JAMES COOK CYCLONE STRUCTURAL TESTING STATION

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THE STRENGTH OF

BATTEN – TO – RAFTER JOINTS

Part 2

RECOMMENDATIONS FOR HIGH WIND AREAS

TECHNICAL REPORT NO. 3

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AN INVESTIGATION INTO THE STRENGTH OF VARIOUS BATTEN-TO-RAFTER JOINTS

Part 2

Recommendations for High Wind Areas

by

G.F. Reardon

INTRODUCTION

A description of a series of tests of batten-to-rafter connections undertaken by the Cyclone Testing Station has been included in another report (Ref. 1). That report, Part 1, also states the reasons for conducting the tests, the main one being that improved techniques of attaching roofing material to battens will result in greater loads being transferred during a wind storm to the fasteners attaching battens to rafters. Although improved methods of fastening this joint have been introduced there is often a paucity of technical data relating to the strength of such fasteners. Part 1 also illustrates the severe loss in holding power of nails in some timbers as the timber dries out.

The intent of this second part is to provide for builders, building inspectors and others a set of simple recommendations on the choice of fasteners suitable for a given set of parameters such as expected wind speed, roofing material etc. Not at all the types of fastener tested in Part 1 have been listed individually in this part, for example although helically grooved nails and annularly grooved nails were tested separately recommendations are made in this document simply for grooved nails.

TYPES OF FASTENER.

Table 1 lists the types of fastener tested and their recommended holding power to resist wind forces. The exclusion of any common fastener type from Table 1 does not mean that its use is not recommended, but merely means that it was not included in the series of tests. A good reason for that would be that sufficient technical data is already

available on the likely performance of the fastener.

For convenience each type of fastener has been given a symbol which is used in the tables presented later in this document. It is stressed that recommendations are made for a fastener unit which usually consists of a number of elements and if all of the elements are not provided in the joint the recommendations cannot apply. For example six nails are specified to be used in conjunction with the steel strap to form joints D and F. While it is acknowledged that a structural joint can be fabricated using four nails only, such a joint would not be strong enough to be used as recommended in this document.

The recommendations are made for hardwood battens attached to medium density hardwood rafters. They do not apply for construction using softwood. Also the recommendations for joints A, B and C are based on the use of a nominally 38mm batten. If thicker battens are used the length of fastener must be increased to compensate for the extra thickness. A penetration length of approximately 37mm is required for the fasteners to perform effectively.

WIND SPEEDS AND ENGINEERING DATA

Three categories have been chosen as being able to cover nearly all combinations of basic wind speed and exposure conditions. In accordance with the currently accepted convention these categories are referred to as W33, W42 and W60.

W33 conditions apply to houses located in sheltered situations such as the suburbs of any major city in Australia, excluding those in cyclone-prone areas.

W42 conditions apply to houses located in sheltered situations in cyclone-prone areas or to houses in poorly sheltered situations in other areas.

W60 conditions apply to houses in poorly sheltered situations in cyclone-prone areas.

When assessing the degree of shelter provided for a house, consideration must be given to the fact that the wind can approach from any angle. Thus

houses bordering onto large open parklands should be considered as poorly sheltered, even though they may be in an otherwise suburban location.

The engineering calculations to establish the recommendations made in Tables 2 to 6 have been performed in accordance with the SAA Wind Loading Code, (Ref. 2). A pressure coefficient of 1.7, allowing for 0.9 uplift on the roof surface and 0.8 internal pressure, has been used in calculations for each table "(a)". For Tables "(b)" which recommend increased hold-down at the eaves the uplift value has been increased to 1.8 resulting in an overall pressure coefficient of 2.6. Although this approach may appear slightly conservative, it is based on recent wind tunnel tests (Ref. 3) which show that for cladding loads the Code recommendations are unconservative in the area of the eaves of a house.

A mass of 7 kg per square metre was assumed for sheet roofing and 58 kg per square metre for tiles.

RECOMMENDED USE OF FASTENERS

Tables 2(a), 3(a) and 4(a) recommend types of fastener sutiable for batten-to-rafter joints over most of the roof area of houses in category W33, W42 and W60 respectively. Tables 2(b) 3(b) and 4(b) recommend fasteners that would be suitable for joints within 900 mm of the fascia or gable. For most types of roof sheeting only two rows of battens need the stronger joints recommended in tables (b), and for tiled roofs three rows of battens need the stronger fixing.

The symbols in the tables relate to those given in Table 1. They are arranged in ascending order of strength, and as such may be substituted for each other. That is a fastener type "C" could be used instead of a type "B", but it could not replace a type "D".

It should be noted that the research program used to produce these recommendations was concerned with the effects of high winds on the joints. Thus joint Type A, 2-75 mm plain nails, which is the weakest joint recommended in the tables is more than adequate to resist winds of intensity W33 for many situations. Recommendations are made therefore for the use of 1-75mm plain nail in such circumstances. Similarly one grooved nail may often be suitable instead of the recommended two plain nails of joint type A.

COST OF MAKING JOINTS

The information given in the tables is based on adequacy of strength no other parameters are taken into account. However there are many instances when any of a number of different fasteners will adequately secure the battens to the rafters. In such circumstances the obvious factor influencing a choice of fastener is cost. Therefore an attempt has been made to obtain the cost of fabricating the recommended joints, and the results are given in Table 7. These costs should be taken as an indication only, as they will vary from location to location and from builder to builder. There was a considerable amount of difficulty encountered in obtaining the costs, as very few builders can provide such information in detail. Also, the costs given in Table 7 were obtained from three different sources and it is probable that costing techniques vary between the sources.

A further aspect involving cost that must be considered is the weakening effect on the rafters of any of the types of fastener. Bolts are the only fasteners recommended that would constitute a weakening of the rafters from the necessity of drilling holes to accommodate them. Thus in some instances where bolts are recommended over the bulk of the roof area, it may be more economical to use a more expensive fastener rather than to increase the width of all the rafters to compensate for bolt holes.

CONCLUSION.

This investigation has provided builders, building surveyors and others with a set of recommendations on the efficient use of fasteners to connect roofing battens to rafters. If, for the purposes of this exercise, efficiency can be defined as the amount of holding power per unit of cost, the power driven screw must be classified as the most efficient, followed by the bolt, grooved nails, bent metal straps, and plain nails the least efficient. However, as each fastener type is rated at a different strength value, there is a use for each one of them, and although the mechanized methods of driving fasteners are proving more efficient the simplicity and reliability of the hammer must still be acknowledged.

REFERENCES.

1. REARDON, G.F. (1979) "The Strength of Batten-to-Rafter Joints Part 1. Test Results and Derivation of Design Loads." Cyclone Testing Station, Technical Report No. 2.

2. STANDARDS ASSOCIATION OF AUSTRALIA. "S.A.A. Loading Code, Part 2 Wind Forces" AS1170 Part 2, 1975.

3. HOLMES, J.D. and MUNARIN, J.L. "Wind Loads on Logan Unit: Belvedere", James Cook University Wind Engineering Report 1/79.

TABLE 1

Recommended fasteners and design loads for wind

Fastener symbol	Type of Fastener	Design Load (kN)
A	2 - 75mm plain shank nails	0.56
B	2 - 75mm grooved nails	0.90
C	1 - 75 x 4.88mm dia (NO. 10) power driven screw	1.9*
D	30 x 1mm steel strap with six 30 x 2.8 nails (as in Fig 1)	3.7
E	10mm dia bolt	6.7$^{\phi}$
F	30 x 1mm steel strap with six 30 x 2.8 nails (as in Fig. 2)	7.2

* May be increased by 75% for joint group J1 timbers

ϕ May be increased by 50% for joint group J1 timbers

TABLE 2(a)

Fasteners needed to secure battens to rafters
over bulk of roof area

Wind Intensity W33
(sheltered locations in suburbs - non-cyclone)

Batten spacing	Roofing type	Fasteners$^{\phi}$ required for rafter spacing of			
		450	600	900	1200
330	tile	A*	A*	A*	A*
370	sheet	A*	A*	A*	A
450	sheet	A*	A*	A	A
600	sheet	A*	A	A	B
900	sheet	A	A	B	C
1200	sheet	A	B	C	C

ϕ See Table 1 for fastener symbols

* 1 - 75mm nail is sufficient

TABLE 2(b)

Fasteners needed to secure battens to rafters
within 1200 of edges of roof

Wind Intensity W33
(sheltered locations in suburbs - non-cyclone)

Batten spacing	Roofing type	Fasteners$^{\phi}$ required for rafters spacing of			
		450	600	900	1200
330	tile	A*	A*	A*	A
370	sheet	A*	A	A	B
450	sheet	A	A	B	B
600	sheet	A	A	B	C
900	sheet	B	B	C	C
1200	sheet	B	C	C	D

ϕ See Table 1 for fastener symbols

* 1 - 75mm nail is sufficient

TABLE 3(a)

Fasteners needed to secure battens to rafters
over bulk of roof area

Wind Intensity W42
(sheltered locations in cyclone areas,
poorly sheltered locations elsewhere)

Batten spacing	Roofing type	Fasterners$^{\phi}$ required for rafter spacing of			
		450	600	900	1200
330	tile	A	A	A	A
370	sheet	A	A	B	B
450	sheet	A	A	B	C
600	sheet	A	B	C	C
900	sheet	B	C	C	C
1200	sheet	C	C	C	D

ϕ See Table 1 for fastener symbols

TABLE 3(b)

Fasteners needed to secure battens to rafters
within 1200 of edges of roof

Wind Intensity W42
(sheltered locations in cyclone areas,
poorly sheltered locations elsewhere)

Batten spacing	Roofing type	Fasteners$^{\phi}$ required for rafter spacing of			
		450	600	900	1200
330	tile	A	A	A	B
370	sheet	A	A	B	C
450	sheet	A	B	C	C
600	sheet	B	C	C	C
900	sheet	C	C	D	D
1200	sheet	C	C	D	E

ϕ See Table 1 for fastener symbols

TABLE 4(a)

Fasteners needed to secure battens to rafters over bulk of roof area

Wind Intensity W60

(poorly sheltered locations in cyclone areas)

Batten spacing	Roofing type	Fasteners$^{\phi}$ required for rafter spacing for			
		450	600	900	1200
330	tile	A	B	B	C
370	sheet	B	B	C	C
450	sheet	B	C	C	C
600	sheet	C	C	C	D
900	sheet	C	C	D	E
1200	sheet	C	D	E	E

ϕ See Table 1 for fastener symbols

TABLE 4(b)

Fasteners needed to secure battens to rafters
within 1200 of edges of roof

Wind Intensity W60
(poorly sheltered locations in cyclone areas)

Batten spacing	Roofing type	Fasteners$^{\phi}$ required for rafter spacing for			
		450	600	900	1200
330	tile	B	B	C	C
370	sheet	B	C	C	D
450	sheet	C	C	D	D
600	sheet	C	C	D	E
900	sheet	D	D	E	E
1200	sheet	D	E	E	- *

ϕ See Table 1 for fastener symbol

* None of the fasteners are suitable using medium density rafters. If rafters are of high density timber, use fastener 'E'.

TABLE 5

Maximum area (m^2) of tiled roof that can be secured by each fastener type

Fastener Symbol	Maximum roof area (m^2) for wind intensity of		
	W33	W42	W60
A	1.12	0.47	0.18
B	1.80	0.75	0.29
C	3.80	1.58	0.62
D	7.4	3.08	1.21
E	13.4	5.58	2.2
F	14.4	6.0	2.3

TABLE 6

Maximum area (m^2) of sheet roof that can be secured by each fastener type

Fastener Symbol	Maximum roof area (m^2) for wind intensity of		
	W33	W42	W60
A	0.54	0.32	0.16
B	0.86	0.52	0.25
C	1.82	1.10	0.53
D	3.56	2.14	1.03
E	6.44	3.87	1.86
F	6.92	4.16	2.0

TABLE 7

Comparative costs of the fasteners recommended

Fastener Symbol	Comparative cost ($)
A	.18
B	.10
C	.21
D	.70
E	.67
F	.80

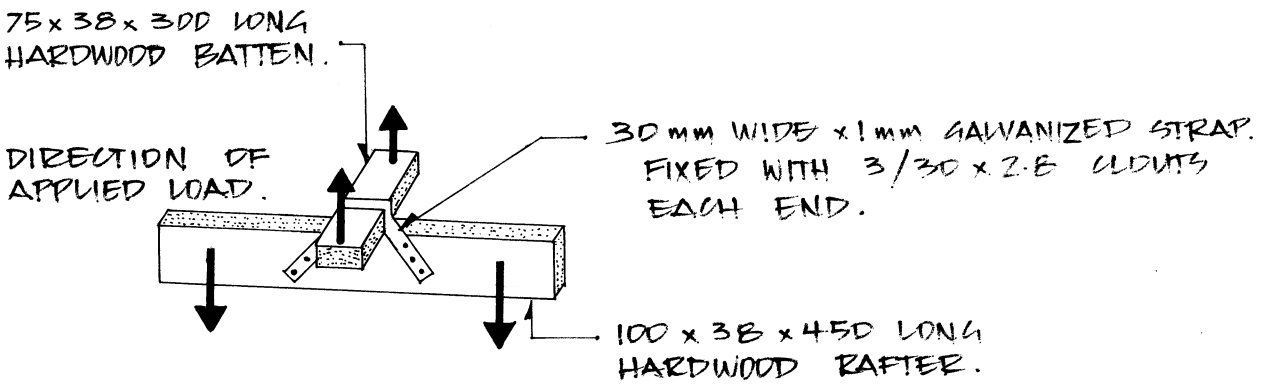

Figure 1.

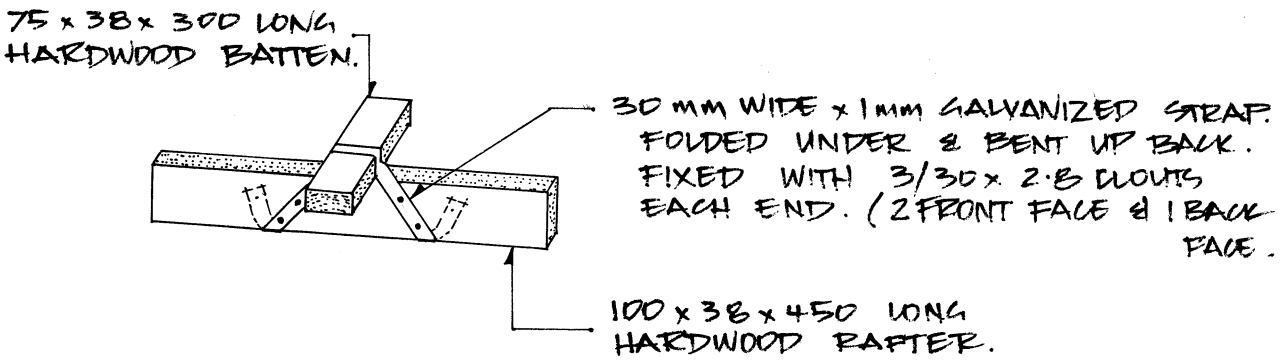

Figure 2.