tolerance would eventually require significant repairs, then this would involve some 117 buildings ($1300 \times 0.9 \times 0.1$). Further, if, say, 5 % of all these buildings would require extensive replating and realignment, then this would be 5.85 buildings i.e. about six projects that may face catastrophic collapse.

If Australia, over the years 1984/5 to 1992/3, averaged some 140,000 residential buildings per year, and in South Australia, the figure would have been about 13,000 units per annum, suppose that, say, 20% of those projects lie within the criteria described for buildings at risk, and 10% of those identified required major repairs, then there would be some 250 plus projects involved. Further if 5 % of the 20% faced collapse then there would be some 15 projects involved, **annually**, which, over thirty years equates to approximately 450 projects.

Now, these numbers were discussed with PRT Fabrication and Consulting P/L, (Mr Nigel Benson), who commented that "*The numbers of buildings quoted, above, grossly underestimates those affected; the actual number of units they have repaired would run into **the hundreds per year***" (Quote, N. Benson, 10.01.08: emphasis in heavy type by writer).

These numbers of projects are substantial and surely warrant further study, at least, to determine the scale of the problems the community faces.

The responsibilities of the professions and the industry for community safety: Issues described in this paper raise many ethical and technical questions and concerns over public safety.

For example, the Planning SA Advisory Notice 18/06 states (in part)
"*.....Councils need to be aware of the situation and have processes in place for responding to community concerns.*

*Buildings at risk******

Buildings having the following characteristics have been identified as being particularly vulnerable:

- *Buildings constructed in the range 1970 – 1997, (and where)*
- *The covering is roof tiles. ******

Where there are buildings in a council area that are known to have all of these characteristics then there is sufficient reason to believe that there may be a risk to public safety and it is recommended that an inspection be undertaken of the roof framing.....Where buildings have ...any signs...of movement will still warrant closer examination of the roof framing but this should be arranged by the building owner. It is suggested that councils include in their inspection policies a section that deals with this matter and covers the following points:

- *The identification and prioritisation of buildings potentially at significant risk.....*
- *A program for inspecting high risk buildings in a convenient but timely manner.....*

In addition councils should consider providing advice to high risk building owners so that they are able to take proactive steps to safeguard their properties

*******Note:** PRT Fabrication and Consulting P/L, (Mr Nigel Benson), comments that

"The problems are not restricted to buildings, alone, as carports and under roof garages are also vulnerable, further, the problems are only not restricted to tiled roofs and severe problems have occurred to steel clad roofs" (Quote, N. Benson, 10.01.08)

In relation to the Planning SA Advisory Notice, above, a web search of several metropolitan council websites showed no apparent entries of such warnings under the "Building /community safety / Buildings at risk" headings. Further, a cursory examination was undertaken of the websites of the professional institutions' involved with "Building and building quality", and, again there are no apparent warnings to property owners.

No criticism is intended in these remarks. A web search hardly covers all of a council's and or professional institutions activities in the area. Further, in the circumstances described in the case study, a member of the community would have no reason to visit the websites mentioned. However, in the event of there being a catastrophic failure with property damage, injury and or loss of life it is possible that legal redress may be available to property owners / purchasers through the failure to warn of the hazards from buildings identified as being "at risk".

It is interesting to note, that, in other

- circumstances, such as bushfire(s), public health and the like, there is ample community advice available, and when a major incident occurs, there are normally several government and other inquiries, and

- industries, such as vehicle and food and drug manufacturing, the manufacturers, themselves, usually issue public notices, contact owners, recall and fix products, usually at no expense to the owners.

Concluding comments

This paper describes a case study concerning the identification and repair of a faulty nail plated trussed roof in a domestic building. The paper covers -

- a review of the signs, causes, possible outcomes from the failure of trussed roofs
- the options of roof replacement and or repair.
- the repair option chosen, the precautions, the work done, the direct and indirect costs and other outcomes
- reflections on the failure and the repair, and
- the potential scale of the problem and the responsibilities of the professions and the industry for community safety.

The paper concludes that the problem of truss nail plates delaminating, is -

- a real, and an expanding issue, with potentially dangerous outcomes,
- not well known amongst general practising industry professionals, and thus it is likely
- not well known amongst property owners and the community at large, however, given the warnings from Planning SA and to Councils and the like,
- relatively well known amongst those professionals associated with building control.

Recommendations

The writer recommends that

- a study be undertaken of a representative sample of "Buildings at risk", in South Australia, to determine the scale of the problem, and, if it is as severe as it seems,
- to develop a widespread industrial and public awareness campaign, to alert all members of the industry and property owners, sellers and buyers of the potential dangers of such buildings, and the technologies that may be used for their repair

References

The websites and records of

- FMG Consulting (and Koukourou Engineers)
- PRT Fabrication and Consulting P/L, and
- Planning SA, particularly their Advisory Notes 17/06 and 18/06, and other publications relating to "Buildings at risk"

Australian Institute of Building Surveyors (SA Chapter)
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The Australian Bureau of Statistics publication 1350.0 Australian Economic
Indicators, January 1994