THE 3 PRINCIPLES OF STRUCTURAL DESIGN FOR STRUCTURAL DETAILING

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Structural Detailing

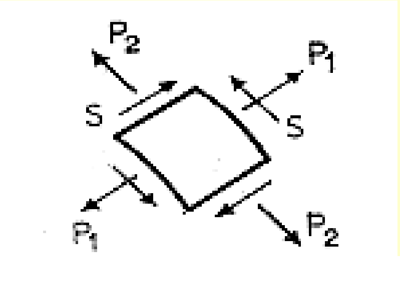
in the DESIGN OFFICE

PRINCIPLE 1 –

EFFICIENT STRUCTURAL SYSTEMS

Membrane stresses are under equilibrium due to direct and shear forces only due to geometrical curvature.

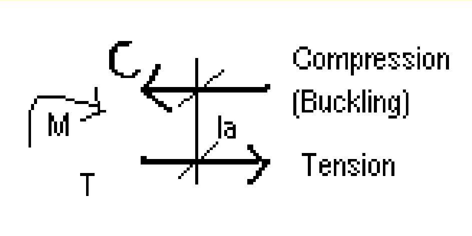
Compressive forces introduce the concept of buckling.



A bending Moment is conceived as direct forces under a couple action.

$$C = T$$

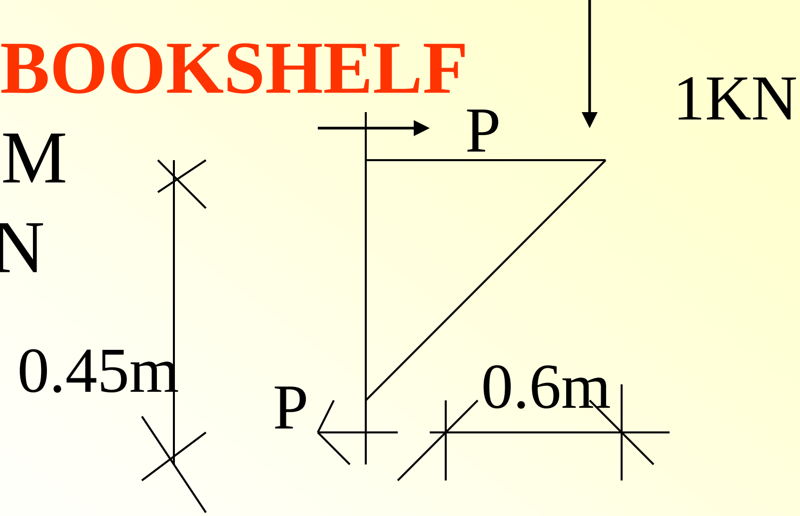
$$M = Cl_a$$

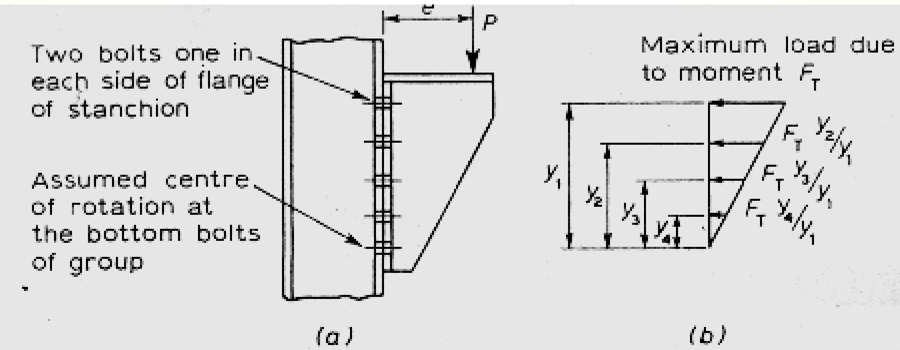


A SIMPLE BOOKSHELF

BM = 1 KN *0.6M = 0.6kN-M

P = 0.6/0.45 = 1.33KN





$$Pe = 2F_t \sum y^2 / y_1$$

$$F_t = \frac{Pey_1}{2\sum y^2}$$

$$F_s = \frac{P}{\text{No. of bolts}}$$

Pull-out values in KN for nylon wall plug – type S-RS			
	size of plug		
materials	**S 6 RS**	**S 8 RS**	**S 10 RS**
Concrete B25 (Bn250)	**2.2**	**4.0**	**3.2**
Solid brick	**1.7**	**3.8**	**3.1**
Perforated brick	**1.0**	**2.1**	**2.2**
Solid lime block	**1.6**	**3.7**	**2.8**
Perforated lime block	**1.1**	**2.1**	**2.6**
Pumice brick			**1.25**

UNIVERSAL BEAM BRIDGE SPLICE

Shear force at splice V = 156KN

Moment at splice = 1560KNm

Universal beam 836 X 292 X 176 kg/m

l_a is the distance between flange plates,

As assumed 20mm thick

l_a = 835 + 20 = 855mm

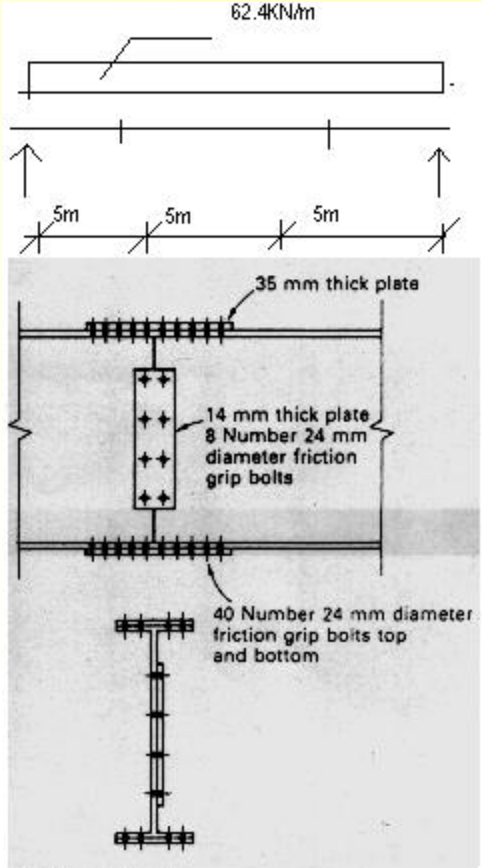
Flange force = 1560 X 10^6/855 = 1825KN

Assume 24mm diameter friction grip bolts

with a Single Shear Capacity = 102KN

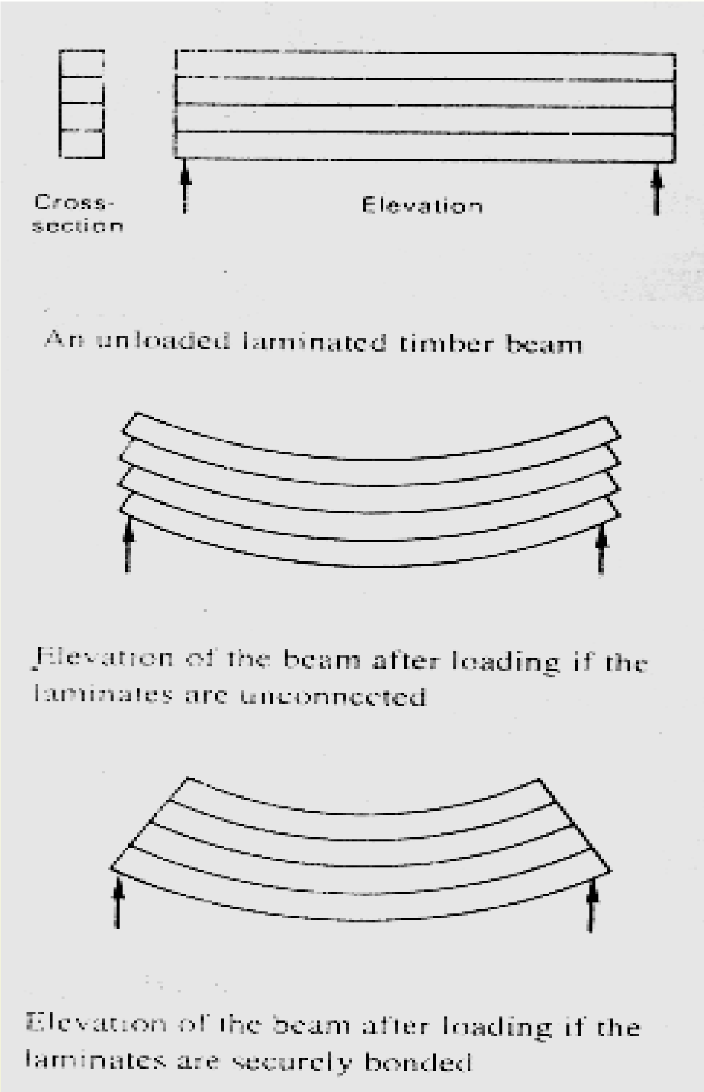
No of flange bolts 1825KN/102KN = 17.9(say 20 per side)

No of web bolts 156KN/102KN = 1.5 (say 4 per side)



The beam splice

PRINCIPLE 2 –
CONNECTIONS IN BUILT UP BEAMS



Source: D. Seward

- **Shear stress $\tau = \frac{VQ}{Ib}$ (used to evaluate stresses in adhesives)**
- **Shear flow $q = \frac{VQ}{I}$ (used to determine size of welds, spacing of connectors)**

EMAMPLE ON THE HORIZONTAL SHEAR STRESSED DEVELOPED

The timber built-up beam shown below is subjected to a design shear force V of 5KN.

a. If the flanges are attached by adhesive, what shear stress must it support?

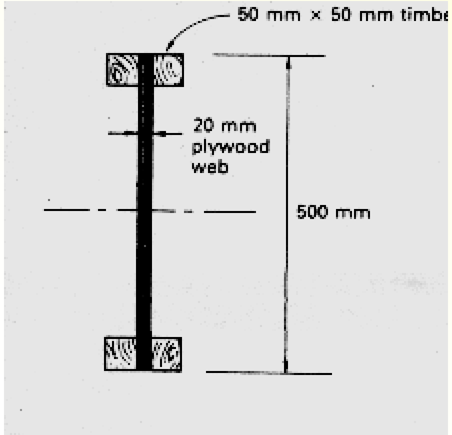
b. If the flanges are attached by nails, and each nail can support a shear load of 100 N, what is the required nail spacing?

Solution

$I_{NA} = I_{self(Web)} + I_{transfer\ (flanges)}$

$= 20 \times 500^3/12 + 2 \times 2 \times 50 \times 50 \times 225^2$

$= 714.6 \times 10^6\ mm^4$



A timber built-up beam

a. Shear stress, $\tau = \dfrac{VQ}{Ib} = \dfrac{5 \times 10^3 \times 50 \times 50 \times 225}{714.6 \times 10^6 \times 50}$

Answer: Shear stress = 0.079 N/mm²

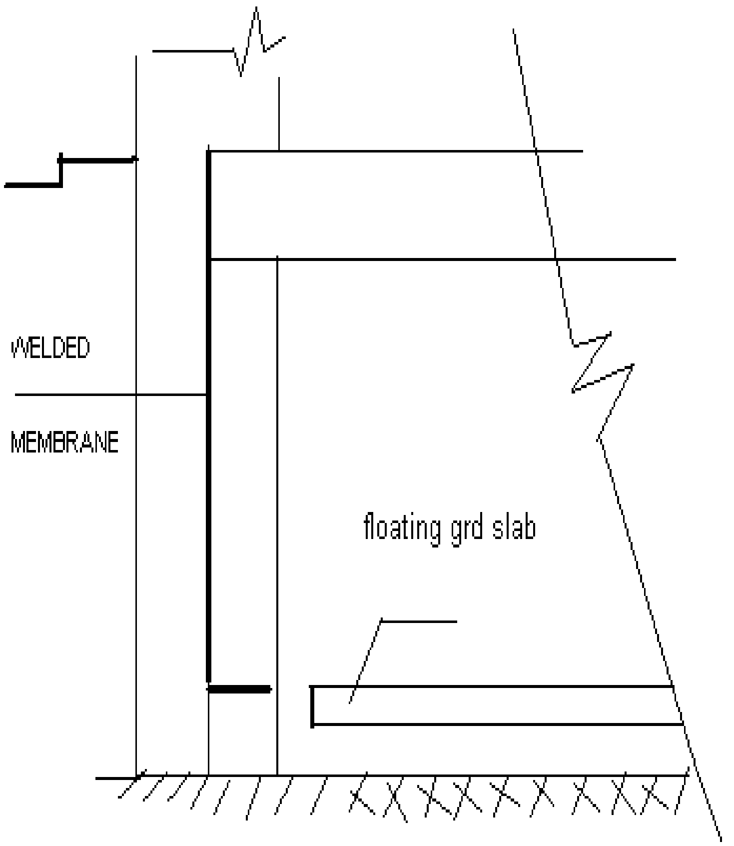
b. Shear flow = 0.079 X 50 = 3.95 N/mm

This means that, for every mm length of beam 3.95 N of shear force must be transmitted. However, one nail will transit 100N.

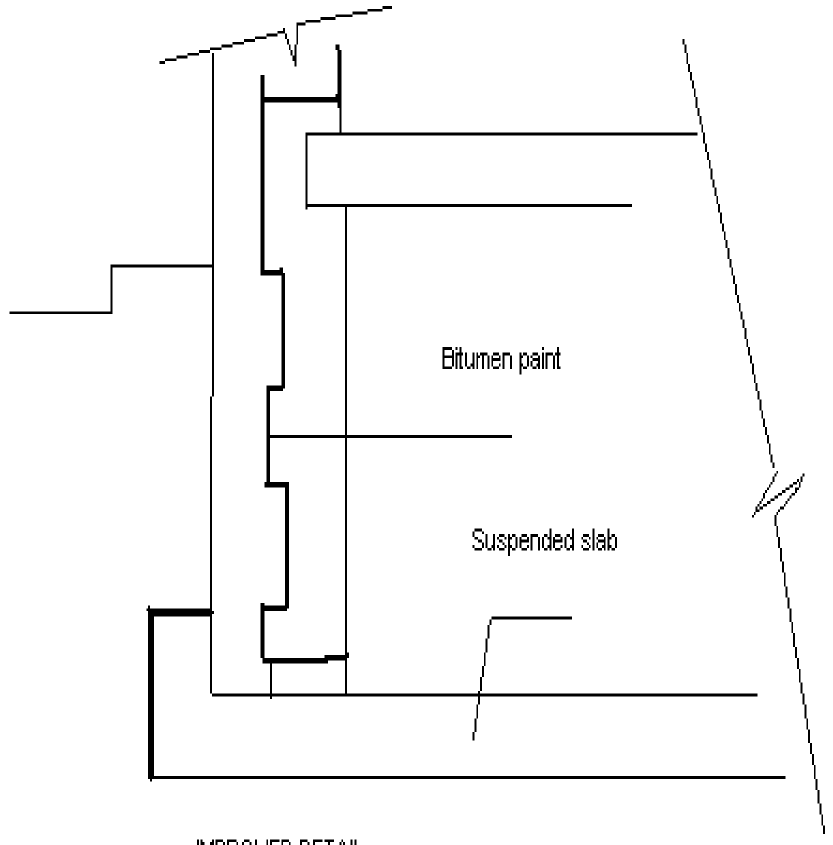
Answer: Nail spacing = $\dfrac{100}{3.95} = 25mm$

Source: D. Seward

WATER PROOFING BASEMENT WALLS



FAULTY DETAIL
Basement wall acts as 2 separate skins.
(no shear key) floating slab subjected to upward water pressure



IMPROVED DETAIL
Whole thickness of basement wall utilized suspended slab designed to take up lift

DETAILING FOR MASONRY WALL PANELS

a) The horizontal bed joints should be filled completely with mortar of mix 1:2:10 (iv) or 1:2:6 (iii), as strength of masonry panels may reduce by 33% with shell bedding effect introduced, failure to fill vertical joints has little effect on the compressive strength but are undesirable for weather and rain & fire, penetration and thermal/sound insulation.

b) Mortar bed joints thicker than 10mm result in a reduction of compressive strength of up to 25% for bed joints of 16 –19mm thickness.

c) Before laying mortar the block is to be well wetted to reduce its suction rate, plus a proportion of lime in the mortar mix will help the mortar mix to retain its water.

d) Regulation 6.02.4m gives the effective thickness for double walling where a bondstone exists as the total thickness (air-cavity < 100mm), whilst Regulation 6.02.4n gives it at 2/3 total thickness where metal ties used.

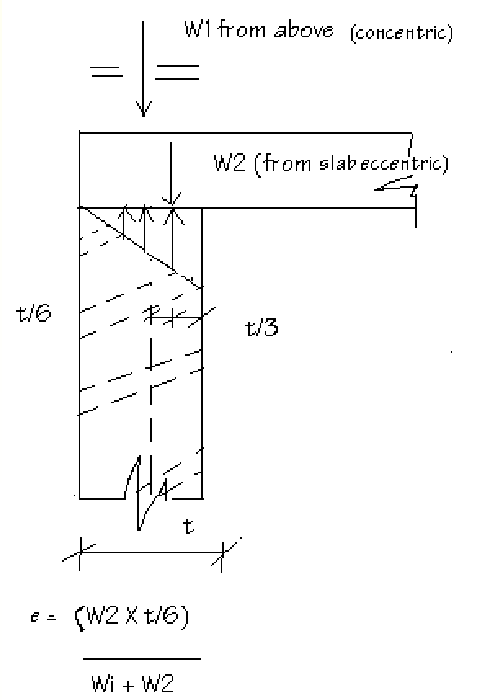
e) For low seismicity design thickness of load bearing walling to be >180mm, with Grade 3 mortar utilised. Slenderness ratio to be limited to h/15 instead of h/20.

STABILITY & FIXITY MOMENT DETAILS IN MASONRY CONSTRUCTION

Stability is considered for 5 storeys or above, but where a soft storey existing at ground floor, it is recommended to include stability reinforcement.

In large multi-storey terraced ware-houses stability detailing also to include effects for wind/seismic actions.

A simplified portal method sufficient.



SIMPLIFIED METHOD FIG - 1

Fixity Moment = (W1 + W2)e

PRINCIPLE 3 –
BEAMS IN REINFORCEMENT