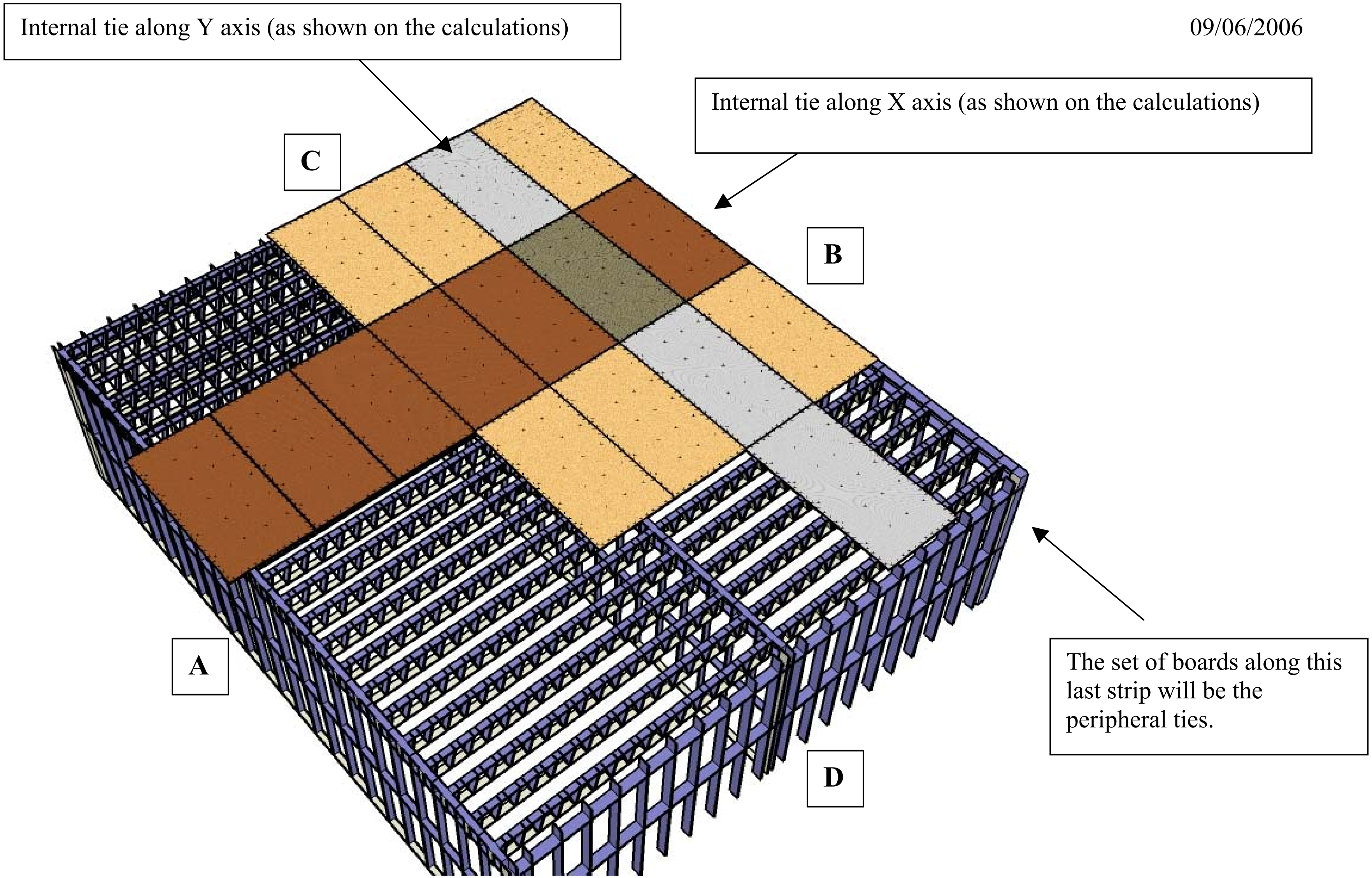
09/06/2006


Internal tie along Y axis (as shown on the calculations)
Internal tie along X axis (as shown on the calculations)
C
B
A
D
The set of boards along this last strip will be the peripheral ties.

09/06/2006

Above picture shows the internal ties and peripheral ties. All of the structural boards are acting as internal/peripheral ties throughout the building. It is considered that having all the boards fixed over the joists& top track of walls we have a continuous member over the whole floor area. Then I have taken two strips from this big diaphragm;
a 2.4m wide strip connecting A&B
a 1.2m wide strip connecting C&D

There isn't a single "member" to tie the external walls as an internal tie (as illustrated on new BS5950) , BUT we have strips of 1.2m wide boards the internal ties along Y axis (same notation as in the calculations) connecting C&D.

Note that according to new BS5950-5, the walls A&B are tied with the joists as per the above drawing hence there wouldn't be a need for utilizing the boards as an internal tie along this direction. But in the 4 storey building for which the calculations are submitted, the joists are not spanning in the same direction throughout the building so all the calculations are made to show that the boards can act as internal ties along both direction. THE BOARDS SHOULD ALWAYS BE FIXED AS SHOWN ON THE DRAWING ABOVE, I.E. THE LONG SIDE OF THE BOARDS ARE PERPENDICULAR TO THE JOISTS.

The internal ties need to be able to transfer double the load of the peripheral ties -because of the tributary width- As stated above all the tying requirements for walls is provided by the floors. So the governing screw schedule for the boards will be calculated according to the internal tying requirements.

$L_{board.x} := 2.4m$

$Tie_{internal.x} := max\left[0.5\cdot(1.4\cdot DEAD\_LOADS\_F + 1.6\cdot LIVE\_LOAD\_F)\cdot L_{board.x}\cdot 4.0m, 15\cdot kN\right]$

La=4.0m & Sd=2.4m

$Tie_{internal.x} = 21.858kN$

09/06/2006

$L_{board.y} := 1.2m$

$Tie_{internal.y} := max[0.5 \cdot (1.4 \cdot DEAD\_LOADS\_F + 1.6 \cdot LIVE\_LOAD\_F) \cdot L_{board.y} \cdot 9.7m, 15 \cdot kN]$

La=9.7m & Sd=1.2m

$Tie_{internal.y} = 26.503kN$

The Peripheral ties;

The internal ties will always govern the design. According to the illustration in the new BS5950-5; the peripheral tie in the above building will be the last set of boards as shown. So we assume that a strip of 1.2m wide boards are acting as the peripheral tie connecting C&D. So the amount of load they need to tie will be the half of the load required to be transferred by the internal ties. Although it is not clear what should be used as the spacing of peripheral ties, I have used 1.2m as the spacing of boards along this direction as I have done above for the internal ties.

$Tie_{peripheral.x} := max[0.25 \cdot (1.4 \cdot DEAD\_LOADS\_F + 1.6 \cdot LIVE\_LOAD\_F) \cdot 2.4m \cdot 4m, 15 \cdot kN]$

$Tie_{peripheral.x} = 15kN$

So the boards around the peripheray of the building should be able to transfer the above load.

Similar to the internal tie calculations, the peripheral tie along the y direction will need to transfer;

$Tie_{peripheral.y} := max[0.25 \cdot (1.4 \cdot DEAD\_LOADS\_F + 1.6 \cdot LIVE\_LOAD\_F) \cdot 1.2m \cdot 9.7m, 15 \cdot kN]$

$Tie_{peripheral.y} = 15kN$

09/06/2006

The floor ties:

Tying force required: $Tie_{floor} := max[[0.5\cdot(1.4\cdot DEAD\_LOADS\_F + 1.6\cdot LIVE\_LOAD\_F)]\cdot Span\_j1, 5\cdot kN\cdot m^{-1}]$

$Tie_{floor} = 7.858\,\frac{kN}{m}$ Force required to be transferred from the joists to the walls as tying force is the tie

So at the end of every joist this force is equal to $Tie_{floor}\cdot Spacing\_j1 = 3.143\,kN$

The connection of the joists to the wall frames are all in tension when this tying force is considered.

For the minimum thickness possible the tensile force that can be transferred from the joists to the walls per screw is;

$screw\_pull\_out := 0.65\cdot 0.75mm\cdot 4.8mm\cdot p_y$ $screw\_pull\_out = 819\,N$

$\frac{Tie_{floor}\cdot Spacing\_j1}{screw\_pull\_out} = 3.838$ **Floor joist to walls connection needs to have at least 4 screws. Minimum provided will be 4 in total , 2 per angle. So the floor ties are adequate.**

Now, since we have established the forces required to be transferred by the ties; below analysis is made to determine how many screws would be needed to fix the boards on the joists&walls to transfer these forces;

Max. force per meter of the 22mm structural board need to transfer;

$$Tie\_force_{board} := max\left(\frac{Tie_{internal.x}}{L_{board.x}}, \frac{Tie_{internal.y}}{L_{board.y}}\right)$$

$Tie\_force_{board} = 22.086kN\cdot m^{-1}$

09/06/2006

Connection strength between the structural board and light steel joists;

There can be three types of failures;

1. Shearing of the plywood veneers
2. Shear failure of the screw shank
3. Tearing of the screw away from the light steel joist.

Following assumptions are made;

1. The screws size used to fix the boards are No.8 by 2inch (3.9x55mm) coarse thread or plywood screw.
2. Minimum edge distance for the screws is 1in. (There is enough space on the joists to satisfy this requirement) For any other application refer to manufacturer's recommendations.

1. Shearing of the plywood veneers:

Attached fastener load tests shows that the ultimate lateral load per No.8 screw through 18mm thick plywood and 2mm thick steel is 700lbf (3.1kN) . Whereas test results also show that the governing mode of failure is limited to screw to framing strength. So for a lesser gauge of steel (0.75mm in this case) we would expect the shear per screw would be governed by the screw to framing connection strength.

$P_{screw} := 3.1\,kN$ (Ultimate load)

2/3. Tearing of the screw & screw strength;

Without referring to any test result for a 3.9mm diameter screw the ultimate shear may be approximated as ;
(Area of the screw) x (yield strength of steel) which gives ;

$$\frac{\pi \cdot 3.9^2}{4} mm^2 \cdot 280 \cdot N \cdot mm^{-2} = 3.345\,kN$$

Whereas the tearing of the screw will be as per below;

$P_{screw} := 3.2 \cdot \sqrt{t\_j1^3 \cdot 3.9mm} \cdot p_y$ $P\_j_{screw} = 1.594\,kN$

So we can conclude that one 3.9x55mm screw connecting 18mm plywood -or similar- to 0.75mm thick steel can transfer 1.59kN.

The required max. lateral shear to be transferred between the boards is according to the above analysis;

$Tie\_force_{board} = 22.1\,kN \cdot m^{-1}$

09/06/2006

$$\frac{Tie\_force_{board}}{P\_j_{screw}} = 13.9\frac{1}{m}$$

Note that the standard fixing method as recommended by the manufacturers are 100mm centers along the two opposite ends of the board, and 300mm centers at the intermediate supports.

With this approach to robustness, -designing the floor as tie to all of the walls, as opposed to designing the internal walls as ties for the walls- in the cases where thicker joists are used (1mm as opposed to 0.75mm as in this example) the screw requirement will be even less.

The floor diaphram is another part of the structure which has to be designed by a certified engineer. As shown on this example, the screw requirements for edges of the boards less than 100mm, by changing the diameter of the screws, the amount of screws required can be decreased significantly.

Also the tying of the walls parallel to the direction of the joists is provided by not only the boards but also the joists. So the additional screws will not be needed for all of the boards. But it is recommended that the screw spacings are kept the same throughout the building to prevent any confusion on site.

In the new BS5950-5 is that there is a new coefficient "n" introduced in the equations which will decrease the demand of force from the ties by 25% for a 4 storey, 50% for a 3 storey, 75% for a 2 storey and there is no need to design for robustness for a single storey. As I haven't shown this in our calculations above, but %25 percent decrease is certainly a very big amount which would change the screw spacings as pointed out above. Attached below are the test results that we are referring to for the screws through the structural board.

Serdar Dundar

09/06/2006

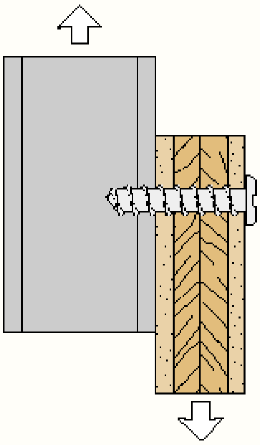
TABLE 2

SHEET METAL SCREWS: PLYWOOD-TO-METAL CONNECTIONS(a)

Framing	Plywood Thickness (in.)	Ultimate Lateral Load (lbf)(b)				
		Screw Size				1/4"-20 Self Tapping Screw
		#8	#10	#12	#14	
0.080-in. Aluminum	1/4	330	360	390	410	590
	1/2	630	850*	860	920	970
	3/4	910*	930*	1250	1330	1440
0.078-in. Galvanized Steel (14 gage)	1/4	360	380	400	410	650
	1/2	700*	890*	900	920	970
	3/4	700*	950*	1300*	1390*	1500

(a) Plywood was A-C EXT (all plies Group 1), face grain parallel to load.

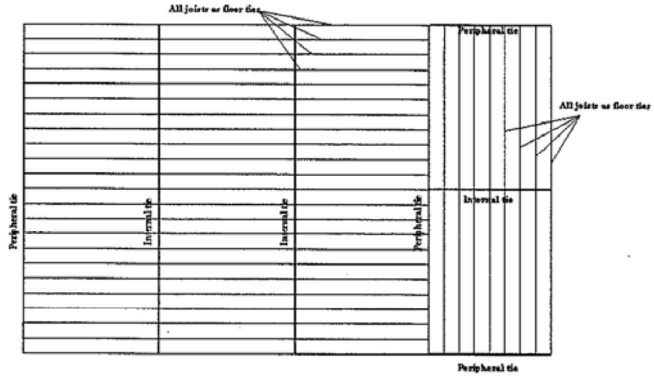
(b) Loads denoted by an asterisk(*) were limited by screw-to-framing strength; others were limited by plywood strength.



09/06/2006

Draft amendment to Clause 2.3.5 of BS5950-5:1998

floor and roof level in two directions approximately at right angles.



Light steel members acting as ties and their end connections, should be capable of resisting the following factored tensile loads, which need not be considered as additive to other loads acting on the members:

- For floor or roof ties* $0.5\ (1.4g_k + 1.6q_k)L_a\,n$ but not less than 5 kN/m
- For internal ties**: $0.5\ (1.4g_k + 1.6q_k)s_t\,L_a\,n$ but not less than 15 kN
- For peripheral ties**: $0.25\ (1.4g_k + 1.6q_k)s_t\,L_a\,n$ but not less than 15 kN

* The equations for roof and floor ties are based on the assumption that ties are provided by members at typically 400mm or 600mm centres, e.g. floor or roof joists.
**Peripheral and internal ties will generally be formed by the head member of the stud walls supporting the joists.

where:
g_k is the specified dead load per unit area of the floor or roof (kN/m^2)
L_a is the largest value, anywhere within the length of the tie, of the mean of any two adjacent spans (m)
q_k is the specified imposed floor or roof load per unit area (kN/m^2)
s_t is the mean transverse spacing of the ties (m)
n is a factor related to the number of storeys in the structure as follows:

Number of storeys	*Value of factor n*
5 or more	*1.0*
4	*0.75*
3	*0.5*
2	*0.25*
1	*0*

This may be assumed to be satisfied if, in the absence of other loading, the member and its end connections are capable of resisting a tensile force equal to its end reaction under factored loads multiplied by n, or the larger end reaction multiplied by n if they are unequal.

b) *Tying of perimeter walls and columns.* A tying member at the periphery of the building, for example at the head of a wall, should be connected back to the rest of the structure. If the vertical loads are resisted by a distributed assembly of closely spaced elements, the tying members should be similarly distributed to ensure that the entire