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①

9.6 x 3.7 PORTALODGE GRANNY FLAT
UNIT FOR MR M. MELLIELIEU

87005/10/14

LOADS — ROOF — DEAD Panels 0.15 kPa
LIVE 0.25 kPa
0.40 kPa

POINT LIVE LOAD = 1.0 kN

not filmed - Retain in archives

FLOOR — Dead — 20mm Part Bd 0.12 kPa
Floor joists 200x50 @ 600c/c 0.10 kPa
Nogs etc 0.03 kPa
0.25 kPa
LIVE (RESIDENTIAL) 1.50 kPa
1.75 kPa.

WIND (MED WIND GOVERNS)
DESIGN FOR CITY SITUATIONS
IN HIGH WIND AREAS
ALL SITUATIONS IN MEDIUM
AND LOW WIND AREAS
HIGH $V_s = 0.64 \times 50 = 32$ m/sec or $0.6 \times 50 = 30$ m/sec
MEDIUM $V_s = 0.83 \times 40 = 33.2$ m/sec or $0.78 \times 40 = 31.2$ m/sec

$V_{50} = 40$ m/sec take GR 1 Class B, H=3
$\Rightarrow S_2 = 0.78$

$V_s = 0.78 \times 40 = 31.2$ m/sec

$q = 0.613 \times 31.2^2 = 0.60$ kPa

For Panel design use Class A ie. $S_2 = 0.83$
$V_s = 0.83 \times 40 = 33.2$ m/sec
$q = 0.613 \times 33.2^2 = 0.68$ kPa.

ROOF PANEL DESIGN — use Rudnev Design Data
— roof span = 1800mm

Dead + Live (per 1220 panel) = 0.4 kPa x 1.22 = 0.488 kN/m

$M_{max} = 0.488 \times \frac{1.8^2}{8} = 0.20$ kN-m

Dead + Point Live $w = 0.15$ kPa $\times 1.22 = 0.183$ kN/m

$M_{max} = 0.183 \times \frac{1.8^2}{8} + \frac{1 \times 1.8}{4} = 0.52$ kN-m

0.7 DEAD + WIND $\quad w = (0.7 \times 0.15 - \overset{G_{nett}}{1.2} \times 0.68) = -0.711 \text{ kPa} \times 1.22$

$= -0.86 \text{ kN/m}$

$\therefore M_{max} = -0.86 \times \frac{1.8^2}{8} = \underline{-0.35} \text{ kN-m}$

From Rudnev design sheet 6B - for 75mm ceiling panel

Max allowable Moment = $\underline{1.50}$ kN-m

+ deflection will be less than $\frac{\text{span}}{200}$ for all load cases

∴ **use** 75mm Roof Panel

WALL PANELS $\quad$ Max Span = 2500mm (spans floor to roof diaphragm)

for Wind load $\quad w = \overset{\phi}{1.1} \times 0.68 \text{ kPa} \times 1.22 = 0.91 \text{ kN/m}$

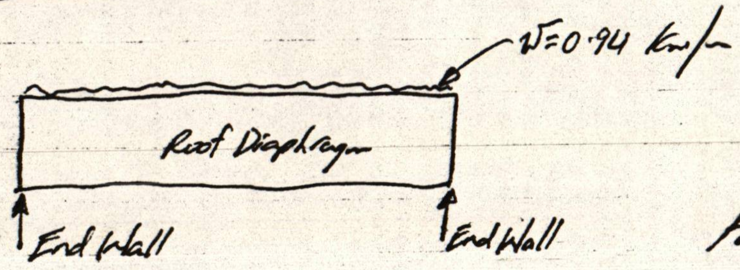
$M_{max} = 0.91 \times \frac{2.5^2}{8} = \underline{0.71} \text{ kN-m}$

from Rudnev Chart for 50mm panel

M_{max} allow = 1.05 kN-m $\quad$ ∴ OK here

use 50mm WALL PANEL

ROOF DIAPHRAGM



shear to roof diaphragm

$= \underset{G_{nett}}{1.3} \times 0.60 \text{ kPa} \times \frac{2.4}{2} = \underline{\underline{0.94 \text{ kN/m}}}$

For 9.6 m unit

End Wall Shear $= 0.94 \text{ kN/m} \times \frac{9.6}{2}$

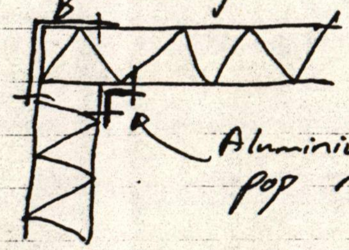
$= 4.5 \text{ kN}$

$= \frac{4.5}{3.6 \text{ m}}$

$= \underline{1.25} \text{ kN/m}$

NEED to Transfer this shear between panels and on to end shear walls.

End Wall Connection.



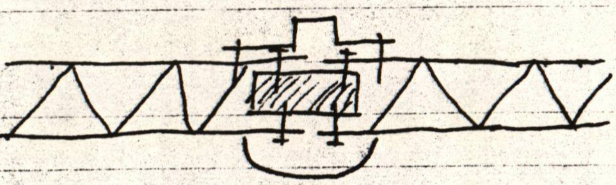
Pop rivets using 4.8mm ϕ rivets in single shear
min failing load = 2.02 kN
Using F.O.S = 3 against failure - allowable load = $\frac{2.02}{3}$
= 0.67 kN

$\therefore$ spacing reqd = $\frac{0.67}{1.25}$ = 0.54 m/rivet

per | **Use** 4.8mm ϕ rivets @ 200 c/c |

Panel/Panel Connection

- use Nails to Transfer shear
- nail size = 2.8mm ϕ x 32 long



Allowable Shear (into timber)
= 171 x 1.5 x 1.25
(1.5: wind; 1.25: metal side plates)

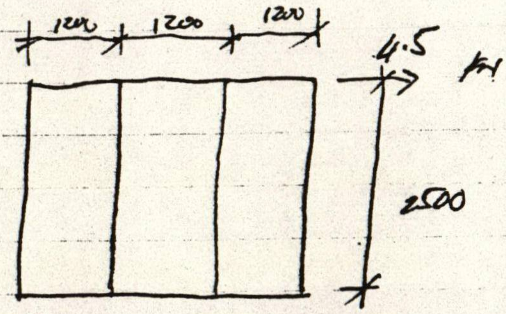
= 321 N

spacing reqd = $\frac{0.321}{1.25}$

= 0.26 m/nail.

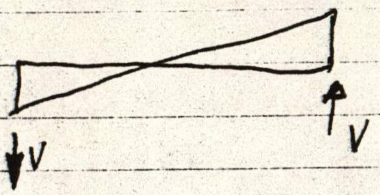
i.e. | **Use** 2.8mm ϕ nails x 32 long @ 150 c/c |

END WALL

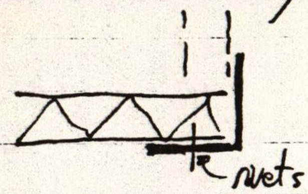


$V = 4.5 \times \frac{2.5}{3.6} = 3.1$ kN

$= \frac{3.1}{2.5} = 1.25$ kN/m



Transfer this to corner flashing



rivet spacing reqd $= \frac{0.67}{1.25} = 0.54$ m

i.e. **use rivets @ 200 c/c**

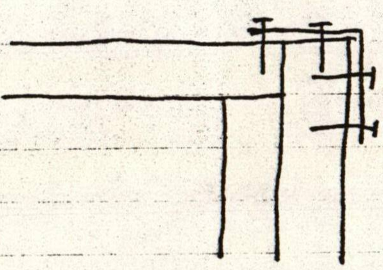
flashing stress $A = (75 + 75) \times 0.9$

$= 135$ mm^2

$f_a = \frac{3.1 \times 10^{-3}}{135 \times 10^{-6}} = 23$ MPa ∴ OK

Corner flashing Connection to Edge Member.

Load to be transfered = 3.1 kN



for 2.80 ϕ nails Basic Load = 171 N

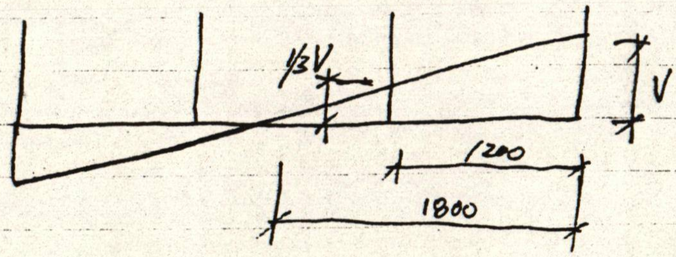
Permissible load $= 171 \times 1.25 \times 1.5 = 321$ N
(metal side plate ↑, Wind ↑)

∴ No. of Nails reqd $= \frac{3.1}{0.321}$

$= 9.7$

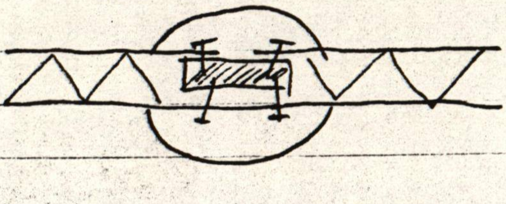
i.e. **Use 5 pairs 2.80ϕ Nails (10-nails Total)**

Check Shear Between End Wall Panels



from Above V = 3.1 kN

Shear @ Panel Joint
$= (1/3 \times 3.1 \times 1.2) + 1/2 \times 2/3 \times 3.1 \times 1.2)$
$= 2.48$ kN



Shear Transfer length = 2.6 − 1.6 = 1.0 m

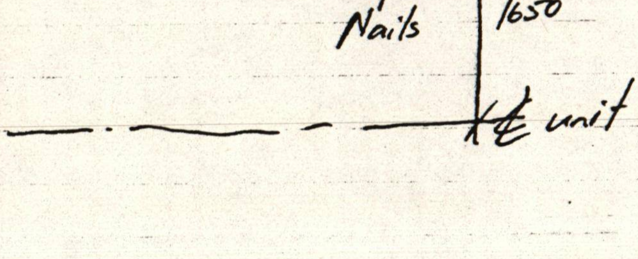
$\therefore$ Shear = $\frac{2.48}{1.0}$ = 2.48 kN/m

Again use nails into timber jointer to transfer shear
From above allow nail load for
2.80 ϕ x 32 long nails
= 321 N

$\therefore$ spacing required = $\frac{0.321}{2.48}$ = 0.129 m

$\therefore$ **use** 2.80 ϕ x 32 long Nails @ 100 c/c
ABOVE AND BELOW END WALL WINDOW

Now Nails to Edge Joist.



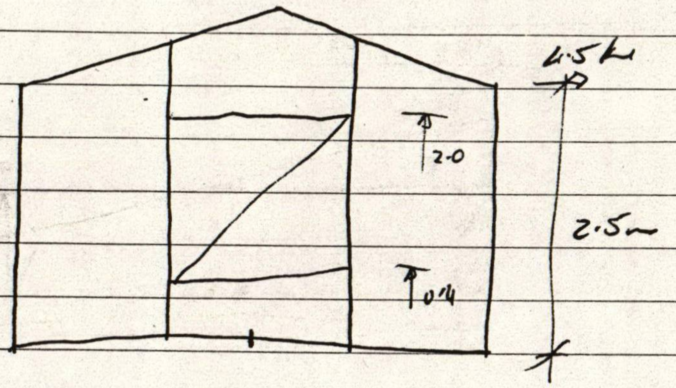
Max Load at Line of Nails = $\frac{4.5 \times 2.5}{1.65 \times 2}$
= 3.41 kN

for 3.55 ϕ Nails − basic load = 269 N
Permissible Load = 269 x 1.5
= 403.5 N

$\therefore$ No. of Nails reqd = $\frac{3.41}{403.5}$
= 8.4

i.e. **use** 10 − 3.55 ϕ x 90 long Nails

Look at Alternative End Wall fixing using cantilever panels with Base fixing.



$M = 4.5 \times 2.5$
$= 11\,250$ kN-mm

fixings @ 100 c/c $\quad \Sigma x^2 = (100^2 + 200^2 + 300^2 + 400^2 + \cdots\ 1800^2) \times 2$
$= 42\,180\,000$

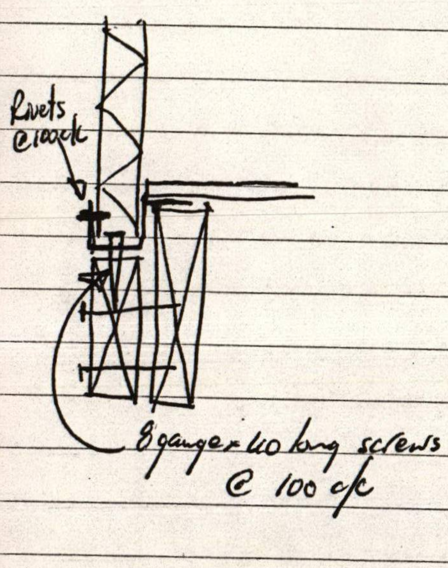
Max fixing load $= \dfrac{11250 \times 1800}{42\,180\,000} = 0.48$ kN

Direct Shear $= \dfrac{4.5 \text{ kN}}{36} = 0.125$ kN

Resultant $= \sqrt{0.48^2 + 0.125^2} = \underline{0.50 \text{ kN}}$

Rivets give 0.67 kN ∴ OK

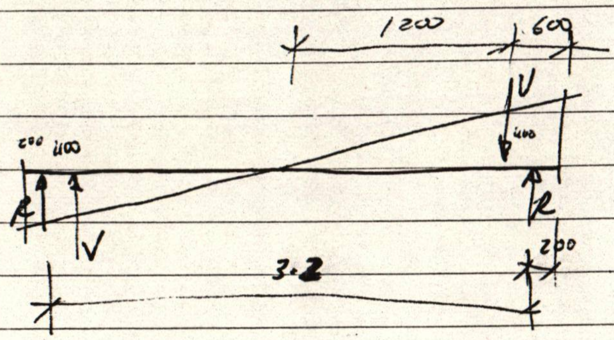
8 gauge × 40 long screw gives 35mm penetration.
Basic load = 15.6 N/mm $\quad k_1 = 1.5 \quad$ Green Timb = 0.8
Allow load = $15.6 \times 35 \times 1.5 \times 0.8$
$= 655$ N > 0.5 kN ∴ OK



Check panel bending at bottom of window
$M = 4.5 \times 2.1 = 9.45$ kNm
½ to 2 panels i.e. $M = 4.73$ kNm
1200 panel skin × 0.55mm $\quad Z = \dfrac{0.00055 \times 1.2^2}{6} = 132 \times 10^{-6}\ m^3$
(one Panel Skin only)

i.e. $f_b = 36$ MPa $\quad f_v = \dfrac{4.5 \times 0.5}{0.55 \times 10^{-3} \times 1.2} = 3.4$ MPa
Portapig Tests gave $f_b = 266$ MPa $\quad f_v = 7.5$ MPa
i.e. have sufficient factor of safety here.

Check Bending of Edge Member



$$V = \frac{4.5 \times 2.5}{2.4} = 4.7\ \text{kN}$$

$$R = \frac{4.7\,(0.4 - 2.8)}{3.2} = 3.5\ \text{kN}$$

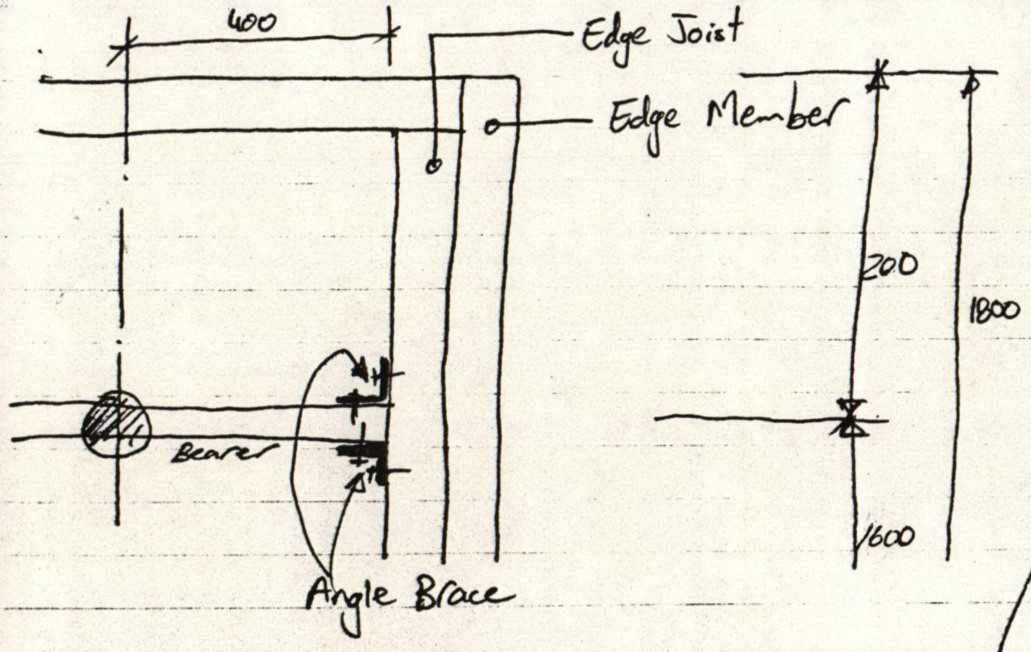
$$M = 3.5 \times 0.4 = 1.4\ \text{kNm}$$

150×50 $Z = 162 \times 10^{-6}\ m^3$ $f_b = 8.7$ MPa

$F_b = 6 \times 1.5 = 9.0$ MPa

∴ OK

i.e. 150×50 + 200×50 Edge Member adequate



Load at Line of Bearer

$= 4.5 \times \frac{2.5}{1.60 \times 2} = \underline{\underline{3.5\ kN}}$

From Lumberlok Chart

use 2-Angle Braces
+ 5- 3.15φ Nails
each end
Total Allow load = 5.0 kN

PLAN AT CORNER

Check Bearer   Bearer Moment = $3.5 \times 0.4 = 1.4$ kNm

using 200x100 $Z = 590 \times 10^{-6}\ m^3$

$f_b = \frac{1.4 \times 10^{-3}}{590 \times 10^{-6}} = 2.4$ MPa   ∴ OK

(*) Check Later for Downward Load.

Bearer Connection to Pile

Max pile uplift = 3.5 kN (from end wall overturning).

Uplift from Roof $= (0.7 \times 0.15 - 1.2 \times 0.6) = -0.615$ kPa $\times 3.6 \times 9.6 = 21.3$ kN

Have 10 Anchor Piles ie. Load to each $= \frac{21.3}{10} = 2.1$ kN

Total Pile Uplift $= 3.5 + 2.1 = 5.6$ kN

Ground floor Dead load $0.7D = 0.7 \times 0.25$ kPa $\times \frac{3.7}{2}$ = 0.324 kN/m

Bearer selfweight $= 0.7 \times 0.11$ = 0.077 kN/m

0.401 kN/m

for 2.5m span + 400 cantilever   min length to pile $= 1.25 + 0.4 = 1.65$ m

ie. Load to pile $= 1.65 \times 0.401 = 0.66$ kN

Nett Pile Uplift $= 5.6 - 0.66 = \underline{4.94\ kN}$

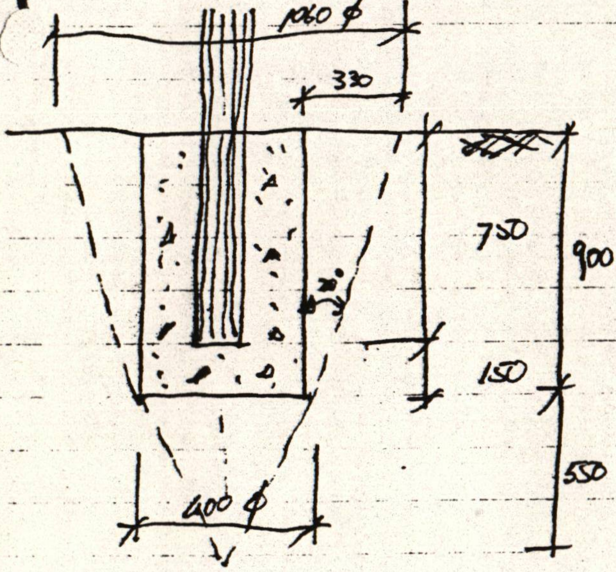
PILE FIXING TO BASE

M12 ϕ Bolt gives 2.07 kN Basic Load $K_1 = 1.5$

Allow Load = $2.07 \times 1.5 = 3.1$ kN

> i.e. use 2-M12 ϕ Bolts to Connect Bearers to Piles.

PILES – check uplift resistance.
– use 900 deep anchor piles × 400 diameter.



For Clay Type Soil

Weight of Soil = $\left(\frac{1}{3} \times \frac{\pi}{4} \times 1.06^2 \times 1.65\right) - \left(\frac{1}{3} \times \frac{\pi}{4} \times 0.4^2 \times 0.55\right) - \left(\frac{\pi}{4} \times 0.4^2 \times 0.9\right) = 0.29\,m^3$ @ 14 kN/m³
= **4.1 kN**

Weight of Concrete = $\left(\frac{\pi}{4} \times 0.4^2 \times 0.9\right) - \left(\frac{\pi}{4} \times 0.14^2 \times 0.75\right) \times 24$ kN/m³
= **2.44 kN**

Pile Weight = $\frac{\pi}{4} \times 0.14^2 \times (0.75 + 0.6) \times 5.5$ kN/m³ = **0.11 kN**

Total uplift resistance = $4.1 + 2.44 + 0.11 =$ **6.65 kN**

F.O.S. against uplift = $\frac{6.65}{4.94} = 1.35$ ∴ **OK**

ALTERNATIVELY consider NZS 4205 P approach.

$$q_s = \frac{q_a}{6}$$

for $q_a = 100$ kPa $\quad q_s = \frac{100}{6} = 16.7$ kPa

$f_s = 16.7 \times \pi \times 0.4 \times 0.9$
= **18.9 kN** i.e. considerably higher than above
∴ Piles adequate for uplift.

> use 10 ANCHOR PILES × 900 DEEP

FLOOR FRAMING

- Floor Dead + Live = 1.75 kPa
- Floor joists @ 600 c/c

$w = 1.75\ kPa \times 0.6 = 1.05\ kN/m$

Span = 3700 − 400 = 3300 $\quad M_{max} = 1.05 \times \frac{3.3^2}{8} = 1.43\ kN\text{-}m$

using 200×50 $\quad Z = 295\times10^{-6}\ m^3$

$f_b = \frac{0.00143}{295\times10^{-6}} = 4.8\ MPa$

Basic stress = 6.0 MPa $\quad K_1 = 1.25$

→ Permissible stress = 6.0 × 1.25 = 7.5 MPa ∴ OK

Deflection $\quad w = (2\times0.25) + 1.5 = 2.0\ kPa \times 0.6 = 1.2\ kN/m$

$\delta = \frac{5\times1.2\times3.3^4}{384\times8000\times2859\times10^{-8}} = 8.1\ mm = \frac{span}{407}$ ∴ OK

use 200×50 Floor Joists @ 600 c/c

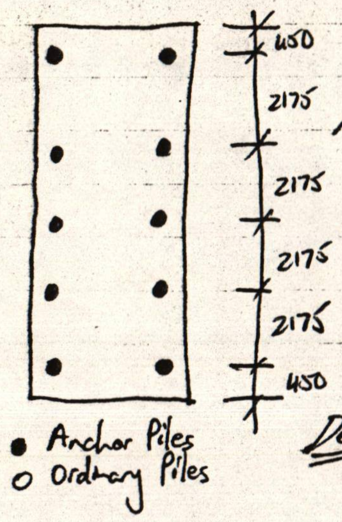
Bearers $\quad$ trib width = $\frac{3.7}{2}$ = 1.85 m × 1.75 kPa = 3.24 kN/m

Selfweight = 0.2×0.1×5.5 kN/m³ = 0.11 kN/m

Roof load = $\frac{3.7}{2}$ × 0.15 kPa = 0.28 kN/m

Wall load = 0.15 kPa × 2.5 high = 0.38 kN/m

Total = 4.01 kN/m



Max span = 2175 mm i.e. $M_{max} = 4.01 \times \frac{2.175^2}{8} = 2.37\ kN\text{-}m$

200×100 $\quad Z = 590\times10^{-6}\ m^3 \quad f_b = \frac{0.00237}{590\times10^{-6}} = 4.0\ MPa$

Basic stress = 6.0 MPa $\quad K_1 = 1.25$ → Permiss. Stress = 6 × 1.25 = 7.5 MPa ∴ OK

Defl $\quad w = (2\times0.25) + 1.5 = 2.0\ kPa \times 1.85 = 3.70$

$+\ 2\times(0.11 + 0.28 + 0.38) = 1.54\ kN/m$

$= 5.24\ kN/m$

$\delta = \frac{5\times5.24\times2.175^4}{384\times8000\times5719\times10^{-8}} = 3.3\ mm = \frac{span}{652}$ ∴ OK

Check Bearer @ end Wall which picks up overturning from end wall.

from Page (8) Bearer Moment = 1·4 kN-m

Bearer Cantilever = 450 mm
load from floor = 4·01 kN/m
M from floor = $4·01 \times \frac{0·45^2}{2}$ = 0·41 kN-m

M_{max} = 1·4 + 0·41 = 1·81 kN-m c.f. 2·37 kN-m above
∴ not critical.

USE	200 x 100 Bearers Supported at 2175 mm c/c

PILE BEARING Load from Bearer = 4·01 kN/m x 2·175 m = 8·7 kN
Additional load from end Wall (Page 8) = 3·5 kN
12·2

for 400 φ encasement + end bearing

bearing pressure = $\frac{12·2}{\pi/4 \times 0·4^2}$ = 97 kPa

this is for D+L+Wind ∴ Allowable Bearing Pressure under NZS 3604 = 100 kPa x 1·33 say = 133 kPa. ∴ OK here

Check for D+L only. – Bearing Pressure = $\frac{8·7}{\pi/4 \times 0·4^2}$ = 69 kPa
< 100 kPa ∴ OK

USE	safe Foundation bearing Pressure of 100 kPa as Required by NZS 3604.

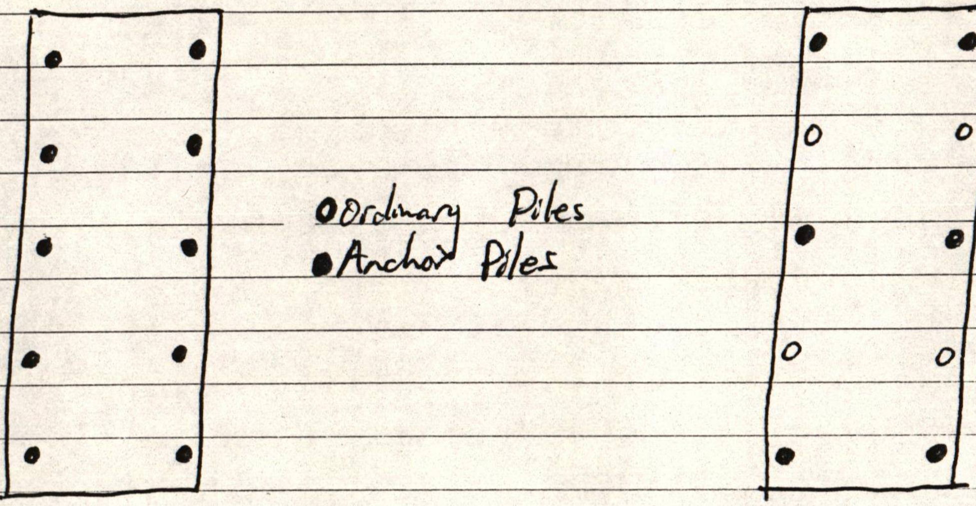
Sub Floor Framing

Use NZS 3604 Approach (Table 2 NZS 3604)

Earthquake Zone A $L < 10$m require 2 SFB's @ 5m c/c

Wind High Wind Zone require 3 SFB's @ 5m c/c
or $1\frac{1}{2}$ " @ 2.5m c/c.

Medium + Low Wind Zones require 2 SFB's @ 5m c/c



Medium + High Wind Areas — Low Wind Areas.

Ridge Beam

Max Span = 6.0m
Trib width = 3.6/2 = 1.8m.

Dead + Live: $w = 0.4$ kPa $\times 1.8 = 0.72$ kN/m $+ 0.2$ (Beam) $= 0.92$ kN/m $M = 0.92 \times \frac{6^2}{8} = 4.14$ kNm

Dead + Point Live: $w = 0.15$ kPa $\times 1.8 + 0.2 = 0.47$ kN/m $P = 1$ kN $M = 0.47 \times 6^2/8 + \frac{1 \times 6}{4} = 3.6$ kNm

0.7 Dead + Wind: $w = 0.7 \times 0.15 - 1.2 \times 0.6 = -0.615$ kPa $\times 1.8 = -1.107$ kN/m $M = 1.107 \times 6^2/8 = -5.0$ kNm
$\times \frac{1.25}{1.5} = 4.2$ kNm

i.e. $M_{max} = 4.2$ kNm

250 x 100 $Z = 933 \times 10^{-6}$ m^3 $f_b = \frac{0.0042}{933 \times 10^{-6}} = 4.4$ MPa

$\frac{D}{B} = \frac{250}{100} = 2.5$ $\frac{L}{B} = \frac{6000}{100} = 60$ $\Rightarrow K_8 = 0.88$ $F_b = 6 \times 1.5 \times 0.88 = 7.9$ MPa
∴ OK

Defln 2D + L: $w = 2 \times 0.15 + 0.25 = 0.55$ kPa $\times 1.8 = 0.99$ kN/m $+ 2 \times 0.2 = 1.39$ kN/m

$\delta = \frac{5 \times 1.39 \times 6^4}{384 \times 8000 \times 11380 \times 10^{-8}} = 26$mm $= \frac{\text{span}}{232}$ i.e. precamber 15mm @ mid-span

use 250 x 100 Ridge Beam Precambered 15mm at Midspan

RIDGE BEAM SUPPORTS.

a) At Centre $P = 0.92\ kN/m \times \frac{9.6}{2} = 4.4\ kN.$

$uplift = 1.107 \times \frac{9.6}{2} = 5.3\ kN$

100x100 Post $A = 8836 \times 10^{-6}\ m^2$ $f_{ac} = \frac{0.0044}{8836 \times 10^{-6}} = 0.5\ MPa.$

$f_{at} = 0.6\ MPa$

$\frac{L}{B} = \frac{2500}{100} = 25$ $F_a' = 7.1\ MPa$

$K_8 = 0.5$ $K_1 = 1.25$ $F_a = 7.1 \times 0.5 \times 1.25 = 4.4\ MPa$ ∴ No Problems here

Basic Tension stress = 4.8 MPa ∴ No Problems here

use 100x100 Post at Centre Support.

Check Joist Connection to joist have 5.3 kN
ST10 Nail Plate gives 50 Nails @ 136 N = 6.8 kN ∴ OK

use ST10 Nail Plate Both sides.

Joist $M = 1.43\ kNm$ (Page 10) from D+L
$P = 4.4\ kN \times \frac{0.47}{0.92} = 2.25\ kN$ (Dead Only)
additional $M = 2.25 \times \frac{3.3}{4} = 1.85\ kNm$

$M_{TOTAL} = 1.43 + 1.85 = 3.28\ kNm$

2/200x50 $Z = 590 \times 10^{-6}\ m^3$ $f_b = \frac{0.00328}{590 \times 10^{-6}} = 5.6\ MPa$ ∴ OK

use Double Joist under Central Support.

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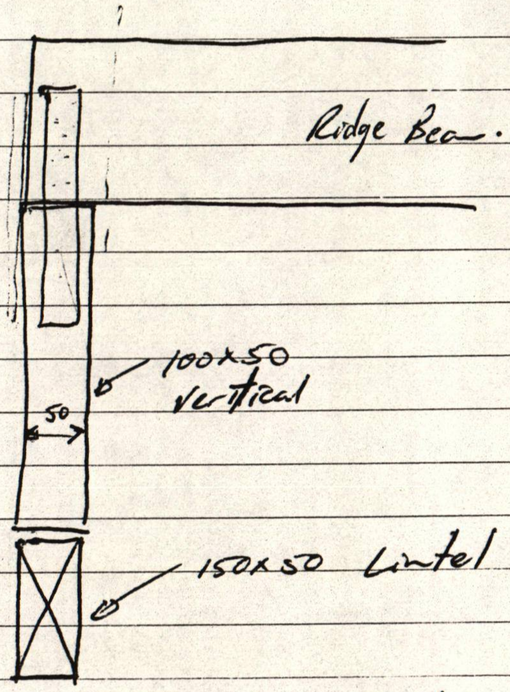
b) EXTERIOR SUPPORT Max load = $1.107 \times \frac{6}{2} = 3.32$ kN



Tylok 10T5 gives 3.4 kN each side i.e. use one each side

Strap + 5 Nails gives 2.5 kN i.e. use one strap each side

All Nail Plates Tylok 10T5

Lintel. $M = 3.32 \times \frac{1.2}{4}$

$= 0.996$ kNm

150x50 $Z = 162 \times 10^{3}$ mm^3

$f_b = \frac{0.996 \times 10^{3}}{162 \times 10^{-6}}$

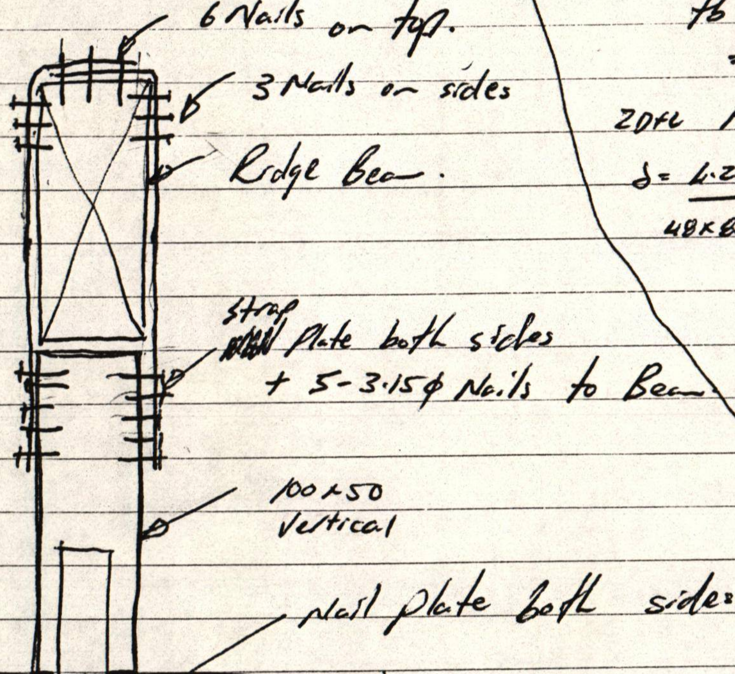
$= 6.1$ MPa i.OK

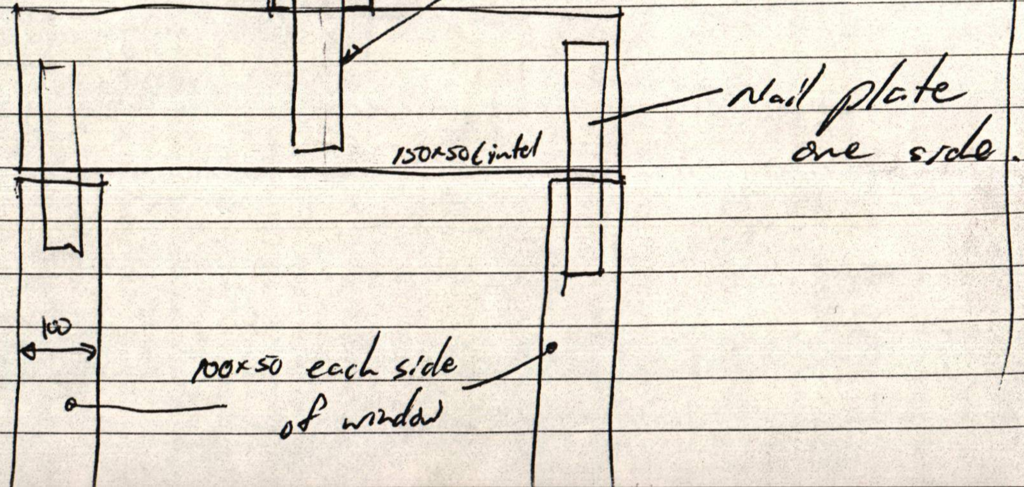
20 PL $P = 1.39 \times \frac{6}{2} = 4.2$ kN

$\delta = \frac{4.2 \times 1.2^3}{48 \times 8000 \times 1170 \times 10^{-8}} = 1.6$

$= \frac{span}{750}$ i.OK

use 150x50 Lintel.





Check fixings to Base

Have 100 × 50 each side of Window
fix to Panel skins to transfer shear.
Max load = $\frac{3.32}{2}$ = 1.66 kN

Nails @ 200 c/c each side gives $\frac{2.6}{0.2} \times 2$ = 26 Nails
$\frac{1.66}{26}$ = 0.064 kN each.

Previous Nail Load (Page 5) = 2.48 k/m × 0.1 m (× nail spacing) = 0.248 kN

total load = 0.248 + 0.064 = 0.312 kN
Allowable load = 321 N ∴ ok

Now Transfer load to base via base rivets & screws.

Base fixing load = 1.66 kN / 12 fixings (1200 Panel with fixings @ 100 c/c)
= 0.138 kN / fixing

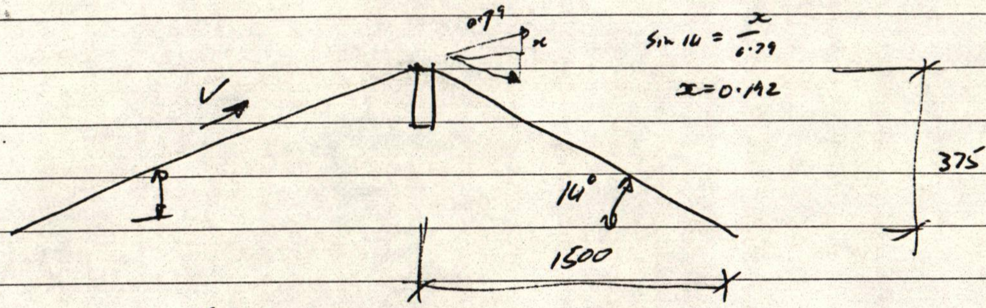
Page 6 gives vertical load = 0.48 kN
total load = 0.48 + 0.138 = 0.618 kN
Horiz load = 0.125 kN

Resultant = 0.631 kN

Allow load = 655N for screws
670N for rivets ∴ ok here.

i.e. Base fixings adequate as Page 6 are adequate

Check load to Ridge Beam from Roof Diaphragm.



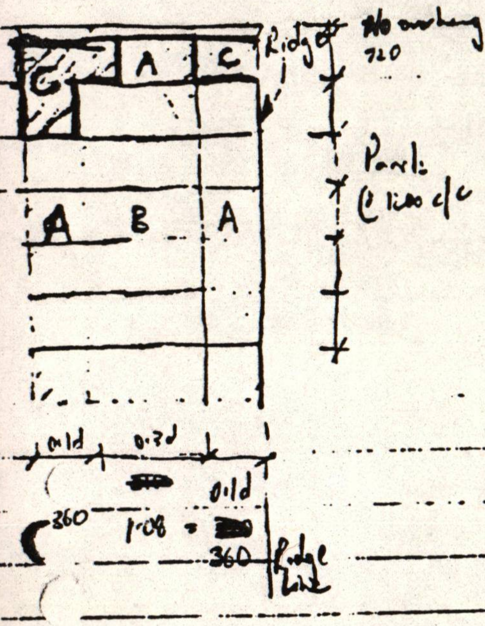
$V_{max} = 1.1 \times 0.6 \times \frac{2.4}{2} = 0.79$ kN/m $\times \frac{9.6}{2} = 3.8$ kN

load to beam = 0.192×2 = 0.383 k/m
Dead load = 0.15×1.8+0.2 = 0.47 k/m
0.853 k/m

Previous design had 1.107 kN/m design load

i.e. Ridge Beam Not critical c.f above

Now look at panel / Ridge Beam connection

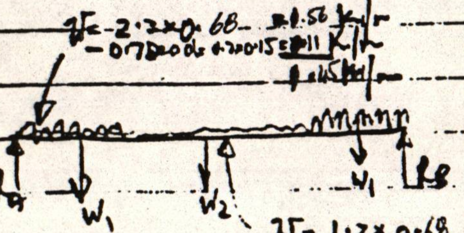


For section A
$Cpe = -2.0$
$Cpi = -0.3$
$Cp = -2.3$

For section B
$Cpe = -0.9$
$Cpi = -0.3$
$Cp = -1.2$

For section C
$Cpe = -3.0$
$Cpi = -0.3$
$Cp = -3.3$

Look at a typical internal Panel



$W_1 = 1.45 \times 0.36 = 0.52$ kN

$W_2 = 0.71 \times 1.08 = 0.77$ kN

$R_A = R_B = W_1 + \frac{1}{2} W_2$

$= 0.52 + \frac{0.77}{2}$

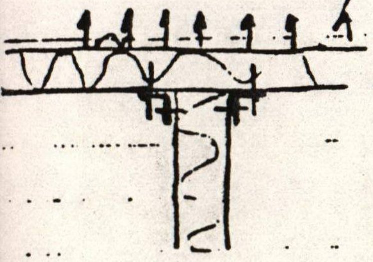
$= 0.91$ kN / m width

use allowable rivet load $= 0.173$ kN/rivet (as per Aotearoa Meat unit see Pages 18 & 19)

$\therefore$ spacing reqd $= \frac{0.173}{0.91} = 0.191$ m/rivet

i.e. use **rivets @ 200 c/c**

Look at transferring shear through rivets



- for rivets into top face will get local failure due to skin delamination and plastic yielding
- can approximate this failure to the wrinkling type failure during bending
- refer 'Analysis of Structural Sandwich Panels' by H.G. Allen
- use Case I Rigid Base

$$\rho = \frac{t}{c}\left(\frac{E_f}{E_c}\right)^{1/3}$$

$t = 0.55$ $E_f = 200000$

$c = 75$ $E_c = 1.33$

$$\rho = \frac{0.55}{75}\left(\frac{200000}{1.33}\right)^{1/3}$$

$$= 0.39$$

From Fig 8.5 $\frac{l}{c} = 0.75$

$$\Rightarrow l = 0.75 \times 0.075 = 0.05625$$

From Eqn 8.17(a) $\sigma_z = -A \frac{\pi^2}{l^2} \sin \frac{\pi x}{l}$

$\sigma_{z\,max} = -A \frac{\pi^2}{l^2}$ i.e. when $\sin \frac{\pi x}{l} = 1$

$$A = \frac{bd^2}{c} \approx bd$$

$$\sigma_{z\,max} = 0.075 \frac{\pi^2}{0.05625^2} = \underline{234 \text{ kPa}}$$

But Polystyrene cross breaking strength = 165 kPa (AS 1366)

∴ this governs design

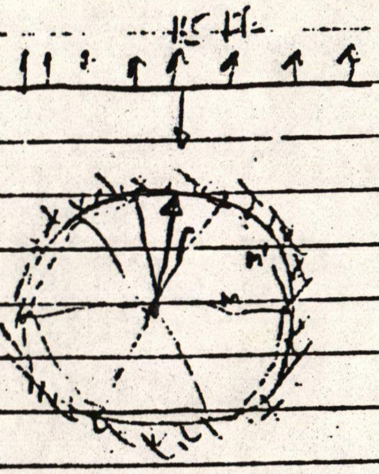
Determine fixing resistance for 0.173 kN rivet load & polystyrene strength of 165 kPa with F.O.S. = 2

$$\frac{0.173}{\pi d^2/4} = 165 \times \frac{1}{2}$$

$d^2 = 2.67\times10^{-3}$

$d = 0.052$ i.e. 52 mm

Determine diameter using yield line theory with glue strength = 165 kPa



$m = m' = \frac{qr^2}{12} = \frac{165 r^2}{12}$ for fully fixed edges

take $m = \frac{bt^2}{4} f_y$ (300 MPa) $= \frac{1\times0.00055^2}{4} \times 300$

$= 0.0227$ kN·m

$\therefore r^2 = \frac{12\times0.0227}{165}$

$= 1.65\times10^{-3}$

$r = 0.041$ m $= 41$ mm

$\therefore d = 41\times2 = 82$ mm c.f. 52 mm above

for s/s edges $m = \frac{qr^2}{6}$

$\therefore 0.0227 = \frac{165\times r^2}{6}$

$\Rightarrow r^2 = 8.25\times10^{-4}$

$r = 0.028$ m

$d = 0.028\times2 = 0.056$ m $= 56$ mm

c.f. 52 mm for poly strength

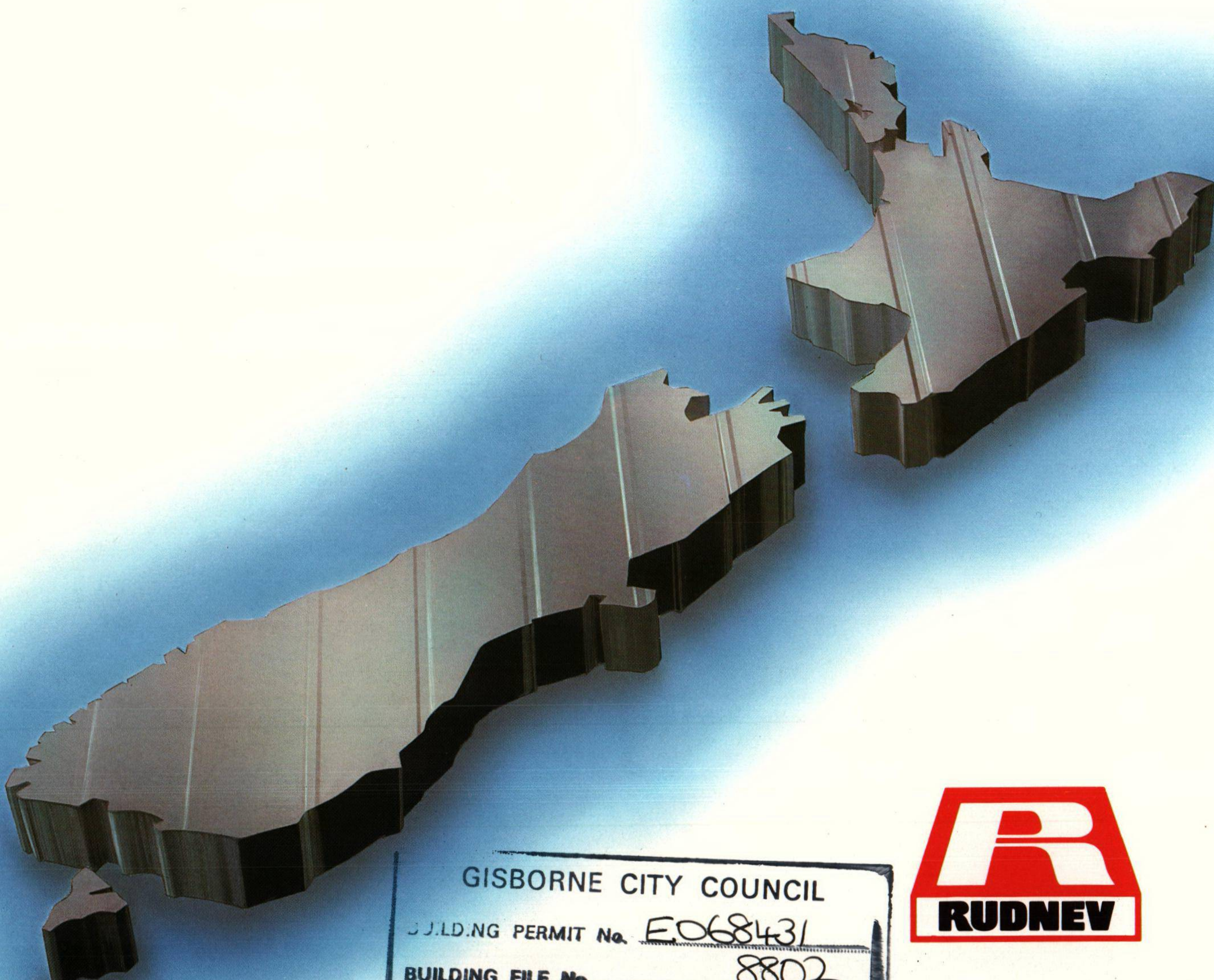
Therefore skin delamination from the styrene will be critical & yielding of the face panel won't occur & because the failure diameters of 56 mm & 52 mm are so close we can assume that the allowable rivet load of 0.173 kN gives a F.O.S ≥ 2.0

CI/SfB	
965	Rh2.n7
APRIL 1986	

RUDNEV

**PREFINISHED
STRUCTURAL
INSULATION
PANELS
SMP PAINT SYSTEM**

Not filmed.



RUDNEV

RUDNEV PREFINISHED STRUCTURAL INSULATION PANELS

Rudnev SMP Panels

Steel-skinned EPS (expanded polystyrene) cored laminated panels with prefinished SMP (silicone modified polyester) paint surface on both faces.

Uses

As part of an integrated panel construction system, Rudnev Panels offer construction advantages wherever there are requirements for internal or external lined surfaces, or thermal insulation between −60° to +76°C, or where the structural strength, long run length and modular panel construction can provide lower construction costs than conventional materials.

Applications

Insulation

Coolstores • Coolrooms • Truck Bodies • Environmental Control

Hygiene

Food Processing • Chemical preparation • Laboratories • Farm dairy sheds

Construction

Commercial buildings • Portable buildings • Domestic housing

Advantages

Cost Saving Panel System

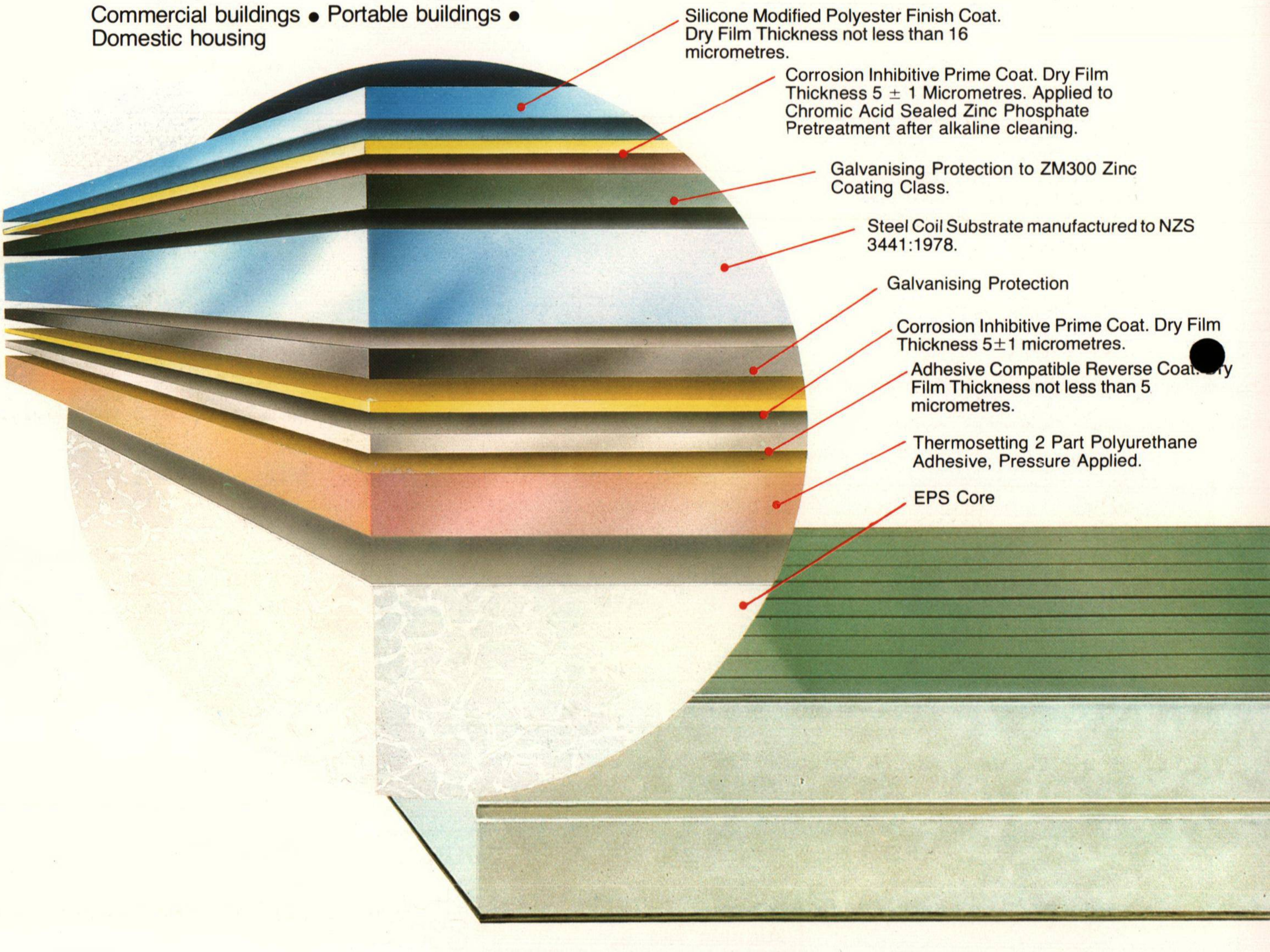
Rudnev Panels offer important cost benefits. Rudnev Construction Systems can reduce construction time significantly and allow simplified one-trade erection. There is design flexibility from the structural strength, custom-made unlimited length, and standard modular construction. Rudnev Panel structures can be easily extended, relocated or remodelled.

Prefinished Surfaces

Rudnev SMP Panels offer a high quality durable paint surface. There is the immediate advantage of no on-site painting, superior quality from a factory-controlled baked finish, and the ongoing cost efficiency of an easily cleaned hygienic, ultra-violet durable surface.

Liteweight Strength

Because Rudnev Panels are light and strong they function as structural elements. No internal wall or roof framing is needed, and the spanning capability of Rudnev Panels can eliminate or reduce the need for other support.



Because of the prefinished nature of the product, special care must be taken. Some of the points to note: the need to wear flat rubber-soled shoes when working on the panels; careful handling of the panels to avoid surface damage; the importance of keeping any roof surface clean of dirt and metal swarf; the use of neutral curing silicone sealants and specialised flashings; appropriate precautions to be observed when cutting; and the use of protective padding on work tools.

Minor surface damage to the coating during installation may be repaired using a specific touch-up paint system, consisting of primer and a top coat, available from the manufacturer. A colour difference will occur with age between the original coating and repaired areas. To reduce this effect, the touch-up paint should be applied carefully and its use kept to a minimum.

Where the panels are being used structurally, only holes specified by the structural engineer shall be made. This includes holes through the panel skins as well as longitudinal or transverse holes through the core.

DESIGN INFORMATION

General

The use of Rudnev Prefinished Structural Insulation Panels in buildings must be the subject of specific design, detail and specification. It is the designer's responsibility to use sound practice when incorporating the panels into a structure. Rudnev (NZ) Limited have a design manual and a series of standard construction and jointing details.

Proposed in-service conditions and the suitability of the Colorsteel finish should be confirmed with the manufacturer, particularly where the conditions could be considered unusual or aggressive – for example in exposed marine locations, severe industrial or geothermal environments, and manufacturing or processing areas such as saltwater fish processing and CIP make-up rooms in the dairy industry. In general Colorsteel FL is a more suitable product for aggressive environments. Rudnev (NZ) Limited provide a specialist advice service and should be consulted on aspects of specification, design, detail, construction and maintenance.

Standards

Structural designs which use Rudnev Panels and which comply with Rudnev (NZ) Limited design manual 'Load-Deflection Data and Allowable Spans', should be accepted as complying with the requirements of NZS 1900: 1985 Chapter 9.1.2.

Strength and Stability

The Rudnev (NZ) Limited design manual 'Load-Deflection Data and Allowable Spans' provides a basis for incorporating the panels in the structural design of typical buildings. The manual also provides a summary of the principles, assumptions and factors of safety used.

Where Rudnev Panels are used for floors, special design and detail is required to spread or transfer loads to avoid compression of the polystyrene core and long term creep under sustained load.

The use of the darker coloured finished panels, where exposed to sunlight, must be referred to Rudnev (NZ) Limited. Increased thermal movement and stresses can result in some situations.

Allowable Spans

Table 2 gives general values for the maximum allowable spans for Rudnev Prefinished Structural Insulation panels when used as ceilings and walls.

TABLE 2

Ceiling Panel* Maximum Spans (m)		
Thickness (mm)	live load 0.25 kPa	live load 0.5 kPa
50	3.9	2.8
75	5.3	3.9
100	6.1	4.7
150	7.4	5.7
200	8.4	6.5
250	8.7	6.8

*Roof Panels require designing for wind uplift, see design manual.

Wall Panel Maximum Spans (m)		
Thickness (mm)	nett wind load 0.35 kPa	nett wind load 0.5 kPa
50	4.4	3.6
75	5.9	5.0
100	7.0	5.9
150	8.6	7.2
200	10.0	8.3
250	10.5	8.8

These values are for general guidance only. The design manual Load Deflection Data and Allowable Spans must be referred to for all structural designs.

Thermal Insulation

Table 3 gives general values for the thermal resistance of the various thicknesses of panel. Values excluding surface resistances should be used when the panels are added to another structure. Values including surface resistances should be used when this is not the case.

These values will be achieved only if properly engineered insulating joints are used.

TABLE 3

Panel thickness (mm)	Thermal Resistance (R-value m^2 °C/W)* excluding surface resistance	Thermal Resistance (R-value m^2 °C/W)* including standard surface resistances totalling 0.12
50	1.4	1.5
75	2.1	2.2
100	2.8	2.9
150	4.4	4.5
200	5.9	6.0
250	7.4	7.5

* Based on:
k= 0.036 W/m°C 50,75 and 100mm thick
k= 0.034 W/m°C 150,200 and 250mm thick

These values are for general guidance. Because R-Values, surface resistances and other factors vary depending on the intended service conditions, a specific design should be carried out for critical applications (e.g. coolstores). Reference should be made to Rudnev (NZ) Limited.

Vapour Barrier

The panel faces are impermeable to moisture vapour. In applications where moisture vapour could enter joints, these joints must be effectively sealed.

Impact

The panels have very good resistance to soft body impact. Hard body or sharp object impact will damage the metal skin and finish.

Service Temperature

The maximum continuous service temperature the panels shall be exposed to is 76°C. Special treatment is required where appliances, plant or equipment (such as solid fuel stoves) generate heat.

Fire

Rudnev Prefinished Structural Insulation Panels are suitable for industrial, commercial and domestic use in areas where there are no specific fire requirements.

The fire-retarded grade expanded polystyrene used in the manufacture of the panels does not ignite in contact with small ignition sources.

During the ignition and developing fire stages the steel skins will protect the expanded polystyrene (EPS) core provided that the design and construction details encapsulate the core, e.g. at joints, penetrations etc, and also restrain the steel skins.

As the fire approaches full development, heat adjacent to the panels will be sufficient to cause the EPS core to melt. With flame contact the molten EPS will burn.

Fully developed fire conditions will result in a progressive loss of the structural integrity of the panels.

Electrical Cables

If electrical cables insulated or sheathed with plasticised PVC are in contact with the polystyrene the loss of plasticiser from the PVC insulation will be accelerated. The effect of the plasticiser on the polystyrene causes it to recede from the cable. When the contact is broken the reaction ceases, but some premature stiffening of the PVC cable may result. The Ministry of Energy does not object to PVC cable being installed in contact with polystyrene where the cable is not subject to flexing. Otherwise cables should be in conduits or ducts.

Maintenance

Regular inspection of the panels should be carried out. Any damage or deterioration must be repaired. All panel joints must be maintained weathertight and sealed as designed.

Routine cleaning of the panels should be carried out and exterior areas of panels sheltered from rainwashing should be well hosed down and washed at regular intervals.

Exterior

Colorsteel 5000 panels surfaces routinely cleaned should have a life to first maintenance of 15–20 years. At this stage it is expected that the coating system will no longer adequately protect the metal substrate and major maintenance, i.e. recoating, will be required if the serviceable life of the panel is to be achieved.

The Colorsteel 5000 panel surfaces can be repainted using a suitable paint system as recommended by the paint manufacturer and following their instructions for previously painted galvanised steel.

Colorsteel FL panel surfaces require only routine cleaning and repair to achieve the serviceable life. These panel surfaces can be easily cleaned by hosing down and washing with clean water. Surface marks can be removed with non-abrasive cleaners including petroleum-based products.

Interior

Colorsteel 5000 panel surfaces can be washed with warm soapy water or hosed down to maintain appearance. Where the internal environment is likely to deposit pollutants on the panel surfaces, regular cleaning maintenance should be carried out.

Colorsteel FL panel surfaces can be washed with warm soapy water, hosed down with water, or cleaned with solvents or non-abrasive cleaners. In aggressive environments regular cleaning maintenance should be carried out.

Durability

The serviceable life of the panels is determined by the life of the prefinished steel skins, providing the conditions under which the panels are used have no adverse affect on the expanded polystyrene core. It is also assumed panel detailing and jointing techniques are used which prevent the entry of moisture to the rear of the panel skins.

Surfaces of the panels should not be subject to chemical spillage, high pressure hosing or steam cleaning.

Exterior

Colorsteel 5000 skinned panels, in non-aggressive areas and well washed, should have a life to first maintenance of 15-20 years. Fading, chalking, and some loss of gloss is likely to have occurred in this time, and earlier recoating may be considered necessary to restore the visual appearance. If properly maintained and in a non-aggressive environment they should have a serviceable life of 40 years.

Colorsteel FL skinned panels should have a serviceable life of at least 40 years provided regular washing is carried out on sheltered areas. Slight chalking will be evident after 10 years exposure.

These durability opinions are based on the anticipated performance of the product at Judgeford, which is expected to be typical of most areas in New Zealand away from exposed marine locations (areas where frequent heavy salt deposits occur) and sources of corrosive pollutants. It assumes the panels are rainwashed with any sheltered areas being hosed down at regular intervals.

Interior

The durability of the interior surface of the panel will depend totally on the use and environment of the area and the maintenance schedule followed. In most cases it is the exterior environment that will govern the durability of the panel.

BASIS OF APPRAISAL

Tests

Load tests of panels were observed by BRANZ. The inter-

Built-in Insulation

Within the warm to sub-zero temperature range, there is no other insulating material that can offer the insulation value and long-term performance at a lower cost than the EPS cored Rudnev Insulation Panel.

Limitations On Use

If it is intended to use Rudnev Insulation Panels in an exposed marine location, in severe industrial or geothermal environments, or at elevated temperatures or humidities, Rudnev (NZ) Limited should be contacted for specialist advice on alternative material specifications which will offer enhanced panel performance.

To achieve maximum performance from Rudnev Construction Systems, all fixing, cutting and sealing must be in accordance with the construction guidelines specified by Rudnev (NZ) Limited.

Materials and Manufacture

Panel Skins

Galvanised steel coil manufactured to NZS 3441:1978, base thickness 0.59mm with hot dipped zinc coating to ZM 300 class. Coil continuously laminated to core with mild rib indents formed in panel face and panel edges roll-formed to standard specifications.

Adhesive

Thermosetting 2-part polyurethane, bonding achieved under pressure.

Core

EPS, 45mm-250mm thick, self-extinguishing 'S' grade expanded polystyrene sheet manufactured to AS 1366 Part 3*, kiln-dried and stress relieved. Machined at panel edges to accept jointing system.

*New Zealand Adoption applied for.

Paint System — SMP Panels

A finish coat of heat-cured silicone modified polyester paint to a dry film thickness of not less than 16 micrometres. Finish coats are applied over a corrosion inhibitive primer after an alkaline cleaned chromic acid sealed zinc phospate pre-treatment.

Mechanical Properties

The mechanical strength of a Rudnev Panel is created by laminated bonding of the separate components into a single strong structural unit. The high strength outer skins carry most of the tension and compression loads, while the polystyrene core serves both to stabilise the outer skins against buckling and resist shear stresses. Strength is a function of panel thickness as the following table shows:

Panel Thickness	Wall Span (1)	Ceiling Span (2)
50	4.38 m	3.9 m
75	5.95 m	5.27 m
100	7.04 m	6.09 m
150	8.63 m	7.36 m
200	9.96 m	8.39 m

(1) Wall spans calculated for a nett wind load of 0.35 Kpa with a 30 percent stress increase allowed under wind load.

(2) Ceiling spans calculated on panel dead load plus 0.25 Kpa live load.

(3) These spans are based on typical project designs incorporating a number of variable design factors. Full engineering calculations should be carried out for specific projects. Design services available from Rudnev (NZ) Ltd.

THE MECHANICAL PROPERTIES SHOWN ARE BASED ON TESTS OF PANEL MANUFACTURED BY RUDNEV (NZ) LTD AND ARE NOT NECESSARILY APPLICABLE TO ANY OTHER PANELS

Vapour Barrier

Panel Skins are impermeable to moisture and edge sealing is achieved with neutral curing silicone or butyl mastic sealants and aluminium extrusions.

Insulation Properties

Rudnev Panels have the following 'R' values:

Panel Thickness (millimetres)	Mean Face Temp (°C)	'R' Value* (m^2 °C/W)
50 mm	25°	1.5
100 mm	25°	2.9
150 mm	10°	4.5
250 mm	10°	7.5

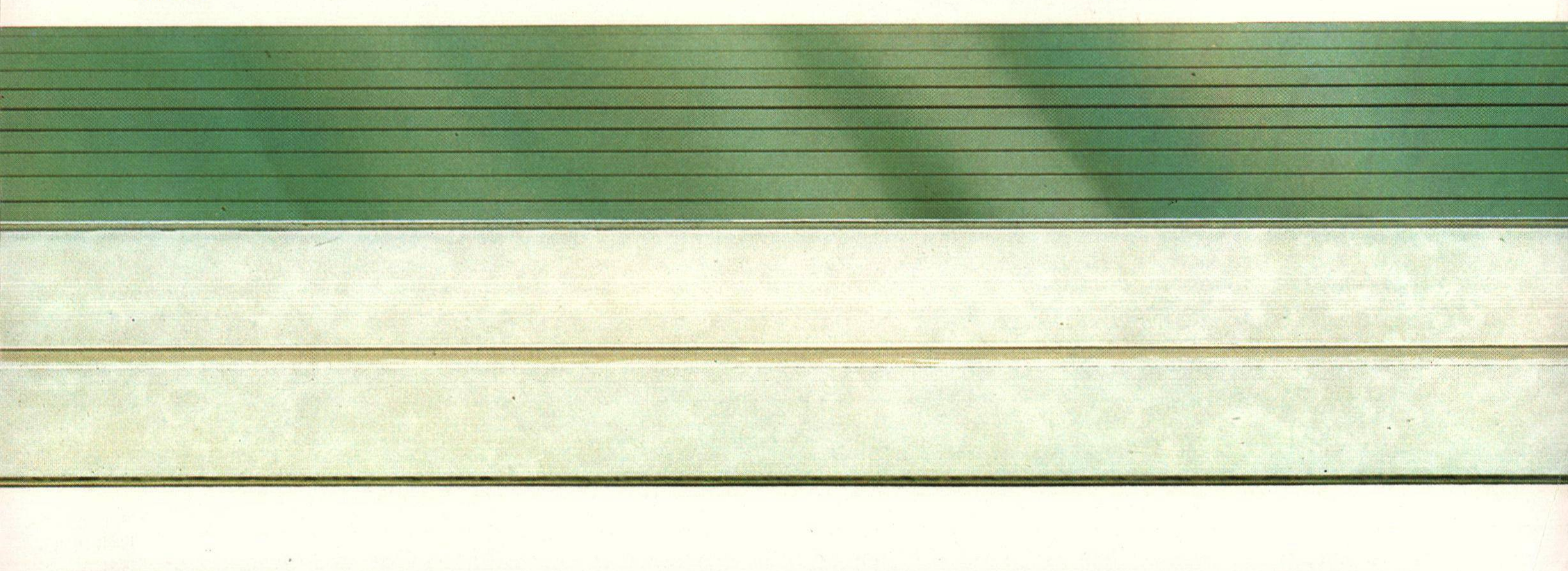
*As determined by NZS 4214:1977, total 'R' value for ceiling panels.

Thermal Bridging

No thermal bridges are created with standard Rudnev Construction Systems. Full thermal insulation thickness can be maintained throughout the panel structure.

Unlike other thermal insulation materials, the long-term performance of EPS does not alter. EPS is dimensionally stable and will not settle, there is no capilliary action and moisture absorption is minimal.

Maximum continuous service temperature is 76°C. Rudnev EPS will stand short term temperatures in excess of this rating dependent on structural loadings. Please consult Rudnev (NZ) Limited for further advice on such applications.



RUDNEV SMP PANELS

Characteristics

Low gloss satin finish with good abrasion and mark resistance, pencil hardness 'F' minimum.

Chemical Resistance

Resistant to short-term contact with most dilute acids and alkalii, but not to extended exposure. Resistant to: animal, mineral and vegetable oils, greases, waxes, and fats, mild detergents and most commercial degreasers. Not resistant to concentrated organic acids and alkalii, for example formic and acetic acids.

Service Life

Under normal conditions, a period of 12-16 years for erosion of original paint surface to base metal can be expected for a north-facing roof exposure — vertical wall exposure results in an increased life expectancy. Compatible air drying paints are available for touch-up purposes.

The coil coated steel finds an ideal end use in Rudnev SMP Panels. Unlike roof and cladding steel, there is only gentle forming of the surface so micro-cracking of the paint is minimised, thus increasing service life. The exposed steel edge is rolled formed and protected by Rudnev jointing systems eliminating edge corrosion. The EPS core stabilises the steel skins and reduces physical damage from buckling on impact.

Weight

The weight per square metre of Steel Faced Panels i.e. Steel/EPS/Steel is approximately:

Panel Thickness (mm)	KG/m²
45	10.5
50	10.6
75	11.0
100	11.4
125	11.8
150	12.2
175	12.6
200	13.0
250	13.8

Dimensions

Length — up to 18 metres (limited only by transportation)

Width — 1200mm (nominal)

Thickness — Dependent on structural/thermal requirements, standard thickness 45mm, 50mm, 75mm, 100mm, 125mm, 150mm, 175mm, 200mm, 250mm.

Weight — From 10.5 kg/m² to 13.8 kg/m² — refer chart below.

Colours

Rudnev SMP Panels are available in a selection of colours from the Colorsteel 5000 standard colour range. Limitations on colour use are imposed in roof applications. All colours other than white are subject to minimum order quantities.

RUDNEV

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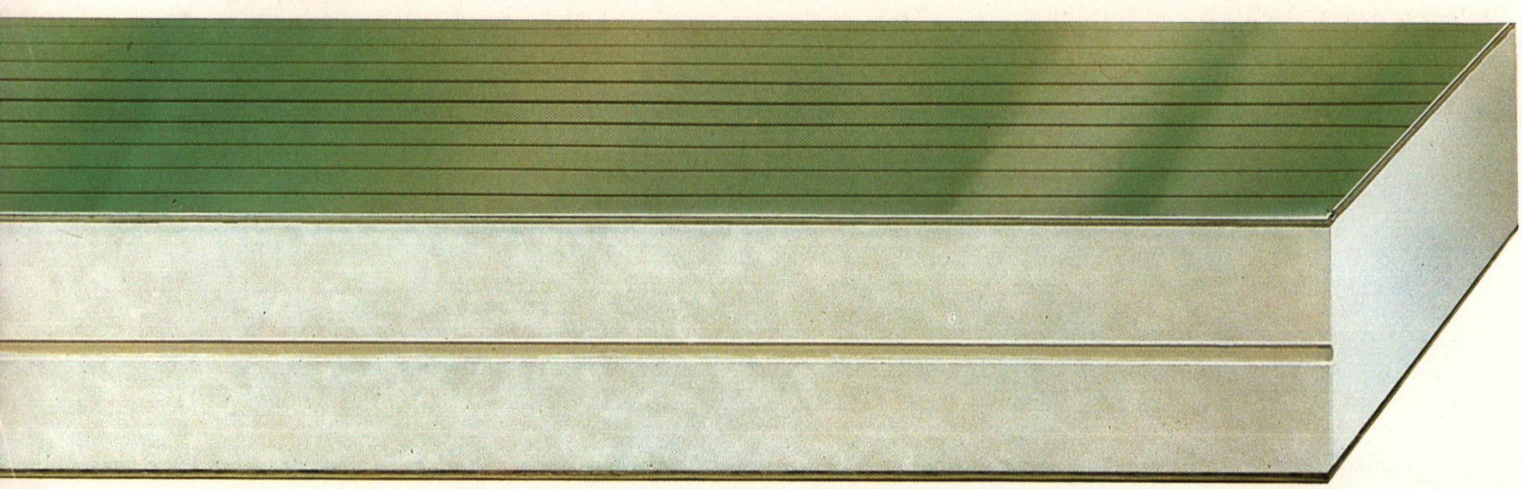


Publication Reference R4C

Appraisal Certificate

BUILDING RESEARCH ASSOCIATION OF NEW ZEALAND
Moonshine Road, Judgeford.
Private Bag, Porirua; Wellington (04) 357-600.

NO. 130 (1986)

CI/SfB 965 Rh2:n7

UDC 725.355:691.714–419.5:691.175.746–405.8

EXPIRES JUNE 1989

Not filmed

Rudnev Prefinished Structural Insulation Panels

APPRAISAL

Product

Rudnev Prefinished Structural Insulation Panels are composed of an expanded polystyrene (EPS) core faced on both sides with a skin of coil-coated galvanised steel. The coil-coat finish is available in either 'Colorsteel 5000' or 'Colorsteel FL'. Panel edges are formed to accept a jointing system.

The panels are nominally 1200mm wide, in a range of thicknesses from 45mm to 250mm, and to required lengths up to 18m. They are manufactured by Rudnev (NZ) Limited, Private Bag, Papatoetoe, Auckland, at factories in Christchurch and Auckland.

Purpose

The panels are for use as modular, prefinished structural insulating components in any suitable building that is specifically designed. This Certificate relates to panels only and does not include the use of the panels in any particular structure. This is the responsibility of the designer.

Opinion

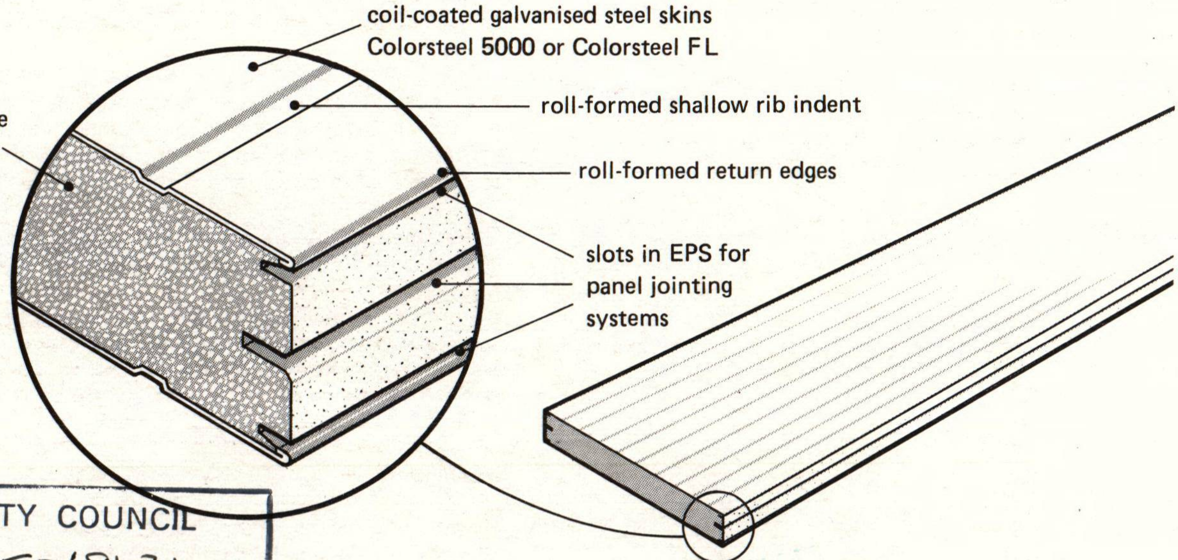
In the opinion of the Association the product is suitable for the above purpose. The panels may be used for walls, ceilings, roofs and floors and also as cladding panels. They are light in weight and have structural and thermal insulation properties.

Validity

The validity of this Certificate is subject to the following conditions:

1. New Zealand Steel Limited supply the coil-coated galvanised steel to their Colorsteel 5000 or Colorsteel FL specification.

2. The panels are manufactured by and comply with the



RUDNEV PREFINISHED STRUCTURAL INSULATION PANELS specification of Rudnev (NZ) Limited.

3. The incorporation of the Rudnev Prefinished Structural Insulation Panels into a building shall be the subject of specific design for all relevant properties. Such incorporation shall also be in accordance with methods that leave room for a rational analysis appropriate to the established properties and behaviour of all the constituent materials and elements, and are approved as being appropriate to achieve adequate strength, serviceability, and where necessary, ductility to sustain the various loading conditions required under NZS 1900 Chapter 8.

   Where appropriate, the design manual of the manufacturer entitled 'Load Deflection Data and Allowable Spans' shall be used.

4. A service of specialist advice shall be provided by Rudnev (NZ) Limited and, where appropriate, details approved by that firm shall be used.

The Certificate will be suspended or withdrawn if the overall standard and expected performance of the product is not maintained. Amendments, if any, to this Certificate will be published in Appraisal Newsletters. Current validity and amendments can be confirmed by contacting any office of the Association.

Quality Control and Workmanship

Rudnev (NZ) Limited are responsible for the quality control of manufacture of the panels.

Workmanship during site installation is the responsibility of Rudnev (NZ) Limited or an approved installer or contractor.

SPECIFICATION

Description

Rudnev Prefinished Structural Insulation Panels are manufactured by a continuous lamination process which bonds prefinished galvanised sheet steel to both sides of an expanded polystyrene (EPS) core. Joints in the EPS core are end-butted. The panels' steel skins can be roll-formed with a shallow rib indent or be plain depending on design requirements. Longitudinal edges are roll-formed to return back under the panel face, providing a smooth accurate edge for joining the panels. The expanded polystyrene (EPS) is also machined on the longitudinal edges to accept a panel jointing system.

Rudnev panels are nominally 1200mm wide and supplied in lengths up to 18m depending on panel thickness, ease of transport and erection. Table 1 gives the nominal standard panel thickness and approximate weight.

TABLE 1

Panel thickness (mm)	weight kg/m^2
45	10.5
50	10.6
75	11.0
100	11.4
125	11.8
150	12.2
175	12.6
200	13.0
250	13.8

Materials

Expanded polystyrene (EPS): A rigid cellular polystyrene manufactured from fire-retardant virgin beads to the requirements of AS 1366 Part 3, "Class S" type which has a minimum compressive stress of 85 kPa at 10% deformation.

Adhesive: The coil-coated steel skins are bonded to the expanded polystyrene core with a thermosetting two-part polyurethane adhesive.

Coil-coated galvanised steel: Two options are available, New Zealand Steel Limited's Colorsteel 5000 and Colorsteel FL. Both use a substrate of galvanised steel manufactured to the requirements of NZS 3441, grade G300, with a base metal thickness of 0.59mm. The galvanised steel has a ZM300 zinc coating class and is cleaned and chemically treated before coil-coating.

Colorsteel 5000 has an oven-cured primer applied to both surfaces of the galvanised steel. The top surface is coated with a silicone modified polyester paint having a dry film thickness of not less than 16 microns. The bottom surface has a grey polyester paint applied. Both surface coatings are oven-cured.

Colorsteel FL has an oven-cured primer applied to both surfaces of the galvanised steel. The top surface has an adhesive bonded lamination of 'Tedlar'* a polyvinyl fluoride film. The film thickness is not less than 33 microns. The bottom surface is coated with an oven-cured grey polyester paint.

(*a registered trademark of E.I.DuPont de Nemours International S.A.)

Panel jointing systems are not included in this Certificate but typically they are profiled aluminium extrusions, e.g. 'H' and 'L'. A hardboard spline is usually used in the panel centre jointing slot.

Colours

The standard colour for Rudnev Prefinished Structural Insulation Panels is white. Other colours in the Colorsteel 5000 and Colorsteel FL range are available subject to certain minimum quantities being ordered. The suitability of colours other than white (because of increased thermal movement) must be confirmed with Rudnev (NZ) Limited.

Handling and Storage

Panels are transported and stored on site with polystyrene fillets between them to avoid damage to the prefinished surfaces.

For short term storage, panels should be stored off the ground on polystyrene dunnage and protected from physical damage. For longer term storage, panels must be stored dry, undercover, and with adequate ventilation.

Colorsteel FL finished panels are supplied with a protective strippable clear plastic film. New Zealand Steel Limited recommend that this film should be protected from direct sunlight if installation is likely to take longer than seven days. If the panels are to be stored for long periods before use then the protective film should be removed within nine months. If these precuations are not taken the film may be difficult to strip off.

Installation

Rudnev Prefinished Structural Insulation Panels are specifically designed, detailed and specified for each building. The working documents for each building must be referred to and followed during installation.

pretation of the results of these tests was assessed by BRANZ, for inclusion in the design manual.

The Colorsteel 5000 panel skin has been subjected to 1000 hours salt spray testing by BRANZ.

Production

The coil-coating processes by New Zealand Steel Limited and the panel manufacture by Rudnev (NZ) Limited have been examined including the methods adopted for quality control, and details obtained of the quality and composition of the materials used.

Site Inspections

Site inspections to assess the ability of the panels to be incorporated in building constructions have been made by the Association.

Manufacturer's Literature

The manufacturer's literature 'Rudnev Prefinished Structural Insulation Panels SMP Paint System', April 1986 has been examined by the Association.

Manufacturer's Design Manual and Details

The manufacturer's design manual 'Rudnev Prefinished Structural Insulating Panels, Load-Deflection Data and Allowable Spans', dated March 1986 and the 'Standard Rudnev Details, Typical Joint Details Sheet F1/A' dated May 1983 have been examined by the Association.

Sources of Information

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For the Association June 1986

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