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Evaluation of floodwater loading on domestic housing

Kail, S.

Kail, S. (2017) 'Evaluation of floodwater loading on domestic housing', The Plymouth Student Scientist, 10(2), p. 80-133.
http://hdl.handle.net/10026.1/14162

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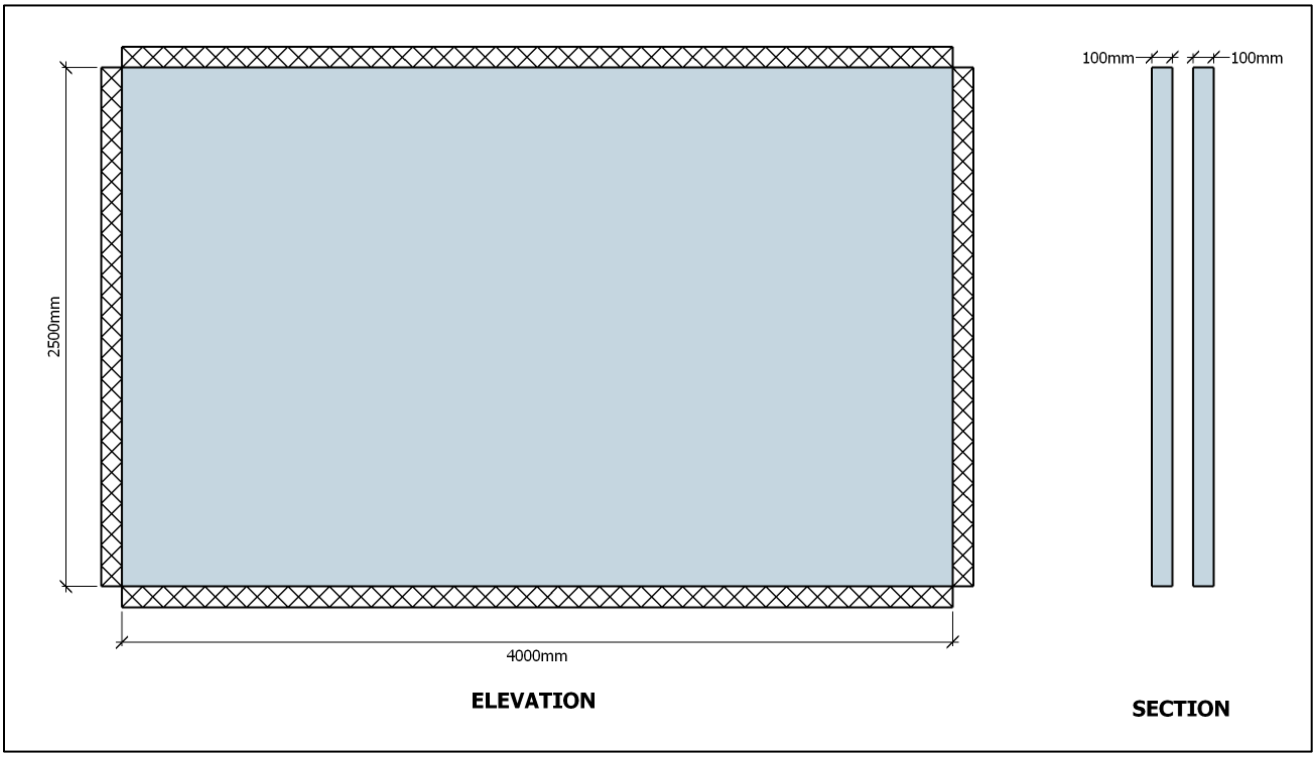
Appendix A - Elevation and section of the original wall panel studied



Appendix B - Moment of resistance parallel to the bed joints calculations for different wall constructions

MARINE SCIENCE & ENGINEERING WITH PLYMOUTH UNIVERSITY — School of Marine Science & Engineering	Job N°	Section	Sheet N° 1	Rev
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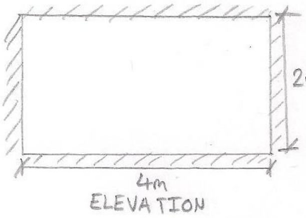
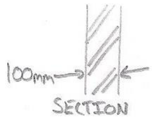
Project: Dissertation – PRCE 507 Project 2

Element: Moment of resistance parallel to bed joints for different wall constructions



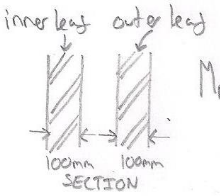
$$M_{Rd,1} = \left(\frac{f_{xk1}}{\gamma_M} + \sigma_d\right) Z$$

Taking f_{xk1} as 0.3 (M4 mortar with clay unit moisture absorption >12%), ignoring σ_d and taking γ_M as 3.



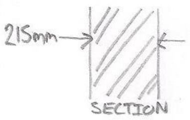
$$M_{Rd,1} = \left(\frac{0.3}{3}\right) \times \left[\frac{10^3 \times 100^2}{6}\right] \times 10^{-6}$$

$$= 0.167 \text{ kNm/m}$$



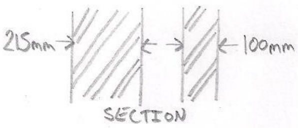
$$M_{Rd,1} = \left(\frac{0.3}{3}\right) \times \left[\frac{10^3 \times 100^2}{6} \times 2\right] \times 10^{-6}$$

$$= 0.333 \text{ kNm/m}$$



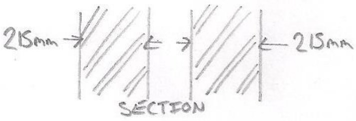
$$M_{Rd,1} = \left(\frac{0.3}{3}\right) \times \left[\frac{10^3 \times 215^2}{6}\right] \times 10^{-6}$$

$$= 0.770 \text{ kNm/m}$$



$$M_{Rd,1} = \left(\frac{0.3}{3}\right) \times \left[\frac{10^3 \times 215^2}{6} + \frac{10^3 \times 100^2}{6}\right] \times 10^{-6}$$

$$= 0.937 \text{ kNm/m}$$



$$M_{Rd,1} = \left(\frac{0.3}{3}\right) \times \left[\frac{10^3 \times 215^2}{6} \times 2\right] \times 10^{-6}$$

$$= 1.541 \text{ kNm/m}$$

Appendix C - Tabulated yield line calulation results for the panel observed in Section 2.1.1

Height/width of lower diagonal yield lines (m)	**Mp (kNm/m)**
0.1	0.035
0.2	0.045
0.3	0.06
0.4	0.084
0.5	0.114
0.6	0.139
0.7	0.154
0.8	0.166
0.9	0.177
1	0.187
1.2	0.202
1.5	0.219
2	0.216

Appendix D1 - 0.1m high/wide lower diagonal yield line calculation

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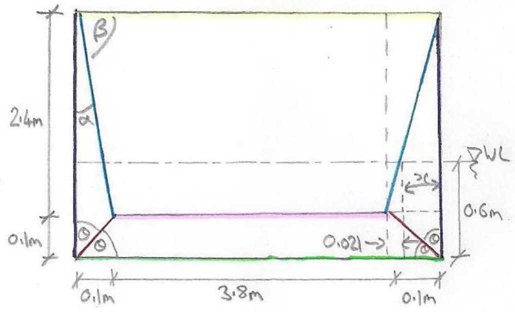
Project: Dissertation - PRCE507 Project 2

Element: 0.1m high/wide lower diagonal yield line - yield line analysis



$\theta = 45^\circ$

$\alpha = \tan^{-1}\left(\frac{0.1}{2.4}\right) = 2.386$

$2.386 \div 45 = 0.053\theta \quad \therefore \alpha = 0.053\theta$

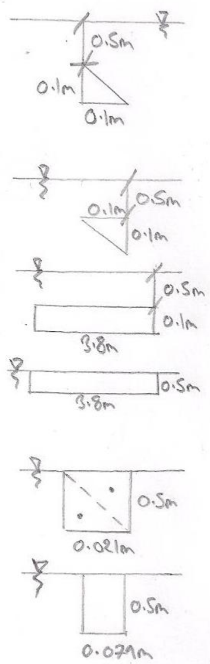
$2 - 0.053 = 1.947 \quad \therefore \beta = 1.947\theta$

$\tan(2.386) = \frac{x}{1.9}$

$x = 0.079\,m$

$0.1 - 0.079 = 0.021\,m$

EWD:



$Load = \rho \cdot g \cdot h_G \cdot A$

$= 1000 \times 9.81 \times (0.5 + \frac{2}{3} \times 0.1) \times \left(\frac{0.1 \times 0.1}{2}\right)$

$= 27.795N = \underline{0.028kN}$

$Load = 1000 \times 9.81 \times (0.5 + \frac{1}{3} \times 0.1) \times \left(\frac{0.1 \times 0.1}{2}\right)$

$= 26.160N = \underline{0.026kN}$

$Load = 1000 \times 9.81 \times (0.5 + 0.05) \times (0.1 \times 3.8)$

$= 2050.290N = \underline{2.050kN}$

$Load = 1000 \times 9.81 \times (0.25) \times (0.5 \times 3.8)$

$= 4659.750N = \underline{4.660kN}$

$Load = 1000 \times 9.81 \times 0.25 \times (0.5 \times 0.021)$

$= 25.751N = \underline{0.026kN}$

Upper triangle: $0.026 \times \frac{1}{3} = 8.667 \times 10^{-3}\,kN$

Lower triangle: $0.026 \times \frac{2}{3} = 0.017kN$

$Load = 1000 \times 9.81 \times 0.25 \times (0.5 \times 0.079)$

$= 96.874N = \underline{0.097kN}$

Project: Dissertation – PRCE507 Project 2

Element: 0.1m high/wide lower diagonal yield line – yield line analysis

$$EWD = \left[0.028\times\left(\frac{0.1\times0.1}{2}\right)\times\frac{\delta}{3}\right]\times2 + \left[0.026\times\left(\frac{0.1\times0.1}{2}\right)\times\frac{\delta}{3}\right]\times2 + \left[0.097\times(0.5\times0.079)\times\frac{\delta}{2}\right]\times2$$
$$+\left[4.660\times(0.5\times3.8)\times\frac{\delta}{2}\right] + \left[2.050\times(0.1\times3.8)\times\frac{\delta}{2}\right] + \left[8.667\times10^{-3}\times\left(\frac{0.5\times0.021}{2}\right)\times\frac{\delta}{3}\right]\times2$$
$$+\left[0.017\times\left(\frac{0.5\times0.021}{2}\right)\times\frac{\delta}{3}\right]\times2$$

$$EWD = 9.333\times10^{-5}\delta + 8.667\times10^{-5}\delta + 3.832\times10^{-3}\delta + 4.427\delta + 0.390\delta + 3.033\times10^{-5}\delta + 5.950\times10^{-5}\delta$$

$$EWD = \underline{4.821\delta}$$

$$IWD = [(M_p\times0.1\times\theta)\times2\times2] + \{[(M_p\times2.4\times0.053\theta)\times2] + [(M_p\times0.1\times1.947\theta)\times2]\} + \{[(M_p\times3.8\times\theta)] + [(M_p\times3.8\times\theta)]\}$$
$$+ (M_p\times4\times\theta) + (M_p\times4\times\theta) + [(M_p\times2.5\times\theta)\times2]$$

$$IWD = \left[\left(M_p\times0.1\times\frac{\delta}{0.1}\right)\times2\times2\right] + \left\{\left[\left(M_p\times2.4\times0.053\times\frac{\delta}{0.1}\right)\times2\right] + \left[\left(M_p\times0.1\times1.947\times\frac{\delta}{2.4}\right)\times2\right]\right\}$$
$$+\left\{\left[M_p\times3.8\times\frac{\delta}{0.1}\right] + \left[M_p\times3.8\times\frac{\delta}{2.4}\right]\right\} + \left(M_p\times4\times\frac{\delta}{2.4}\right) + \left(M_p\times4\times\frac{\delta}{0.1}\right) + \left[\left(M_p\times2.5\times\frac{\delta}{0.1}\right)\times2\right]$$

$$IWD = 4M_p\delta + (2.544M_p\delta + 0.162M_p\delta) + (38M_p\delta + 1.583M_p\delta) + 1.667M_p\delta + 40M_p\delta + 50M_p\delta$$

$$IWD = \underline{137.956M_p\delta}$$

$$EWD = IWD$$

$$4.821\delta = 137.956M_p\delta$$

$$\underline{\underline{M_p = 0.035\,kNm/m}}$$

Appendix D2 - 0.2m high/wide lower diagonal yield line calculation

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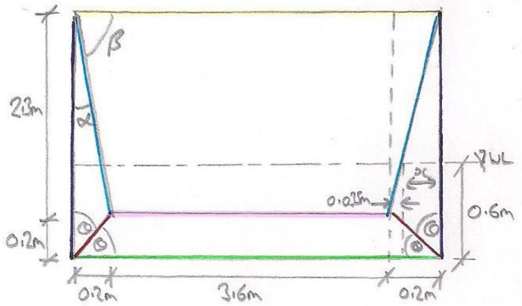
Project: Dissertation - PRCE507 Project 2

Element: 0.2m high/wide lower diagonal yield line - yield line analysis



$\theta = 45°$

$\alpha = \tan^{-1}\left(\frac{0.2}{2.3}\right) = 4.970$

$4.970 \div 45 = 0.110\theta \quad \therefore \alpha = 0.110\theta$

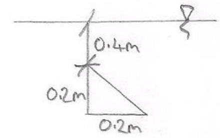
$2 - 0.110 = 1.890 \quad \therefore \beta = 1.890\theta$

$\tan(4.970) = \frac{x}{1.9}$

$x = 0.165m$

$0.2 - 0.165 = 0.035m$

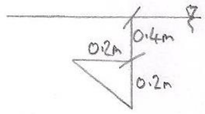
EWD:



$Load = \rho \cdot g \cdot h_G \cdot A$

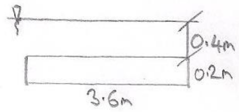
$= 1000 \times 9.81 \times (0.4 + \frac{2}{3} \times 0.2) \times \left(\frac{0.2 \times 0.2}{2}\right)$

$= 104.640N = \underline{0.105kN}$



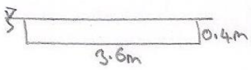
$Load = 1000 \times 9.81 \times (0.4 + \frac{1}{3} \times 0.2) \times \left(\frac{0.2 \times 0.2}{2}\right)$

$= 91.560N = \underline{0.092kN}$



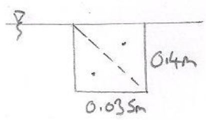
$Load = 1000 \times 9.81 \times (0.4 + 0.1) \times (0.2 \times 3.6)$

$= 3531.600N = \underline{3.532kN}$



$Load = 1000 \times 9.81 \times (0.2) \times (3.6 \times 0.4)$

$= 2825.280N = \underline{2.825kN}$

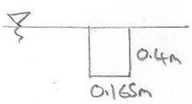


$Load = 1000 \times 9.81 \times 0.2 \times (0.4 \times 0.035)$

$= 27.468N = \underline{0.027kN}$

Upper triangle: $0.027 \times \frac{1}{3} = 9 \times 10^{-3} kN$

Lower triangle: $0.027 \times \frac{2}{3} = 0.018kN$



$Load = 1000 \times 9.81 \times 0.2 \times (0.4 \times 0.165)$

$= 129.492N = \underline{0.129kN}$

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Element: 0.2 high/wide lower diagonal yield line - yield line analysis

$$EWD=\left[0.105\times\left(\frac{0.2\times0.2}{2}\right)\times\frac{\delta}{3}\right]\times2+\left[0.092\times\left(\frac{0.2\times0.2}{2}\right)\times\frac{\delta}{3}\right]\times2+\left[3.532\times(0.2\times3.6)\times\frac{\delta}{2}\right]$$
$$+\left[2.825\times(0.4\times3.6)\times\frac{\delta}{2}\right]+\left[9\times10^{-3}\times\left(\frac{0.4\times0.035}{2}\right)\times\frac{\delta}{3}\right]\times2+\left[0.018\times\left(\frac{0.4\times0.035}{2}\right)\times\frac{\delta}{3}\right]\times2$$
$$+\left[0.129\times(0.4\times0.165)\times\frac{\delta}{2}\right]\times2$$

$$EWD=1.4\times10^{-3}\delta+1.227\times10^{-3}\delta+1.272\delta+2.034\delta+4.2\times10^{-5}\delta+8.4\times10^{-5}\delta+8.514\times10^{-3}\delta$$

$$EWD=\underline{3.317\delta}$$

$$IWD=\left[(M_p\times0.2\times\theta)\times2\times2\right]+\left\{\left[(M_p\times2.3\times0.11\theta)\times2\right]+\left[(M_p\times0.2\times1.89\theta)\times2\right]\right\}+\left[(M_p\times3.6\times\theta)+(M_p\times3.6\times\theta)\right]$$
$$+(M_p\times4\times\theta)+(M_p\times4\times\theta)+\left[(M_p\times2.5\times\theta)\times2\right]$$

$$IWD=\left[\left(M_p\times0.2\times\frac{\delta}{0.2}\right)\times2\times2\right]+\left\{\left[\left(M_p\times2.3\times0.11\times\frac{\delta}{0.2}\right)\times2\right]+\left[\left(M_p\times0.2\times1.89\times\frac{\delta}{2.3}\right)\times2\right]\right\}+\left[\left(M_p\times3.6\times\frac{\delta}{0.2}\right)+\left(M_p\times3.6\times\frac{\delta}{2.3}\right)\right]$$
$$+\left(M_p\times4\times\frac{\delta}{2.3}\right)+\left(M_p\times4\times\frac{\delta}{0.2}\right)+\left[\left(M_p\times2.5\times\frac{\delta}{0.2}\right)\times2\right]$$

$$IWD=4M_p\delta+(2.53M_p\delta+0.329M_p\delta)+(18M_p\delta+1.565M_p\delta)+1.739M_p\delta+20M_p\delta+25M_p\delta$$

$$IWD=\underline{73.163M_p\delta}$$

$$EWD=IWD$$

$$3.317\delta=73.163M_p\delta$$

$$\underline{\underline{M_p=0.045\ kNm/m}}$$

Appendix D3 - 0.3m high/wide lower diagonal yield line calculation

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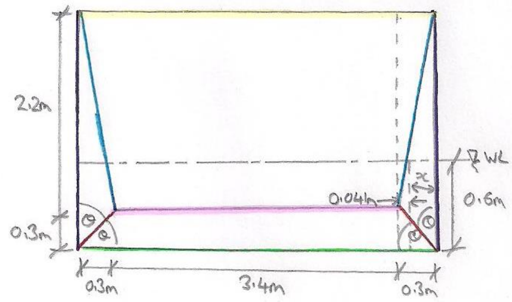
Element: 0.3m high/wide lower diagonal yield line – yield line analysis



$\theta = 45^\circ$

$\alpha = \tan^{-1}\left(\frac{0.3}{2.2}\right) = 7.765$

$7.765 \div 45 = 0.173\theta \quad \therefore \alpha = 0.173\theta$

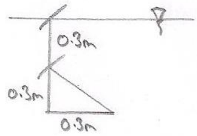
$2 - 0.173 = 1.827 \quad \therefore \beta = 1.827\theta$

$\tan(7.765) = \frac{x}{1.9}$

$x = 0.259\text{m}$

$0.3 - 0.259 = 0.041\text{m}$

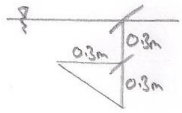
EWD:



$Load = \rho \cdot g \cdot h_G \cdot A$

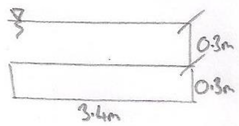
$= 1000 \times 9.81 \times (0.3 + \frac{2}{3} \times 0.3) \times \left(\frac{0.3 \times 0.3}{2}\right)$

$= 220.725\text{N} = \underline{0.221\text{kN}}$



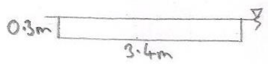
$Load = 1000 \times 9.81 \times (0.3 + \frac{1}{3} \times 0.3) \times \left(\frac{0.3 \times 0.3}{2}\right)$

$= 176.580\text{N} = \underline{0.177\text{kN}}$



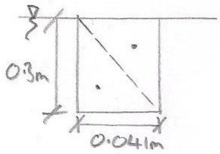
$Load = 1000 \times 9.81 \times (0.3 + 0.15) \times (0.3 \times 3.4)$

$= 4502.790\text{N} = \underline{4.503\text{kN}}$



$Load = 1000 \times 9.81 \times 0.15 \times (0.3 \times 3.4)$

$= 1500.930\text{N} = \underline{1.501\text{kN}}$

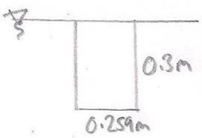


$Load = 1000 \times 9.81 \times 0.15 \times (0.3 \times 0.041)$

$= 18.0995\text{N} = \underline{0.018\text{kN}}$

Upper triangle: $0.018 \times \frac{1}{3} = 6 \times 10^{-3}\text{kN}$

Lower triangle: $0.018 \times \frac{2}{3} = 0.012\text{kN}$



$Load = 1000 \times 9.81 \times 0.15 \times (0.3 \times 0.259)$

$= 114.336\text{N} = \underline{0.114\text{kN}}$

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Project: Dissertation - PRCE507 Project 2

Element: 0.3m high/wide lower diagonal yield line - yield line analysis

$$EWD = \left[0.221\times\left(\frac{0.3\times0.3}{2}\right)\times\frac{\delta}{3}\right]\times2 + \left[0.177\times\left(\frac{0.3\times0.3}{2}\right)\times\frac{\delta}{3}\right]\times2 + \left[4.503\times(0.3\times3.4)\times\frac{\delta}{2}\right] + \left[1.501\times(0.3\times3.4)\times\frac{\delta}{2}\right] + \left[6\times10^{-3}\times\left(\frac{0.041\times0.3}{2}\right)\times\frac{\delta}{3}\right]\times2 + \left[0.012\times\left(\frac{0.041\times0.3}{2}\right)\times\frac{\delta}{3}\right]\times2 + \left[0.114\times(0.3\times0.259)\times\frac{\delta}{2}\right]\times2$$

$$EWD = 6.630\times10^{-3}\delta + 5.31\times10^{-3}\delta + 2.297\delta + 0.766\delta + 2.460\times10^{-5}\delta + 4.920\times10^{-5}\delta + 8.858\times10^{-3}\delta$$

$$\underline{EWD = 3.084\delta}$$

$$IWD = [(M_p\times0.3\times\theta)\times2\times2] + \{[(M_p\times2.2\times0.17\theta)\times2] + [(M_p\times0.3\times1.83\theta)\times2]\} + [(M_p\times3.4\times\theta) + (M_p\times3.4\times\theta)] + (M_p\times4\times\theta) + (M_p\times4\times\theta) + [(M_p\times2.5\times\theta)\times2]$$

$$IWD = \left[\left(M_p\times0.3\times\frac{\delta}{0.3}\right)\times2\times2\right] + \left\{\left[\left(M_p\times2.2\times0.17\times\frac{\delta}{0.3}\right)\times2\right] + \left[\left(M_p\times0.3\times1.83\times\frac{\delta}{2.2}\right)\times2\right]\right\} + \left[\left(M_p\times3.4\times\frac{\delta}{0.3}\right) + \left(M_p\times3.4\times\frac{\delta}{2.2}\right)\right] + \left(M_p\times4\times\frac{\delta}{2.2}\right) + \left(M_p\times4\times\frac{\delta}{0.3}\right) + \left[\left(M_p\times2.5\times\frac{\delta}{0.3}\right)\times2\right]$$

$$IWD = 4M_p\delta + (2.493M_p\delta + 0.499M_p\delta) + (11.333M_p\delta + 1.545M_p\delta) + 1.818M_p\delta + 13.333M_p\delta + 16.667M_p\delta$$

$$IWD = 51.688M_p\delta$$

$$EWD = IWD$$

$$3.084\delta = 51.688M_p\delta$$

$$\underline{M_p = 0.060\ \text{kNm/m}}$$

Appendix D4 - 0.4m high/wide lower diagonal yield line calculation

MARINE SCIENCE & ENGINEERING WITH PLYMOUTH UNIVERSITY **School of Marine Science & Engineering**

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Engineer	SK	Checked	
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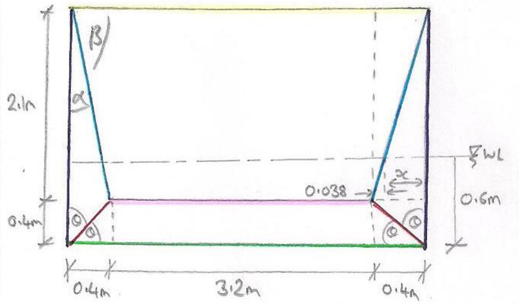
Project: Dissertation - PRCE507 Project 2

Element: 0.4m high/wide lower diagonal yield line - yield line analysis



$\theta = 45°$

$\alpha = \tan^{-1}\left(\frac{0.4}{2.1}\right) = 10.784$

$10.784 \div 45 = 0.240$ $\therefore \alpha = 0.240\theta$

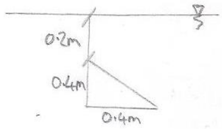
$2 - 0.240 = 1.760$ $\therefore \beta = 1.760\theta$

$\tan(10.784) = \frac{x}{1.9}$

$x = 0.362m$

$0.4 - 0.362 = 0.038m$

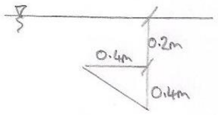
FWD:



$Load = \rho \cdot g \cdot h_G \cdot A$

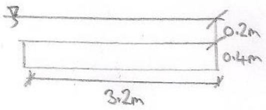
$= 1000 \times 9.81 \times (0.2 + \frac{2}{3} \times 0.4) \times \left(\frac{0.4 \times 0.4}{2}\right)$

$= 366.240N = \underline{0.366kN}$



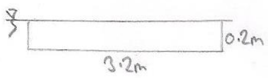
$Load = 1000 \times 9.81 \times (0.2 + \frac{1}{3} \times 0.4) \times \left(\frac{0.4 \times 0.4}{2}\right)$

$= 261.600N = \underline{0.262kN}$



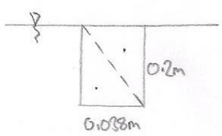
$Load = 1000 \times 9.81 \times 0.4 \times (0.4 \times 3.2)$

$= 5022.720N = \underline{5.023kN}$



$Load = 1000 \times 9.81 \times 0.1 \times (0.2 \times 3.2)$

$= 627.840N = \underline{0.628kN}$

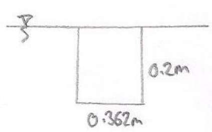


$Load = 1000 \times 9.81 \times 0.1 \times (0.2 \times 0.038)$

$= 7.456N = \underline{0.007kN}$

Upper triangle: $0.007 \times \frac{1}{3} = 0.002kN$

Lower triangle: $0.007 \times \frac{2}{3} = 0.005kN$



$Load = 1000 \times 9.81 \times 0.1 \times (0.2 \times 0.362)$

$= 71.024N = \underline{0.071kN}$

MARINE SCIENCE & ENGINEERING WITH PLYMOUTH UNIVERSITY	School of Marine Science & Engineering	Job No.	Section	Sheet No. 2	Rev
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Project: Dissertation - PRCE507 Project 2

Element: 0.4m high/wide lower diagonal yield line - yield line analysis

$$EWD = \left[0.366 \times \left(\frac{0.4 \times 0.4}{2}\right) \times \frac{\delta}{3}\right] \times 2 + \left[0.262 \times \left(\frac{0.4 \times 0.4}{2}\right) \times \frac{\delta}{3}\right] \times 2 + \left[5.023 \times (0.4 \times 3.2) \times \frac{\delta}{2}\right]$$
$$+ \left[0.628 \times (0.2 \times 3.2) \times \frac{\delta}{2}\right] + \left[0.002 \times \left(\frac{0.2 \times 0.038}{2}\right) \times \frac{\delta}{3}\right] \times 2 + \left[0.005 \times \left(\frac{0.2 \times 0.038}{2}\right) \times \frac{\delta}{3}\right] \times 2 + \left[0.071 \times (0.2 \times 0.362) \times \frac{\delta}{2}\right] \times 2$$

$$EWD = 0.020\delta + 0.014\delta + 3.215\delta + 0.201\delta + 5.067 \times 10^{-6}\delta + 1.267 \times 10^{-5}\delta + 5.140 \times 10^{-3}\delta$$

$$\underline{EWD = 3.455\delta}$$

$$IWD = [(M_p \times 0.4 \times \theta) \times 2 \times 2] + \{[(M_p \times 2.1 \times 0.24\theta) \times 2 + [(M_p \times 0.4 \times 1.76\theta) \times 2]\} + [(M_p \times 3.2 \times \theta) + (M_p \times 3.2 \times \theta)]$$
$$+ (M_p \times 4 \times \theta) + (M_p \times 4 \times \theta) + [(M_p \times 2.5 \times \theta) \times 2]$$

$$IWD = \left[\left(M_p \times 0.4 \times \frac{\delta}{0.4}\right) \times 2 \times 2\right] + \left\{\left[\left(M_p \times 2.1 \times 0.24 \times \frac{\delta}{0.4}\right) \times 2 + \left[\left(M_p \times 0.4 \times 1.76 \times \frac{\delta}{2.1}\right) \times 2\right]\right\} + \left[\left(M_p \times 3.2 \times \frac{\delta}{0.4}\right) + \left(M_p \times 3.2 \times \frac{\delta}{2.1}\right)\right]$$
$$+ \left(M_p \times 4 \times \frac{\delta}{2.1}\right) + \left(M_p \times 4 \times \frac{\delta}{0.4}\right) + \left[\left(M_p \times 2.5 \times \frac{\delta}{0.4}\right) \times 2\right]$$

$$IWD = 4M_p\delta + (2.520M_p\delta + 0.670M_p\delta) + (8M_p\delta + 1.524M_p\delta) + 1.905M_p\delta + 10M_p\delta + 12.5M_p\delta$$

$$IWD = \underline{41.119M_p\delta}$$

$$EWD = IWD$$

$$3.455\delta = 41.119M_p\delta$$

$$\underline{\underline{M_p = 0.084 \text{ kNm/m}}}$$

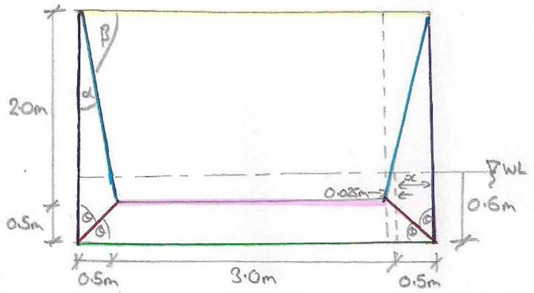
Appendix D5 - 0.5m high/wide lower diagonal yield line calculation

MARINE SCIENCE & ENGINEERING WITH PLYMOUTH UNIVERSITY **School of Marine Science & Engineering**

Job No		Section		Sheet No	1	Rev	
Engineer	SK	Checked					
Date	24/11/15	Rev. Date					

Project: Dissertation - PRCE507 Project 2

Element: 0.5m high/wide lower diagonal yield line - yield line analysis



$\theta = 45°$

$\alpha = \tan^{-1}\left(\frac{0.5}{2.0}\right) = 14.036$

$14.036 \div 45 = 0.312 \quad \therefore \alpha = 0.312\theta$

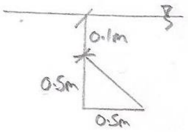
$2 - 0.312 = 1.688 \quad \therefore \beta = 1.688\theta$

$\tan(14.036) = \frac{x}{1.9}$

$x = 0.475m$

$0.5 - 0.475 = 0.025m$

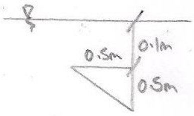
EWD:



$Load = \rho \cdot g \cdot h_G \cdot A$

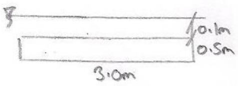
$= 1000 \times 9.81 \times (0.1 + \frac{2}{3} \times 0.5) \times \left(\frac{0.5 \times 0.5}{2}\right)$

$= 531.375N = \underline{0.531kN}$



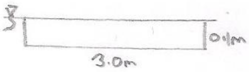
$Load = 1000 \times 9.81 \times (0.1 + \frac{1}{3} \times 0.5) \times \left(\frac{0.5 \times 0.5}{2}\right)$

$= 327.000N = \underline{327.000kN}$



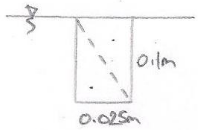
$Load = 1000 \times 9.81 \times (0.1 + \frac{0.5}{2}) \times (0.5 \times 3.0)$

$= 5150.250N = \underline{5.150kN}$



$Load = 1000 \times 9.81 \times \left(\frac{0.1}{2}\right) \times (0.1 \times 3)$

$= 147.150N = \underline{0.147kN}$

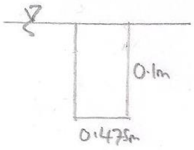


$Load = 1000 \times 9.81 \times \left(\frac{0.1}{2}\right) \times (0.1 \times 0.025)$

$= 1.226N = \underline{0.001kN}$

Upper triangle: $0.001 \times \frac{1}{3} = 0.0003kN$

Lower triangle: $0.001 \times \frac{2}{3} = 0.0007kN$



$Load = 1000 \times 9.81 \times \left(\frac{0.1}{2}\right) \times (0.1 \times 0.475)$

$= 23.299N = \underline{0.023kN}$

School of Marine Science & Engineering (Marine Science & Engineering with Plymouth University)	Job No.	Section	Sheet No. 2	Rev
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Project: Dissertation - PRCE507 Project 2

Element: 0.5m high/wide lower diagonal yield line - yield line analysis

$$EWD=\left[0.531\times\left(\frac{0.5\times0.5}{2}\right)\times\frac{\delta}{3}\right]\times2+\left[0.327\times\left(\frac{0.5\times0.5}{2}\right)\times\frac{\delta}{3}\right]\times2+\left[5.150\times(3\times0.5)\times\frac{\delta}{2}\right]$$
$$+\left[0.147\times(0.1\times3)\times\frac{\delta}{2}\right]+\left[0.0003\times\left(\frac{0.1\times0.025}{2}\right)\times\frac{\delta}{3}\right]\times2+\left[0.007\times\left(\frac{0.1\times0.025}{2}\right)\times\frac{\delta}{3}\right]\times2$$
$$+\left[0.023\times(0.475\times0.1)\times\frac{\delta}{2}\right]\times2$$

$$EWD=0.044\delta+0.027\delta+3.863\delta+0.022\delta+2.5\times10^{-7}\delta+5.833\times10^{-7}\delta+1.093\times10^{-3}\delta$$

$$EWD=3.957\delta$$

$$IWD=\left[(M_p\times0.5\times\theta)\times2\times2\right]+\left\{\left[(M_p\times2\times0.31\theta)\times2\right]+\left[(M_p\times0.5\times1.69\theta)\times2\right]\right\}+\left[(M_p\times3.0\times\theta)+(M_p\times3.0\times\theta)\right]$$
$$+(M_p\times4\times\theta)+(M_p\times4\times\theta)+\left[(M_p\times2.5\times\theta)\times2\right]$$

$$IWD=\left[(M_p\times0.5\times\frac{\delta}{0.5})\times2\times2\right]+\left\{\left[(M_p\times2\times0.31\times\frac{\delta}{0.5})\times2\right]+\left[(M_p\times0.5\times1.69\times\frac{\delta}{2.0})\times2\right]\right\}$$
$$+\left[(M_p\times3.0\times\frac{\delta}{2.0})+(M_p\times3.0\times\frac{\delta}{0.5})\right]+(M_p\times4\times\frac{\delta}{2.0})+(M_p\times4\times\frac{\delta}{0.5})+\left[(M_p\times2.5\times\frac{\delta}{0.5})\times2\right]$$

$$IWD=4M_p\delta+(2.480M_p+0.845M_p)+(1.5M_p\delta+6M_p\delta)+2M_p\delta+8M_p\delta+10M_p\delta$$

$$IWD=34.825M_p\delta$$

$$EWD=IWD$$

$$3.957\delta=34.825M_p\delta$$

$$M_p=0.114\,kNm/m$$

Appendix D6 - 0.6m high/wide lower diagonal yield line calculation

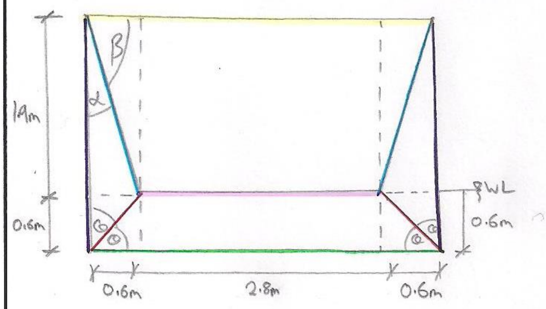
MARINE SCIENCE & ENGINEERING WITH PLYMOUTH UNIVERSITY

School of Marine Science & Engineering

Job No.	Section	Sheet No.	Rev
		1	
Engineer	SK	Checked	
Date	24/11/15	Rev. Date	

Project: Dissertation - PRCE507 Project

Element: 0.6m high/wide lower diagonal yield line - yield line analysis



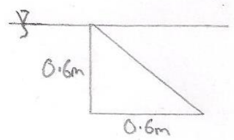
$\theta = 45^\circ$

$\alpha = \tan^{-1}\left(\frac{0.6}{1.9}\right) = 17.526$

$17.526 \div 45 = 0.389 \quad \therefore \alpha = 0.389\theta$

$2 - 0.389 = 1.611 \quad \therefore \beta = 1.611\theta$

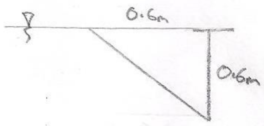
EWD:



$Load = \rho \cdot g \cdot h_G \cdot A$

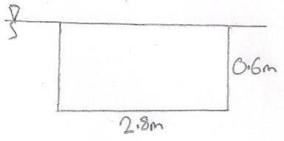
$= 1000 \times 9.81 \times \left(\frac{2}{3} \times 0.6\right) \times \left(\frac{0.6 \times 0.6}{2}\right)$

$= 706.320N = \underline{0.706kN}$



$Load = 1000 \times 9.81 \times \left(\frac{1}{3} \times 0.6\right) \times \left(\frac{0.6 \times 0.6}{2}\right)$

$= 353.160N = \underline{0.353kN}$



$Load = 1000 \times 9.81 \times \frac{0.6}{2} \times (0.6 \times 2.8)$

$= 4944.240N = \underline{4.944kN}$

MARINE SCIENCE & ENGINEERING WITH PLYMOUTH UNIVERSITY — School of Marine Science & Engineering	Job No.		Section		Sheet No. 2		Rev	
	Engineer	SK	Checked					
	Date	24/11/15	Rev. Date					

Project: Dissertation - PRCE507 Project 2

Element: 0.6m high/wide lower diagonal yield line - yield line analysis

$$EWD=\left[0.706\times\left(\frac{0.6\times0.6}{2}\right)\times\frac{\delta}{3}\right]\times2+\left[0.353\times\left(\frac{0.6\times0.6}{2}\right)\times\frac{\delta}{3}\right]\times2+\left[4.944\times(2.8\times0.6)\times\frac{\delta}{2}\right]$$

$$EWD=0.085\delta+0.042\delta+4.153\delta$$

$$EWD=\underline{4.280\delta}$$

$$IWD=[(M_p\times0.6\times\theta)\times2\times2]+\{[(M_p\times1.9\times0.39\theta)\times2+(M_p\times0.6\times1.61\theta)\times2]\}+[(M_p\times2.8\times\theta)+(M_p\times2.8\times\theta)]$$
$$+(M_p\times4\times\theta)+(M_p\times4\times\theta)+[(M_p\times2.5\times\theta)\times2]$$

$$IWD=\left[\left(M_p\times0.6\times\frac{\delta}{0.6}\right)\times2\times2\right]+\left\{\left[\left(M_p\times1.9\times0.39\times\frac{\delta}{0.6}\right)\times2+\left(M_p\times0.6\times1.61\times\frac{\delta}{1.9}\right)\times2\right]\right\}$$
$$+\left[\left(M_p\times2.8\times\frac{\delta}{0.6}\right)+\left(M_p\times2.8\times\frac{\delta}{1.9}\right)\right]+\left(M_p\times4\times\frac{\delta}{1.9}\right)+\left(M_p\times4\times\frac{\delta}{0.6}\right)+\left[\left(M_p\times2.5\times\frac{\delta}{0.6}\right)\times2\right]$$

$$IWD=4M_p\delta+(2.470M_p\delta+1.017M_p\delta)+(4.667M_p\delta+1.474M_p\delta)+2.105M_p\delta+6.667M_p\delta+8.333M_p\delta$$

$$IWD=\underline{30.733M_p\delta}$$

$$EWD=IWD$$

$$4.280\delta=30.733M_p\delta$$

$$\underline{\underline{M_p=0.139\,kNm/m}}$$

Appendix D7 - 0.7m high/wide lower diagonal yield line calculation

MARINE SCIENCE & ENGINEERING WITH PLYMOUTH UNIVERSITY — School of Marine Science & Engineering	Job N°		Section		Sheet N° 1		Rev	
	Engineer	SK			Checked			
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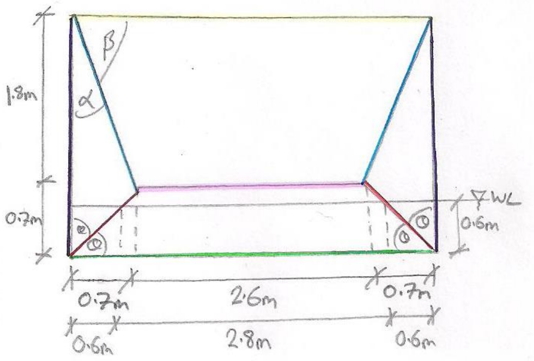
Project: Dissertation - PRCE507 Project 2

Element: 0.7m high/wide lower diagonal yield line - yield line analysis



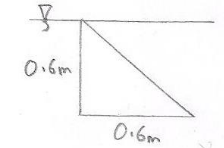
$\Theta = 45°$

$\alpha = \tan^{-1}\left(\frac{0.7}{1.8}\right) = 21.251°$

$21.251 \div 45 = 0.47 \quad \therefore \alpha = 0.47\Theta$

$2 - 0.47 = 1.53 \quad \therefore \beta = 1.53\Theta$

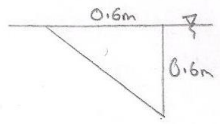
FWD:



$Load = \rho \cdot g \cdot h_c \cdot A$

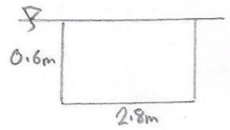
$= 1000 \times 9.81 \times \left(\frac{2}{3} \times 0.6\right) \times \left(\frac{0.6 \times 0.6}{2}\right)$

$= 706.320N = \underline{0.706kN}$



$Load = 1000 \times 9.81 \times \left(\frac{1}{3} \times 0.6\right) \times \left(\frac{0.6 \times 0.6}{2}\right)$

$= 353.160N = \underline{0.353kN}$



$Load = 1000 \times 9.81 \times \frac{0.6}{2} \times (0.6 \times 2.8)$

$= 4944.240N = \underline{4.944kN}$

MARINE SCIENCE & ENGINEERING WITH PLYMOUTH UNIVERSITY

School of Marine Science & Engineering

Job No.		Section		Sheet No.	2	Rev	
Engineer	SK	Checked					
Date	24/11/15	Rev. Date					

Project: Dissertation - PRCE507 Project 2

Element: 0.7m high/wide lower diagonal yield line - yield line analysis

$$EWD = \left[0.706 \times \left(\frac{0.6 \times 0.6}{2}\right) \times \frac{\delta}{3}\right] \times 2 + \left[0.353 \times \left(\frac{0.6 \times 0.6}{2}\right) \times \frac{\delta}{3}\right] \times 2 + \left[4.944 \times (2.8 \times 0.6) \times \frac{\delta}{2}\right]$$

$$EWD = 0.085\delta + 0.042\delta + 4.153\delta$$

$$EWD = \underline{4.280\delta}$$

$$IWD = \left[(M_p \times 0.7 \times \theta) \times 2 \times 2\right] + \left\{\left[(M_p \times 1.8 \times 0.47\theta) \times 2\right] + \left[(M_p \times 0.7 \times 1.53\theta) \times 2\right]\right\} + \left[(M_p \times 2.6 \times \theta) + (M_p \times 2.6 \times \theta)\right] + (M_p \times 4 \times \theta) + (M_p \times 4 \times \theta) + \left[(M_p \times 2.5 \times \theta) \times 2\right]$$

$$IWD = \left[\left(M_p \times 0.7 \times \frac{\delta}{0.7}\right) \times 2 \times 2\right] + \left\{\left[\left(M_p \times 1.8 \times 0.47 \times \frac{\delta}{0.7}\right) \times 2\right] + \left[\left(M_p \times 0.7 \times 1.53 \times \frac{\delta}{1.8}\right) \times 2\right]\right\} + \left[\left(M_p \times 2.6 \times \frac{\delta}{0.7}\right) + \left(M_p \times 2.6 \times \frac{\delta}{1.8}\right)\right] + \left(M_p \times 4 \times \frac{\delta}{1.8}\right) + \left(M_p \times 4 \times \frac{\delta}{0.7}\right) + \left[\left(M_p \times 2.5 \times \frac{\delta}{0.7}\right) \times 2\right]$$

$$IWD = 4M_p\delta + (2.417M_p\delta + 1.190M_p\delta) + (3.714M_p\delta + 1.444M_p\delta) + 2.222M_p\delta + 5.714M_p\delta + 7.143M_p\delta$$

$$IWD = 27.844M_p\delta$$

$$EWD = IWD$$

$$4.280\delta = 27.844M_p\delta$$

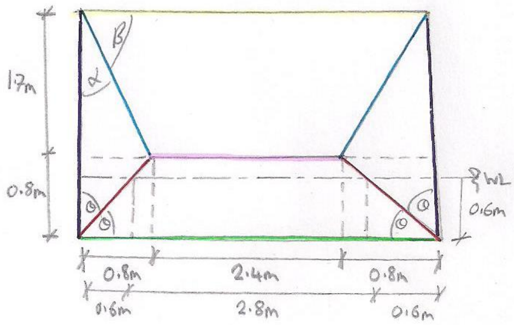
$$\underline{M_p = 0.154 \text{ kNm/m}}$$

Appendix D8 - 0.8m high/wide lower diagonal yield line calculation

MARINE SCIENCE & ENGINEERING WITH PLYMOUTH UNIVERSITY — **School of Marine Science & Engineering**	Job No.		Section		Sheet No. 1	Rev
	Engineer	SK	Checked			
	Date	24/11/15	Rev. Date			

Project: Dissertation – PRCE507 Project 2

Element: 0.8m high/wide lower diagonal yield line – yield line analysis



$\theta = 45°$

$\alpha = \tan^{-1}\left(\frac{0.8}{1.7}\right) = 25.201°$

$25.201 \div 45 = 0.560 \quad \therefore \alpha = 0.560\theta$

$2 - 0.560 = 1.440 \quad \therefore \beta = 1.440\theta$

$EWD = \underline{4.280\delta}$ (Same as in '0.6m high/wide lower diagonal yield line – yield line analysis')

$IWD = [(M_p \times 0.8 \times \theta) \times 2 \times 2] + \{[(M_p \times 1.7 \times 0.560\theta) \times 2] + [(M_p \times 0.8 \times 1.440\theta) \times 2]\} + [(M_p \times 2.4 \times \theta) + (M_p \times 2.4 \times \theta)] + (M_p \times 4 \times \theta) + (M_p \times 4 \times \theta) + [(M_p \times 2.5 \times \theta) \times 2]$

$IWD = [(M_p \times 0.8 \times \frac{\delta}{0.8}) \times 2 \times 2] + \{[(M_p \times 1.7 \times 0.56 \times \frac{\delta}{0.8}) \times 2] + [(M_p \times 0.8 \times 1.44 \times \frac{\delta}{1.7}) \times 2]\} + [(M_p \times 2.4 \times \frac{\delta}{0.8}) + (M_p \times 2.4 \times \frac{\delta}{1.7})] + (M_p \times 4 \times \frac{\delta}{1.7}) + (M_p \times 4 \times \frac{\delta}{0.8}) + [(M_p \times 2.5 \times \frac{\delta}{0.8}) \times 2]$

$IWD = 4M_p\delta + (2.380M_p\delta + 1.355M_p\delta) + (3M_p\delta + 1.412M_p\delta) + 2.353M_p\delta + 5M_p\delta + 6.250M_p\delta$

$IWD = \underline{25.750M_p\delta}$

$EWD = IWD$

$4.280\delta = 25.750M_p\delta$

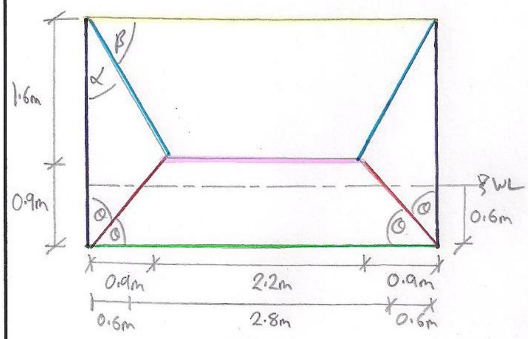
$\underline{M_p = 0.166 \text{ kNm/m}}$

Appendix D9 - 0.9m high/wide lower diagonal yield line calculation

MARINE SCIENCE & ENGINEERING WITH PLYMOUTH UNIVERSITY — **School of Marine Science & Engineering**	Job No	Section	Sheet No 1	Rev
	Engineer	SK	Checked	
	Date	24/11/15	Rev. Date	

Project: Dissertation – PRCE507 Project 2

Element: 0.9m high/wide lower diagonal yield line - yield line analysis



$\theta = 45°$

$\alpha = \tan^{-1}\left(\frac{0.9}{1.6}\right) = 29.358°$

$29.358 \div 45 = 0.652 \quad \therefore \alpha = 0.652\theta$

$2 - 0.652 = 1.348 \quad \therefore \beta = 1.348\theta$

$EWD = \underline{4.280\delta}$ (Same as in '0.6m high/wide lower diagonal yield line - yield line analysis')

$IWD = [(M_p \times 0.9 \times \theta) \times 2 \times 2] + \{[(M_p \times 1.6 \times 0.65\theta) \times 2] + [(M_p \times 0.9 \times 1.35\theta) \times 2]\} + [(M_p \times 2.2 \times \theta) + (M_p \times 2.2 \times \theta)]$
$+ (M_p \times 4 \times \theta) + (M_p \times 4 \times \theta) + [(M_p \times 2.5 \times \theta) \times 2]$

$IWD = [(M_p \times 0.9 \times \frac{\delta}{0.9}) \times 2 \times 2] + \{[(M_p \times 1.6 \times 0.65 \times \frac{\delta}{0.9}) \times 2] + [(M_p \times 0.9 \times 1.35 \times \frac{\delta}{1.6}) \times 2]\} + [(M_p \times 2.2 \times \frac{\delta}{0.9}) + (M_p \times 2.2 \times \frac{\delta}{1.6})]$
$+ (M_p \times 4 \times \frac{\delta}{1.6}) + (M_p \times 4 \times \frac{\delta}{0.9}) + [(M_p \times 2.5 \times \frac{\delta}{0.9}) \times 2]$

$IWD = 4M_p\delta + (2.311M_p\delta + 1.519M_p\delta) + (2.444M_p\delta + 1.375M_p\delta) + 2.500M_p\delta + 4.444M_p\delta + 5.556M_p\delta$

$IWD = \underline{24.149M_p\delta}$

$EWD = IWD$

$\underline{4.280\delta = 24.149M_p\delta}$

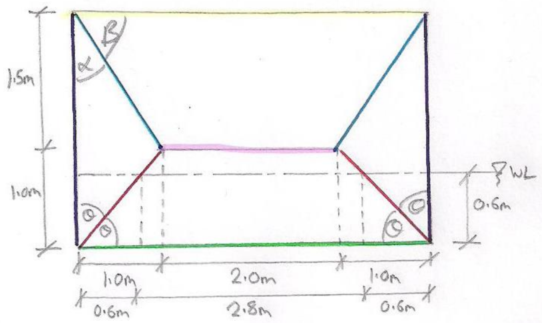
$\underline{M_p = 0.177 kNm/m}$

Appendix D10 - 1.0m high/wide lower diagonal yield line calculation

MARINE SCIENCE & ENGINEERING WITH PLYMOUTH UNIVERSITY — School of Marine Science & Engineering	Job No.	Section	Sheet No. 1	Rev
	Engineer	SK	Checked	
	Date	24/11/15	Rev. Date	

Project: Dissertation - PRCE507 Project 2

Element: 1.0m high/wide lower diagonal yield line - yield line analysis



$\theta = 45^\circ$

$\alpha = \tan^{-1}\left(\frac{1.0}{1.5}\right) = 33.690^\circ$

$33.690 \div 45 = 0.749 \quad \therefore \alpha = 0.749\theta$

$2 - 0.749 = 1.251 \quad \therefore \beta = 1.251\theta$

EWD = 4.280δ (Same as in '0.6m high/wide lower diagonal yield line - yield line analysis')

$IWD = [(M_p \times 1.0 \times \theta) \times 2 \times 2] + \{[(M_p \times 1.5 \times 0.75 \times \theta) \times 2] + [(M_p \times 1.0 \times 1.25 \times \theta) \times 2]\} + [(M_p \times 2.0 \times \theta) + (M_p \times 2.0 \times \theta)] + (M_p \times 4 \times \theta) + (M_p \times 4 \times \theta) + [(M_p \times 2.5 \times \theta) \times 2]$

$IWD = [(M_p \times 1.0 \times \frac{\delta}{0.1}) \times 2 \times 2] + \{[(M_p \times 1.5 \times 0.75 \times \frac{\delta}{1.0}) \times 2] + [(M_p \times 1.0 \times 1.25 \times \frac{\delta}{1.5}) \times 2]\} + [(M_p \times 2.0 \times \frac{\delta}{1.0}) + (M_p \times 2.0 \times \frac{\delta}{1.5})] + (M_p \times 4 \times \frac{\delta}{1.5}) + (M_p \times 4 \times \frac{\delta}{1.0}) + [(M_p \times 2.5 \times \frac{\delta}{1.0}) \times 2]$

$IWD = 4M_p\delta + (2.250M_p\delta + 1.667M_p\delta) + (2M_p\delta + 1.333M_p\delta) + 2.667M_p\delta + 4M_p\delta + 5M_p\delta$

$IWD = 22.917M_p\delta$

EWD = IWD

$4.280\delta = 22.917M_p\delta$

$M_p = 0.187$ kNm/m

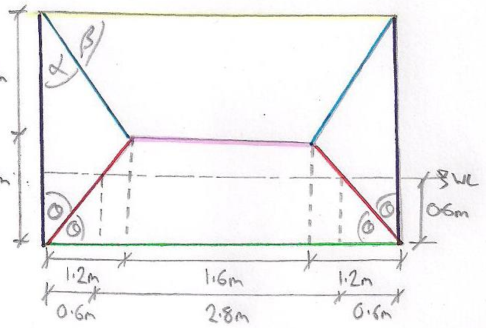
Appendix D11 - 1.2m high/wide lower diagonal yield line calculation

School of Marine Science & Engineering

Job N°	Section	Sheet N°	Rev
		1	
Engineer	SK	Checked	
Date	24/11/15	Rev. Date	

Project: Dissertation - PRCE507 Project 2

Element: 1.2m high/wide lower diagonal yield line - yield line analysis



$\theta = 45^\circ$

$\alpha = \tan^{-1}\left(\frac{1.2}{1.3}\right) = 42.709$

$42.709 \div 45 = 0.949 \quad \therefore \alpha = 0.949\theta$

$2 - 0.949 = 1.051 \quad \therefore \beta = 1.051\theta$

EWD = 4.280δ (Same as in '0.6m high/wide lower diagonal yield line - yield line analysis')

$$IWD = [(M_p \times 1.2 \times \theta) \times 2 \times 2] + \{[(M_p \times 1.3 \times 0.95\theta) \times 2] + [(M_p \times 1.2 \times 1.05\theta) \times 2]\} + [(M_p \times 1.6 \times \theta) + (M_p \times 1.6 \times \theta)] + (M_p \times 4 \times \theta) + (M_p \times 4 \times \theta) + [(M_p \times 2.5 \times \theta) \times 2]$$

$$IWD = [(M_p \times 1.2 \times \frac{\delta}{1.2}) \times 2 \times 2] + \{[(M_p \times 1.3 \times 0.95 \times \frac{\delta}{1.2}) \times 2] + [(M_p \times 1.2 \times 1.05 \times \frac{\delta}{1.3}) \times 2]\} + [(M_p \times 1.6 \times \frac{\delta}{1.2}) + (M_p \times 1.6 \times \frac{\delta}{1.3})] + (M_p \times 4 \times \frac{\delta}{1.3}) + (M_p \times 4 \times \frac{\delta}{1.2}) + [(M_p \times 2.5 \times \frac{\delta}{1.2}) \times 2]$$

$$IWD = 4M_p\delta + (2.058M_p\delta + 1.938M_p\delta) + (1.333M_p\delta + 1.231M_p\delta) + 3.077M_p\delta + 3.333M_p\delta + 4.167M_p\delta$$

$IWD = 21.137M_p\delta$

EWD = IWD

$4.280\delta = 21.137M_p\delta$

$M_p = 0.202$ kNm/m

Appendix D12 - 1.5m high/wide lower diagonal yield line calculation

MARINE SCIENCE & ENGINEERING WITH PLYMOUTH UNIVERSITY

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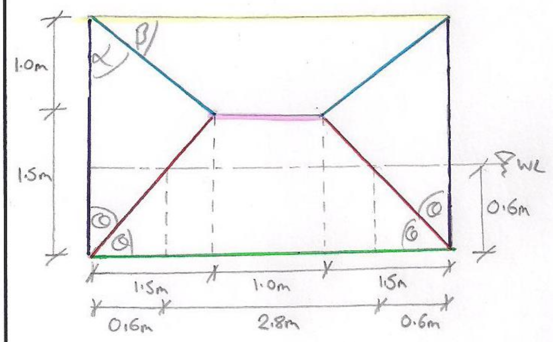
Job N°	Section	Sheet N°	Rev
		1	
Engineer	SK	Checked	
Date	25/11/15	Rev. Date	

Project: Dissertation - PRCE507 Project 2

Element: 1.5m high/wide lower diagonal yield line - yield line analysis



$\theta = 45^\circ$

$\alpha = \tan^{-1}\left(\frac{1.5}{1.0}\right) = 56.310^\circ$

$56.310 \div 45 = 1.251 \quad \therefore \alpha = 1.251\theta$

$2 - 1.251 = 0.749 \quad \therefore \beta = 0.749\theta$

EWD = 4.280δ (Same as in '0.6m high/wide lower diagonal yield line - yield line analysis')

$$IWD = [(M_p \times 1.5 \times \theta) \times 2 \times 2] + \{[(M_p \times 1.0 \times 1.25\theta) \times 2] + [(M_p \times 1.5 \times 0.75\theta) \times 2]\} + [(M_p \times 1.0 \times \theta) + (M_p \times 1.0 \times \theta)] + (M_p \times 4 \times \theta) + (M_p \times 4 \times \theta) + [(M_p \times 2.5 \times \theta) \times 2]$$

$$IWD = [(M_p \times 1.5 \times \tfrac{\delta}{1.5}) \times 2 \times 2] + \{[(M_p \times 1.0 \times 1.25 \times \tfrac{\delta}{1.5}) \times 2] + [(M_p \times 1.5 \times 0.75 \times \tfrac{\delta}{1.0}) \times 2]\} + [(M_p \times 1.0 \times \tfrac{\delta}{1.5}) + (M_p \times 1.0 \times \tfrac{\delta}{1.0})] + (M_p \times 4 \times \tfrac{\delta}{1.0}) + (M_p \times 4 \times \tfrac{\delta}{1.5}) + [(M_p \times 2.5 \times \tfrac{\delta}{1.5}) \times 2]$$

$$IWD = 4M_p\delta + (1.667M_p\delta + 2.250M_p\delta) + (0.667M_p\delta + 1M_p\delta) + 4M_p\delta + 2.667M_p\delta + 3.333M_p\delta$$

$$IWD = 19.584M_p\delta$$

$$EWD = IWD$$

$$4.280\delta = 19.584M_p\delta$$

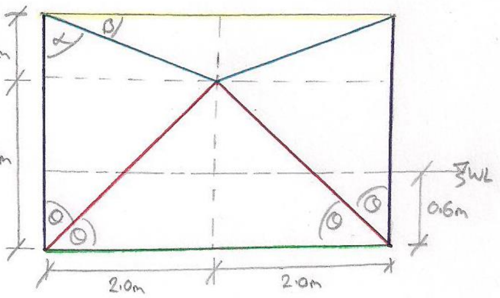
$$M_p = 0.219\ kNm/m$$

Appendix D13 - 2.0m high/wide lower diagonal yield line calculation

MARINE SCIENCE & ENGINEERING WITH PLYMOUTH UNIVERSITY — School of Marine Science & Engineering	Job No.	Section	Sheet No. 1	Rev
	Engineer	SK	Checked	
	Date	28/11/15	Rev. Date	

Project: Dissertation – PRCE507 Project 2

Element: 2.0 high/wide lower diagonal yield line – yield line analysis



$\theta = 45^\circ$

$\alpha = \tan^{-1}\left(\frac{2.0}{0.5}\right) = 75.964^\circ$

$75.964 \div 45 = 1.688 \quad \therefore \alpha = 1.688\theta$

$2 - 1.688 = 0.312 \quad \therefore \beta = 0.312\theta$

$EWD = 4.280\delta$ (Same as in '0.6m high/wide lower diagonal yield line – yield line analysis')

$$IWD = [(M_p \times 2.0 \times \theta) \times 2 \times 2] + \{[(M_p \times 0.5 \times 1.69\theta) \times 2] + [(M_p \times 2.0 \times 0.31\theta) \times 2]\} + (M_p \times 4 \times \theta) + (M_p \times 4 \times \theta) + [(M_p \times 2.5 \times \theta) \times 2]$$

$$IWD = [(M_p \times 2.0 \times \tfrac{\delta}{2.0}) \times 2 \times 2] + \{[(M_p \times 0.5 \times 1.69 \times \tfrac{\delta}{2.0}) \times 2] + [(M_p \times 2.0 \times 0.31 \times \tfrac{\delta}{0.5}) \times 2]\} + (M_p \times 4 \times \tfrac{\delta}{2.0}) + (M_p \times 4 \times \tfrac{\delta}{0.5}) + [(M_p \times 2.5 \times \tfrac{\delta}{2.0}) \times 2]$$

$$IWD = 4M_p\delta + (0.845M_p\delta + 2.480M_p\delta) + 2M_p\delta + 8M_p\delta + 2.5M_p\delta$$

$$IWD = 19.825M_p\delta$$

$$EWD = IWD$$

$$4.280\delta = 19.825M_p\delta$$

$$M_p = 0.216\ kNm/m$$

Appendix E - Original panel modelled as a simply supported beam spanning vertically

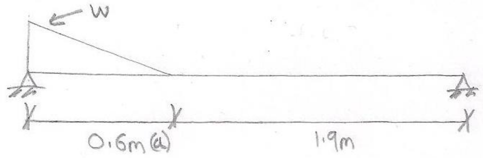
MARINE SCIENCE & ENGINEERING WITH PLYMOUTH UNIVERSITY

School of Marine Science & Engineering

Job N°	Section	Sheet N°	Rev
		1	
Engineer	SK	Checked	
Date	22/11/15	Rev. Date	

Project: Dissertation - PRCE507 Project 2

Element: Panel modelled as a simply supported beam spanning vertically



$$M_{max} = \frac{Wa}{3} \times \left(1 - m + \frac{2m}{3} \times \sqrt{\frac{m}{3}}\right) \quad ; \quad m = \frac{a}{L} = \frac{0.6}{2.5} = 0.24$$

$$W = \rho \times g \times h$$
$$W = 1000 \times 9.81 \times 0.6$$
$$W = 5.886\ kN/m^2$$

$$M_{max} = \frac{5.886 \times 0.6}{3} \times \left(1 - 0.24 + \frac{2 \times 0.24}{3} \times \sqrt{\frac{0.24}{3}}\right)$$
$$= 1.177 \times (0.760 + 0.045)$$
$$= \underline{\underline{0.947\ kNm}}$$

Using Steel Designers' Manual (Davison and Owens, 2012)

Appendix F - Tabulated FEA results for maximum bending moment with varying panel width

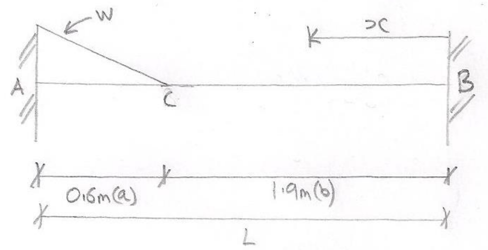
Wall Width (m)	Maximum Bending Moment (kNm/m)
1	0.0339
2	0.1495
4	0.1994
6	0.2217
8	0.2307
10	0.2311

Appendix G - Original panel modelled as beam with fixed supports spanning vertically

MARINE SCIENCE & ENGINEERING WITH PLYMOUTH UNIVERSITY — School of Marine Science & Engineering	Job No	Section	Sheet No 1	Rev
	Engineer	SK	Checked	
	Date	22/11/15	Rev. Date	

Project: Dissertation – PRCE 507 Project 2

Element: Panel modelled as a beam with fixed supports spanning vertically



In AC: $M_x = R_B \times x + M_B - \frac{2w(x-b)^3}{6ab}$

$R_B = \frac{Wa^2}{10L^3} \times (5L - 2a)$
$= \frac{5.886 \times 0.6^2}{10 \times 2.5^3} \times (5 \times 2.5 - 2 \times 0.6)$
$= 0.0136 \times 11.3$
$= 0.1532\ kN$

$M_B = -\frac{Wa^2}{30L^2}(5L - 3a)$
$= -\frac{5.886 \times 0.6^2}{30 \times 2.5^2} \times (5 \times 2.5 - 3 \times 0.6)$
$= -0.0484\ kNm$

@ $x = 2.0m$
$M_x = 0.1532 \times 2.0 - 0.0484 - \frac{2 \times 5.886 \times (2 - 1.9)^3}{6 \times 0.6 \times 1.9}$
$= 0.2563\ kNm$

@ $x = 2.1m$
$M_x = 0.1532 \times 2.1 - 0.0484 - \frac{2 \times 5.886 \times (2.1 - 1.9)^3}{6 \times 0.6 \times 1.9}$
$= 0.2596\ kNm$

@ $x = 2.2m$
$M_x = 0.1532 \times 2.2 - 0.0484 - \frac{2 \times 5.886 \times (2.2 - 1.9)^3}{6 \times 0.6 \times 1.9}$
$= 0.2422\ kNm$

@ $x = 2.05m$
$M_x = 0.1532 \times 2.05 - 0.0484 - \frac{2 \times 5.886 \times (2.05 - 1.9)^3}{6 \times 0.6 \times 1.9}$
$= 0.2599\ kNm = 0.260\ kNm$

Using Steel Designers' Manual (Davison and Owens, 2012)

Appendix H - Tabulated yield line analysis results for maximum bending moment with varying panel width

Wall Width (m)	**Lower Diagonal Yield Line Height/Width (m)**	**Maximum Bending Moment (kNm/m)**
1	0.5	0.003
2	0.5	0.02
4	0.6	0.192
6	0.7	0.345
8	0.7	0.563
10	0.7	0.797

Appendix I1 - 1m wide wall panel yield line calculation

MARINE SCIENCE & ENGINEERING WITH PLYMOUTH UNIVERSITY — **School of Marine Science & Engineering**

Job N°	Section	Sheet N°	Rev
		1	
Engineer	SK	Checked	
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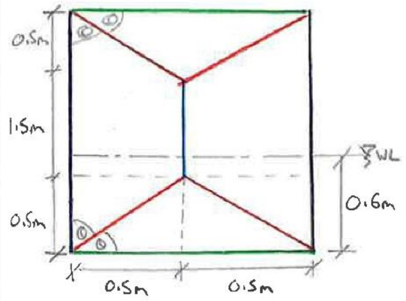
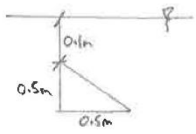
Project: Dissertation - PRCE507 Project 2

Element: 1.0m wide wall panel yield line calculation

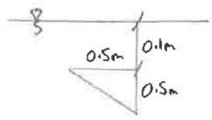


$\theta = 45^\circ$

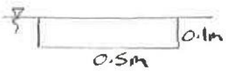
EWD:



$$\text{Load} = \rho \cdot g \cdot h_G \cdot A$$
$$= 1000 \times 9.81 \times \left(0.1 + \tfrac{2}{3} \times 0.5\right) \times \left(\frac{0.5 \times 0.5}{2}\right)$$
$$= 531.375\,N = \underline{0.531\,kN}$$



$$\text{Load} = 1000 \times 9.81 \times \left(0.1 + \tfrac{1}{3} \times 0.5\right) \times \left(\frac{0.5 \times 0.5}{2}\right)$$
$$= 327.000\,N = \underline{0.327\,kN}$$



$$\text{Load} = 1000 \times 9.81 \times 0.05 \times (0.1 \times 0.5)$$
$$= 24.525\,N = \underline{0.025\,kN}$$

$$EWD = \left[0.531 \times \left(\frac{0.5 \times 0.5}{2}\right) \times \frac{\delta}{3}\right] \times 2 + \left[0.327 \times \left(\frac{0.5 \times 0.5}{2}\right) \times \frac{\delta}{3}\right] \times 2 + \left[0.025 \times (0.5 \times 0.1) \times \frac{\delta}{2}\right] \times 2$$

$$EWD = 0.044\delta + 0.027\delta + 1.250 \times 10^{-3}\delta$$

$$EWD = \underline{0.072\delta}$$

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Project: Dissertation - PRCE507 Project 2

Element: 1.0m wide wall panel yield line calculation

$$IWD = [(M_p \times 0.5 \times \theta) \times 4 \times 2] + [(M_p \times 1.5 \times \theta) \times 2] + [(M_p \times 1 \times \theta) \times 2] + [(M_p \times 2.5 \times \theta) \times 2]$$

$$IWD = [(M_p \times 0.5 \times \frac{\delta}{0.5}) \times 4 \times 2] + [(M_p \times 1.5 \times \frac{\delta}{0.5}) \times 2] + [(M_p \times 1 \times \frac{\delta}{0.5}) \times 2] + [(M_p \times 2.5 \times \frac{\delta}{0.5}) \times 2]$$

$$IWD = 8M_p\delta + 6M_p\delta + 4M_p\delta + 10M_p\delta$$

$$IWD = 28.000M_p\delta$$

$$EWD = IWD$$

$$0.072\delta = 28.000M_p\delta$$

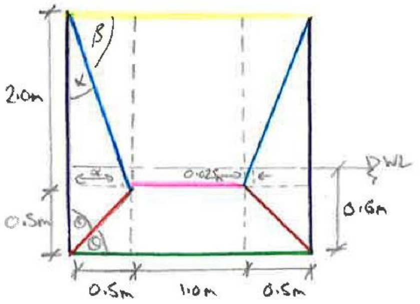
$$M_p = 2.571 \times 10^{-3} \text{ kNm/m}$$

Appendix I2 - 2m wide wall panel yield line calculation

MARINE SCIENCE & ENGINEERING WITH PLYMOUTH UNIVERSITY — School of Marine Science & Engineering	Job N°	Section	Sheet N° 1	Rev
	Engineer	SK	Checked	
	Date	8/12/15	Rev. Date	

Project: Dissertation - PRCE507 Project 2

Element: 2.0m wide wall panel yield line calculation



$\theta = 45°$

$\alpha = \tan^{-1}\left(\frac{0.5}{2.0}\right) = 14.036$

$14.036 \div 45 = 0.312$ $\therefore \alpha = 0.312\theta$

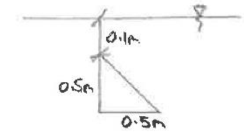
$2 - 0.312 = 1.688$ $\therefore \beta = 1.688\theta$

$\tan(14.036) = \frac{x}{1.9}$

$x = 0.475m$

$0.5 - 0.475 = 0.025m$

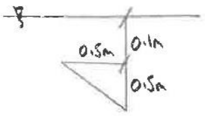
EWD:



$Load = \rho \cdot g \cdot h_G \cdot A$

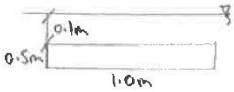
$= 1000 \times 9.81 \times (0.1 + \frac{2}{3} \times 0.5) \times \left(\frac{0.5 \times 0.5}{2}\right)$

$= 531.375N = 0.531kN$



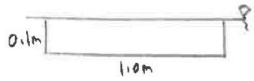
$Load = 1000 \times 9.81 \times (0.1 + \frac{1}{3} \times 0.5) \times \left(\frac{0.5 \times 0.5}{2}\right)$

$= 327.000N = 0.327kN$



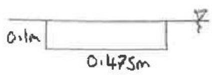
$Load = 1000 \times 9.81 \times (0.1 + \frac{0.5}{2}) \times (1 \times 0.5)$

$= 1716.750N = 1.717kN$



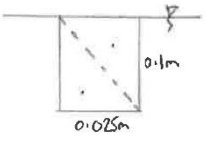
$Load = 1000 \times 9.81 \times \left(\frac{0.1}{2}\right) \times (0.1 \times 1.0)$

$= 49.050N = 0.049kN$



$Load = 1000 \times 9.81 \times \left(\frac{0.1}{2}\right) \times (0.1 \times 0.475)$

$= 23.299N = 0.023kN$



$Load = 1000 \times 9.81 \times \left(\frac{0.1}{2}\right) \times (0.1 \times 0.025)$

$= 1.226N = 0.0012kN$

Using knowledge that lower triangle will receive $\frac{2}{3}$ of this loading:

$\therefore$ Lower tringle $= 0.0012 \times \frac{2}{3} = 0.0008kN$

$\therefore$ Upper tringle $= 0.0012 \times \frac{1}{3} = 0.0004kN$

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Project: Dissertation - PRCE507 Project 2

Element: 2.0m wide wall panel yield line calculation

$$EWD = \left[0.531 \times \left(\frac{0.5 \times 0.5}{2}\right) \times \frac{\delta}{3}\right] \times 2 + \left[0.327 \times \left(\frac{0.5 \times 0.5}{2}\right) \times \frac{\delta}{3}\right] \times 2 + \left[1.717 \times (1 \times 0.5) \times \frac{\delta}{2}\right]$$
$$+ \left[0.049 \times (1 \times 0.1) \times \frac{\delta}{2}\right] + \left[0.023 \times (1 \times 0.475) \times \frac{\delta}{2}\right] \times 2 + \left[0.0004 \times \left(\frac{0.025 \times 0.1}{2}\right) \times \frac{\delta}{3}\right] \times 2$$
$$+ \left[0.0008 \times \left(\frac{0.025 \times 0.1}{2}\right) \times \frac{\delta}{3}\right] \times 2$$

$$EWD = 0.044\delta + 0.027\delta + 0.429\delta + 0.002\delta + 0.001\delta + \underbrace{3.333 \times 10^{-7}\delta + 6.667 \times 10^{-7}\delta}$$

(Negligible but included to show process)

$$EWD = 0.503\delta$$

$$IWD = [(M_p \times 0.5 \times \theta) \times 2 \times 2] + \{[(M_p \times 2 \times 0.31\theta) \times 2] + [(M_p \times 0.5 \times 1.69\theta) \times 2]\} + [(M_p \times 1.0 \times \theta) + (M_p \times 1.0 \times \theta)]$$
$$+ (M_p \times 2 \times \theta) + (M_p \times 2 \times \theta) + [(M_p \times 2.5 \times \theta) \times 2]$$

$$IWD = \left[\left(M_p \times 0.5 \times \frac{\delta}{0.5}\right) \times 2 \times 2\right] + \left\{\left[\left(M_p \times 2 \times 0.31 \times \frac{\delta}{0.5}\right) \times 2\right] + \left[\left(M_p \times 0.5 \times 1.69 \times \frac{\delta}{2.0}\right) \times 2\right]\right\} + \left[\left(M_p \times 1.0 \times \frac{\delta}{0.5}\right) + \left(M_p \times 1.0 \times \frac{\delta}{2.0}\right)\right]$$
$$+ \left(M_p \times 2 \times \frac{\delta}{0.5}\right) + \left(M_p \times 2 \times \frac{\delta}{2.0}\right) + \left[\left(M_p \times 2.5 \times \frac{\delta}{0.5}\right) \times 2\right]$$

$$IWD = 4M_p\delta + (2.480M_p\delta + 0.845M_p\delta) + (2M_p\delta + 0.5M_p\delta) + 4M_p\delta + M_p\delta + 10M_p\delta$$

$$IWD = 24.825M_p\delta$$

$$EWD = IWD$$

$$0.503\delta = 24.825M_p\delta$$

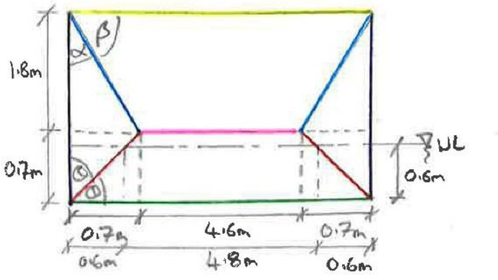
$$M_p = 0.020 \text{ kNm/m}$$

Appendix I3 - 6m wide wall panel yield line calculation

MARINE SCIENCE & ENGINEERING WITH PLYMOUTH UNIVERSITY — School of Marine Science & Engineering	Job N°		Section		Sheet N° 1		Rev	
	Engineer	SK			Checked			
	Date	13/12/15			Rev. Date			

Project: Dissertation - PRCE507 Project 2

Element: 6.0m wide wall panel yield line calculation



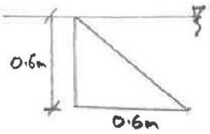
$\Theta = 45°$

$\alpha = \tan^{-1}\left(\frac{0.7}{1.8}\right) = 21.251$

$21.251 \div 45 = 0.472 \quad \therefore \alpha = 0.472\Theta$

$2 - 0.472 = 1.528 \quad \therefore \beta = 1.528\Theta$

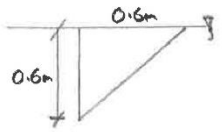
EWD:



$Load = \rho \cdot g \cdot h_G \cdot A$

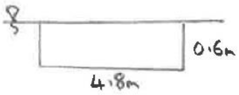
$= 1000 \times 9.81 \times \left(\frac{2}{3} \times 0.6\right) \times \left(\frac{0.6 \times 0.6}{2}\right)$

$= 706.320N = 0.706kN$



$Load = 1000 \times 9.81 \times \left(\frac{1}{3} \times 0.6\right) \times \left(\frac{0.6 \times 0.6}{2}\right)$

$= 353.160N = 0.353kN$



$Load = 1000 \times 9.81 \times \frac{0.6}{2} \times (0.6 \times 4.8)$

$= 8475.840N = 8.476kN$

$EWD = \left[0.706 \times \left(\frac{0.6 \times 0.6}{2}\right) \times \frac{\delta}{3}\right] \times 2 + \left[0.353 \times \left(\frac{0.6 \times 0.6}{2}\right) \times \frac{\delta}{3}\right] \times 2 + \left[8.476 \times (4.8 \times 0.6) \times \frac{\delta}{2}\right]$

$EWD = 0.085\delta + 0.042\delta + 12.205\delta$

$EWD = 12.332\delta$

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Project: Dissertation - PRCE507 Project 2

Element: 6.0m wide wall panel yield line calculation

$$IWD = [(M_p \times 0.7 \times \theta) \times 2 \times 2] + \{[(M_p \times 1.8 \times 0.47\theta) \times 2] + [(M_p \times 0.7 \times 1.53\theta) \times 2]\} + [(M_p \times 4.6 \times \theta) + (M_p \times 4.6 \times \theta)]$$
$$+ (M_p \times 6 \times \theta) + (M_p \times 6 \times \theta) + [(M_p \times 2.5 \times \theta) \times 2]$$

$$IWD = [(M_p \times 0.7 \times \frac{\delta}{0.7}) \times 2 \times 2] + \{[(M_p \times 1.8 \times 0.47 \times \frac{\delta}{0.7}) \times 2] + [(M_p \times 0.7 \times 1.53 \times \frac{\delta}{1.8}) \times 2]\} + [(M_p \times 4.6 \times \frac{\delta}{0.7}) + (M_p \times 4.6 \times \frac{\delta}{1.8})]$$
$$+ (M_p \times 6 \times \frac{\delta}{0.7}) + (M_p \times 6 \times \frac{\delta}{1.8}) + [(M_p \times 2.5 \times \frac{\delta}{0.7}) \times 2]$$

$$IWD = 4M_p\delta + (2.417M_p\delta + 1.190M_p\delta) + (6.571M_p\delta + 2.555M_p\delta) + 8.571M_p\delta + 3.333M_p\delta + 7.143\delta$$

$$\underline{IWD = 35.780M_p\delta}$$

$$EWD = IWD$$

$$12.332\delta = 35.780M_p\delta$$

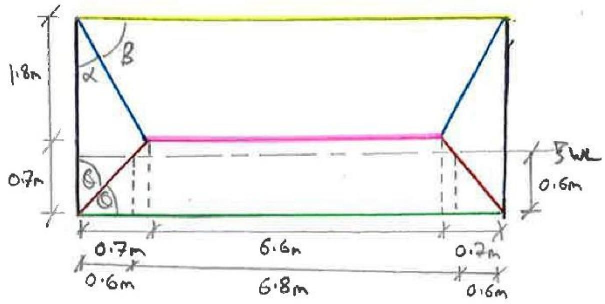
$$\underline{M_p = 0.345 \text{ kNm/m}}$$

Appendix I4 - 8m wide wall panel yield line calculation

MARINE SCIENCE & ENGINEERING WITH PLYMOUTH UNIVERSITY — School of Marine Science & Engineering	Job N°	Section	Sheet N° 1	Rev
	Engineer	SK	Checked	
	Date	13/12/15	Rev. Date	

Project: Dissertation - PRCE507 Project 2

Element: 8.0m wide wall panel yield line calculation



$\theta = 45°$

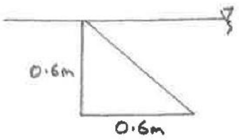
$\alpha = \tan^{-1}\left(\frac{0.7}{1.8}\right)$

$\alpha = 21.251°$

$21.251 \div 45 = 0.472 \quad \therefore \alpha = 0.472\theta$

$2 - 0.472 = 1.528 \quad \therefore \beta = 1.528\theta$

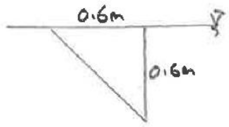
EWD:



$Load = \rho \cdot g \cdot h_G \cdot A$

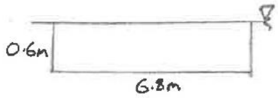
$= 1000 \times 9.81 \times \left(\frac{2}{3} \times 0.6\right) \times \left(\frac{0.6 \times 0.6}{2}\right)$

$= 706.320N = 0.706kN$



$Load = 1000 \times 9.81 \times \left(\frac{1}{3} \times 0.6\right) \times \left(\frac{0.6 \times 0.6}{2}\right)$

$= 353.160N = 0.353kN$



$Load = 1000 \times 9.81 \times \left(\frac{0.6}{2}\right) \times (0.6 \times 6.8)$

$= 12007.440N = 12.007kN$

$EWD = \left[0.706 \times \left(\frac{0.6 \times 0.6}{2}\right) \times \frac{\delta}{3}\right] \times 2 + \left[0.353 \times \left(\frac{0.6 \times 0.6}{2}\right) \times \frac{\delta}{3}\right] \times 2 + \left[12.007 \times (6.8 \times 0.6) \times \frac{\delta}{2}\right]$

$EWD = 0.085\delta + 0.042\delta + 24.494\delta$

$EWD = \underline{24.621\delta}$

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Project: Dissertation - PRCE507 Project 2

Element: 8.0m wide wall panel yield line calculation

$$IWD = \left[(M_p \times 0.7 \times \theta) \times 2 \times 2\right] + \left\{\left[(M_p \times 1.8 \times 0.47\theta) \times 2\right] + \left[(M_p \times 0.7 \times 1.53\theta) \times 2\right]\right\} + \left[(M_p \times 6.6 \times \theta) + (M_p \times 6.6 \times \theta)\right]$$
$$+ (M_p \times 8 \times \theta) + (M_p \times 8 \times \theta) + \left[(M_p \times 2.5 \times \theta) \times 2\right]$$

$$IWD = \left[(M_p \times 0.7 \times \frac{\delta}{0.7}) \times 2 \times 2\right] + \left\{\left[(M_p \times 1.8 \times 0.47 \times \frac{\delta}{0.7}) \times 2\right] + \left[(M_p \times 0.7 \times 1.53 \times \frac{\delta}{1.8}) \times 2\right]\right\} + \left[(M_p \times 6.6 \times \frac{\delta}{0.7}) + (M_p \times 6.6 \times \frac{\delta}{1.8})\right]$$
$$+ (M_p \times 8 \times \frac{\delta}{0.7}) + (M_p \times 8 \times \frac{\delta}{1.8}) + \left[(M_p \times 2.5 \times \frac{\delta}{0.7}) \times 2\right]$$

$$IWD = 4M_p\delta + (2.417M_p\delta + 1.190M_p\delta) + (9.429M_p\delta + 3.667M_p\delta) + 11.429M_p\delta + 4.444M_p\delta + 7.143M_p\delta$$

$$IWD = 43.719M_p\delta$$

$$EWD = IWD$$

$$24.621\delta = 43.719M_p\delta$$

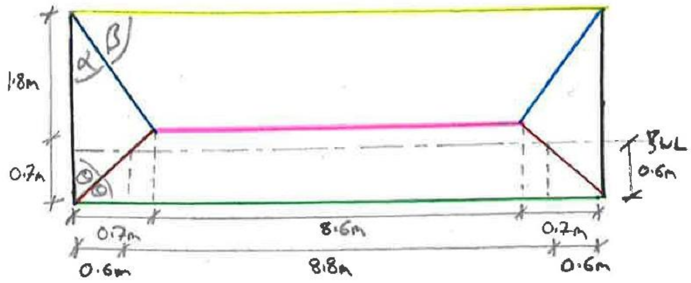
$$M_p = 0.563 \text{ kNm/m}$$

Appendix I5 - 10m wide wall panel yield line calculation

MARINE SCIENCE & ENGINEERING WITH PLYMOUTH UNIVERSITY — School of Marine Science & Engineering	Job N°	Section	Sheet N° 1	Rev
	Engineer	SK	Checked	
	Date	13/12/15	Rev. Date	

Project: Dissertation - PRCE507 Project 2

Element: 10.0m wide wall panel yield line calculation



$\theta = 45°$

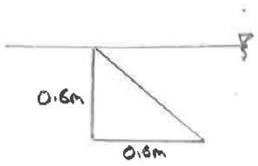
$\alpha = \tan^{-1}\left(\frac{0.7}{1.8}\right)$

$\alpha = 21.251°$

$21.251 \div 45 = 0.472 \quad \therefore \alpha = 0.472\theta$

$2 - 0.472 = 1.528 \quad \therefore \beta = 1.528\theta$

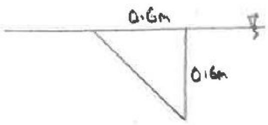
EWD:



$\text{Load} = \rho \cdot g \cdot h_G \cdot A$

$= 1000 \times 9.81 \times \left(\frac{2}{3} \times 0.6\right) \times \left(\frac{0.6 \times 0.6}{2}\right)$

$= 706.320\text{N} = 0.706\text{kN}$



$\text{Load} = 1000 \times 9.81 \times \left(\frac{1}{3} \times 0.6\right) \times \left(\frac{0.6 \times 0.6}{2}\right)$

$= 353.160\text{N} = 0.353\text{kN}$

$\text{Load} = 1000 \times 9.81 \times \left(\frac{0.6}{2}\right) \times (0.6 \times 8.8)$

$= 15539.040\text{ N} = 15.539\text{kN}$

$EWD = \left[0.706 \times \left(\frac{0.6 \times 0.6}{2}\right) \times \frac{\delta}{3}\right] \times 2 + \left[0.353 \times \left(\frac{0.6 \times 0.6}{2}\right) \times \frac{\delta}{3}\right] \times 2 + \left[15.539 \times (8.8 \times 0.6) \times \frac{\delta}{2}\right]$

$EWD = 0.085\delta + 0.042\delta + 41.023\delta$

$EWD = \underline{41.150\delta}$

Project: Dissertation - PRCE507 Project 2

Element: 10.0m wide wall panel yield line calculation

$$IWD = [(M_p \times 0.7 \times \theta) \times 2 \times 2] + \{[(M_p \times 1.8 \times 0.47\theta) \times 2] + [(M_p \times 0.7 \times 1.53\theta) \times 2]\} + [(M_p \times 8.6 \times \theta) + (M_p \times 8.6 \times \theta)]$$
$$+ (M_p \times 10 \times \theta) + (M_p \times 10 \times \theta) + [(M_p \times 2.5 \times \theta) \times 2]$$

$$IWD = [(M_p \times 0.7 \times \tfrac{\delta}{0.7}) \times 2 \times 2] + \{[(M_p \times 1.8 \times 0.47 \times \tfrac{\delta}{0.7}) \times 2] + [(M_p \times 0.7 \times 1.53 \times \tfrac{\delta}{1.8}) \times 2]\} + [(M_p \times 8.6 \times \tfrac{\delta}{0.7}) + (M_p \times 8.6 \times \tfrac{\delta}{1.8})]$$
$$+ (M_p \times 10 \times \tfrac{\delta}{0.7}) + (M_p \times 10 \times \tfrac{\delta}{1.8}) + [(M_p \times 2.5 \times \tfrac{\delta}{0.7}) \times 2]$$

$$IWD = 4M_p\delta + (2.417M_p\delta + 1.190M_p\delta) + (12.286M_p\delta + 4.778M_p\delta) + 14.286M_p\delta + 5.556M_p + 7.143M_p\delta$$

$$IWD = \underline{51.656M_p\delta}$$

$$EWD = IWD$$

$$41.150\delta = 51.656M_p\delta$$

$$\underline{\underline{M_p = 0.797 kNm/m}}$$

Appendix J - Free top edge yield line analysis calculation

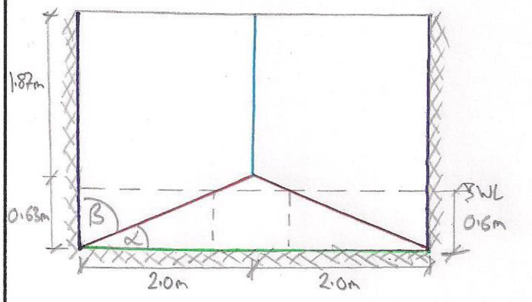
MARINE SCIENCE & ENGINEERING WITH PLYMOUTH UNIVERSITY

School of Marine Science & Engineering

Job No	Section	Sheet No	Rev
		1	
Engineer	SK	Checked	
Date	7/12/15	Rev. Date	

Project: Dissertation - PRCE507 Project 2

Element: Free top edge yield line calculation



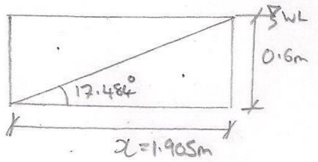
$\theta = 45^\circ$

$\alpha = \tan^{-1}\left(\frac{0.63}{2.0}\right) = 17.484^\circ$

$17.484 \div 45 = 0.389 \quad \therefore \alpha = 0.389\theta$

$2 - 0.389 = 1.611 \quad \therefore \beta = 0.611\theta$

EWD:



$\tan(17.484) = \frac{0.6}{x}$

$x = 1.905m$

$Load = \rho \cdot g \cdot h_G \cdot A$

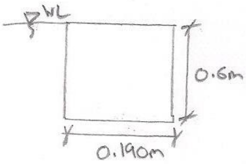
$= 1000 \times 9.81 \times \frac{0.6}{2} \times (0.6 \times 1.905)$

$= 3363.849N = 3.364kN$

Using knowledge that lower triangle will receive $\frac{2}{3}$ of this load in comparison to the upper triangle which will receive $\frac{1}{3}$.

$\therefore$ Upper triangle $= 3.364 \times \frac{1}{3} = 1.121kN$

$\therefore$ Lower triangle $= 3.364 \times \frac{2}{3} = 2.243kN$



$4 - 1.905 \times 2 = 0.190m$

$Load = 1000 \times 9.81 \times \frac{0.6}{2} \times (0.6 \times 0.190)$

$= 335.502N = 0.335kN$

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Project: Dissertation - PRCE 507 Project 2

Element: Free top edge yield line calculation

$$EWD = \left[1.121\times\left(\frac{0.6\times1.905}{2}\right)\times\frac{\delta}{3}\right]\times2 + \left[2.243\times\left(\frac{0.6\times1.905}{2}\right)\times\frac{\delta}{3}\right]\times2 + \left[0.335\times(0.6\times0.190)\times\frac{\delta}{2}\right]$$

$$EWD = 0.427\delta + 0.855\delta + 0.019\delta$$

$$EWD = \underline{1.301\delta}$$

$$IWD = \{[(M_p\times2.0\times0.39\theta)\times2] + [(M_p\times0.63\times1.61\theta)\times2]\} + [(M_p\times1.87\times\theta)\times2] + (M_p\times4\times\theta) + [(M_p\times2.5\times\theta)\times2]$$

$$IWD = \left\{\left[\left(M_p\times2.0\times0.39\times\frac{\delta}{0.63}\right)\times2\right] + \left[\left(M_p\times0.63\times1.61\times\frac{\delta}{2.0}\right)\times2\right]\right\} + \left[\left(M_p\times1.87\times\frac{\delta}{2}\right)\times2\right] + \left(M_p\times4\times\frac{\delta}{0.63}\right) + \left[\left(M_p\times2.5\times\frac{\delta}{2}\right)\times2\right]$$

$$IWD = (2.476M_p\delta + 1.014M_p\delta) + 1.870M_p\delta + 6.349M_p\delta + 2.5M_p\delta$$

$$IWD = \underline{14.209M_p\delta}$$

$$EWD = IWD$$

$$1.301\delta = 14.209M_p\delta$$

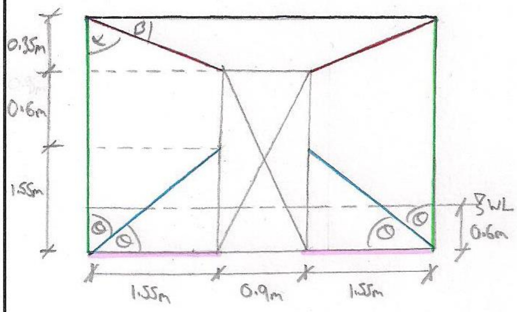
$$\underline{\underline{M_p = 0.092\ kNm/m}}$$

Appendix K1 - Opening for door frame yield line calculation

School of Marine Science & Engineering	Job No	Section	Sheet No 1	Rev
	Engineer	SK	Checked	
	Date	29/11/15	Rev. Date	

Project: Dissertation – PRCE507 Project 2

Element: Panel opening for door yield line analysis



$\theta = 45°$

$\alpha = \tan^{-1}\left(\frac{1.55}{0.35}\right) = 77.276°$

$77.276 \div 45 = 1.717 \quad \therefore \alpha = 1.717\theta$

$2 - 1.717 = 0.283 \quad \therefore \beta = 0.283\theta$

EWD = 4.280δ (Same as in '0.6m high/wide lower diagonal yield line – yield line analysis')

$IWD = [(M_p \times 1.55 \times \theta) \times 2 \times 2] + \{[(M_p \times 0.35 \times 1.72\theta) \times 2] + [(M_p \times 1.55 \times 0.28\theta) \times 2]\} + (M_p \times 4 \times \theta) + [(M_p \times 1.55 \times \theta) \times 2] + [(M_p \times 2.5 \times \theta) \times 2]$

$IWD = [(M_p \times 1.55 \times \frac{\delta}{1.55}) \times 2 \times 2] + \{[(M_p \times 0.35 \times 1.72 \times \frac{\delta}{1.55}) \times 2] + [(M_p \times 1.55 \times 0.28 \times \frac{\delta}{0.35}) \times 2]\} + (M_p \times 4 \times \frac{\delta}{0.35}) + [(M_p \times 1.55 \times \frac{\delta}{1.55}) \times 2] + [(M_p \times 2.5 \times \frac{\delta}{1.55}) \times 2]$

$IWD = 4M_p\delta + (0.777M_p\delta + 2.480M_p\delta) + 11.429M_p\delta + 2M_p\delta + 3.226M_p\delta$

$IWD = 23.912M_p\delta$

$EWD = IWD$

$4.280\delta = 23.912M_p\delta$

$M_p = 0.179\,kNm/m$

Appendix K2 - Opening for window frame yield line calculation

MARINE SCIENCE & ENGINEERING WITH PLYMOUTH UNIVERSITY **School of Marine Science & Engineering**

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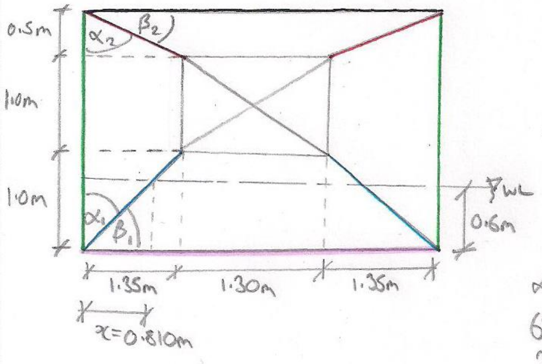
Project: Dissertation - PRCE507 Project 2

Element: Panel opening for window yield line analysis



$\theta = 45°$

$\alpha_1 = \tan^{-1}\left(\frac{1.35}{1.0}\right) = 53.471°$

$53.471 \div 45 = 1.188 \quad \therefore \alpha_1 = 1.188\theta$

$2 - 1.188 = 0.812 \quad \therefore \beta_1 = 0.812\theta$

$\alpha_2 = \tan^{-1}\left(\frac{1.35}{0.5}\right) = 69.677°$

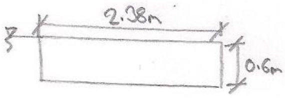
$69.677 \div 45 = 1.548 \quad \therefore \alpha_2 = 1.548\theta$

$2 - 1.548 = 0.452 \quad \therefore \beta_2 = 0.452\theta$

$\tan(53.471) = \frac{x}{0.6}$

$x = 0.810m$

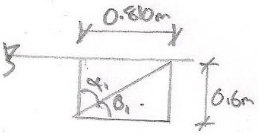
EWD:



$Load = \rho \cdot g \cdot h_G \cdot A$

$= 1000 \times 9.81 \times 0.3 \times (0.6 \times 2.38)$

$= 4202.604N = \underline{4.203kN}$



$Load = 1000 \times 9.81 \times 0.3 \times (0.6 \times 0.810)$

$= 1430.298N = \underline{1.430kN}$

Using knowledge that the upper triangle will receive 1/3 of this force:

$\therefore$ Upper triangle = 0.477kN

$\therefore$ Lower triangle = 0.953kN

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Element: Panel opening for window yield line analysis

$$EWD = \left[0.477 \times \left(\frac{0.6 \times 0.81}{2}\right) \times \frac{\delta}{3}\right] \times 2 + \left[0.953 \times \left(\frac{0.6 \times 0.81}{2}\right) \times \frac{\delta}{3}\right] \times 2 + \left[4.203 \times (0.6 \times 2.38) \times \frac{\delta}{2}\right]$$

$$EWD = 0.077\delta + 0.154\delta + 3.001\delta$$

$$\underline{EWD = 3.232\delta}$$

$$IWD = \left\{\left[(M_p \times 1.0 \times 1.19\theta) \times 2\right] + \left[(M_p \times 1.35 \times 0.81\theta) \times 2\right]\right\} + \left\{\left[(M_p \times 0.5 \times 1.55\theta) \times 2\right] + \left[(M_p \times 1.35 \times 0.45\theta) \times 2\right]\right\} + (M_p \times 4 \times \theta) + (M_p \times 4 \times \theta) + \left[(M_p \times 2.5 \times \theta) \times 2\right]$$

$$IWD = \left\{\left[\left(M_p \times 1.0 \times 1.19 \times \frac{\delta}{1.35}\right) \times 2\right] + \left[\left(M_p \times 1.35 \times 0.81 \times \frac{\delta}{1.0}\right) \times 2\right]\right\} + \left\{\left[\left(M_p \times 0.5 \times 1.55 \times \frac{\delta}{1.35}\right) \times 2\right] + \left[\left(M_p \times 1.35 \times 0.45 \times \frac{\delta}{0.5}\right) \times 2\right]\right\} + \left(M_p \times 4 \times \frac{\delta}{0.5}\right) + \left(M_p \times 4 \times \frac{\delta}{1.0}\right) + \left[\left(M_p \times 2.5 \times \frac{\delta}{1.35}\right) \times 2\right]$$

$$IWD = (1.763M_p\delta + 2.187M_p\delta) + (1.148M_p\delta + 2.430M_p\delta) + 8M_p\delta + 4M_p\delta + 3.704M_p\delta$$

$$\underline{IWD = 23.232M_p\delta}$$

$$EWD = IWD$$

$$3.232\delta = 23.232M_p\delta$$

$$\underline{M_p = 0.139 \text{ kNm/m}}$$

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Appendix K3 - Opening for large sliding door frame yield line calculation

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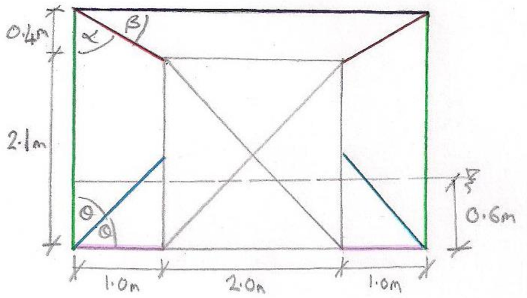
Project: Dissertation - PRCE507 Project 2

Element: Panel opening for large sliding door yield line analysis



$\theta = 45°$

$\alpha = \tan^{-1}\left(\frac{1.0}{0.4}\right) = 68.199°$

$68.199 \div 45 = 1.516 \quad \therefore \alpha = 1.516\theta$

$2 - 1.516 = 0.484 \quad \therefore \beta = 0.484\theta$

EWD = 4.280δ (Same as in '0.6m high/wide lower diagonal yield line - yield line analysis')

$IWD = [(M_p \times 1.0 \times \theta) \times 2 \times 2] + \{[(M_p \times 0.4 \times 1.516\theta) \times 2] + [(M_p \times 1.0 \times 0.484\theta) \times 2]\} + (M_p \times 4 \times \theta) + [(M_p \times 1 \times \theta) \times 2] + [(M_p \times 2.5 \times \theta) \times 2]$

$IWD = [(M_p \times 1.0 \times \frac{\delta}{1.0}) \times 2 \times 2] + \{[(M_p \times 0.4 \times 1.516 \times \frac{\delta}{1.0}) \times 2] + [(M_p \times 1.0 \times 0.484 \times \frac{\delta}{0.4}) \times 2]\} + (M_p \times 4 \times \frac{\delta}{0.4}) + [(M_p \times 1 \times \frac{\delta}{1.0}) \times 2] + [(M_p \times 2.5 \times \frac{\delta}{1.0}) \times 2]$

$IWD = 4M_p\delta + (1.213M_p\delta + 2.420M_p\delta) + 10M_p\delta + 2M_p\delta + 5M_p\delta$

$IWD = 24.633 M_p\delta$

$EWD = IWD$

$4.280\delta = 24.633 M_p\delta$

$M_p = 0.174$ kNm/m

Last Updated November 25, 2015

Appendix L - Characteristic compressive strength of masonry calculation

MARINE SCIENCE & ENGINEERING WITH PLYMOUTH UNIVERSITY — School of Marine Science & Engineering	Job N°		Section		Sheet N° 1	Rev
	Engineer	SK	Checked			
	Date	22/11/15	Rev. Date			

Project: Dissertation – PRCE507 Project 2

Element: Characteristic compressive strength of masonry calculation

$f_b = 5 N/mm^2$ (Assuming a normalized mean compressive strength of the units, in the direction of the applied action effect of 5N/mm)

$f_m = 4 N/mm^2$ (Mortar strength class M4)

$K = 0.40$ ((Constant for Clay Group 1, general purpose mortar)

$\alpha = 0.7$ and $\beta = 0.3$ ((constants for general purpose mortar).

$f_K = K f_b^{\alpha} f_m^{\beta}$

$f_K = 0.4 \times 5^{0.7} \times 4^{0.3}$

$f_K = 1.870 N/mm^2$

Appendix M - Moment of resistance parallel to the bed joints calculations for different applied vertical loads

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Element: Moment of resistance parallel to bed joints for different applied vertical loads

The design vertical load per unit area is limited to: $< 0.2 \times \frac{f_k}{\gamma_M}$

$< 0.2 \times \frac{1.870}{3}$

$< 0.125\ N/mm^2$

Loading = $1 kN/m^2$; Area = $4m \times 3m = 12m^2$

Total load supported by inner leaf = $12 \times 1 = 12 kN = 12000 N$

Plan area of inner leaf = $4 \times 0.1 = 0.4 m^2 = 400000 mm^2$

$\sigma_d = 12000/400000 = 0.03 N/mm^2$

$0.03 < 0.125$ ∴ OK

$M_{Rd,1} = \left(\frac{f_{xk1}}{\gamma_M} + \sigma_d\right) \cdot Z$

$= \left(\frac{0.3}{3} + 0.03\right) \times \left(\frac{10^3 \times 100^2}{6} \times 2\right) \times 10^{-6} = 0.433 kNm/m$

Loading = $2 kN/m^2$; Area = $4m \times 3m = 12m^2$

Total load supported by inner leaf = $12 \times 2 = 24 kN = 24000 N$

Plan area of inner leaf = $4 \times 0.1 = 0.4 m^2 = 400000 mm^2$

$\sigma_d = 24000/400000 = 0.06 N/mm^2$

$0.06 < 0.125$ ∴ OK

$M_{Rd,1} = \left(\frac{0.3}{3} + 0.06\right) \times \left(\frac{10^3 \times 100^2}{6} \times 2\right) \times 10^{-6} = 0.533 kNm/m$

Loading = $3 kN/m^2$; Area = $4m \times 3m = 12m^2$

Total load supported by inner leaf = $12 \times 3 = 36 kN = 36000 N$

Plan area of inner leaf = $4 \times 0.1 = 0.4 m^2 = 400000 mm^2$

$\sigma = 36000/400000 = 0.09 N/mm^2$

$0.09 < 0.125$ ∴ OK

$M_{Rd,1} = \left(\frac{0.3}{3} + 0.09\right) \times \left(\frac{10^3 \times 100^2}{6} \times 2\right) \times 10^{-6} = 0.633 kNm/m$

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Element: Moment of resistance parallel to bed joints for different applied vertical loads

Loading = $4 kN/m^2$; Area = $4m \times 3m = 12m^2$

Total area supported by inner leaf = $12 \times 4 = 48 kN = 48000 N$

Plan area of inner leaf = $4 \times 0.1 = 0.4 m^2 = 400000 mm^2$

$\sigma = 48000/400000 = 0.12 N/mm^2$

$0.12 < 0.125 \therefore$ OK

$M_{Rd,1} = \left(\frac{0.3}{3} + 0.12\right) \times \left(\frac{10^3 \times 100^2}{6} \times 2\right) \times 10^{-6} = 0.733 kNm/m$

Loading = $5 kN/m^2$; Area = $4m \times 3m = 12m^2$

Total area supported by inner leaf = $12 \times 5 = 60 kN = 60000 N$

Plan area of inner leaf = $4 \times 0.1 = 0.4 m^2 = 400000 mm^2$

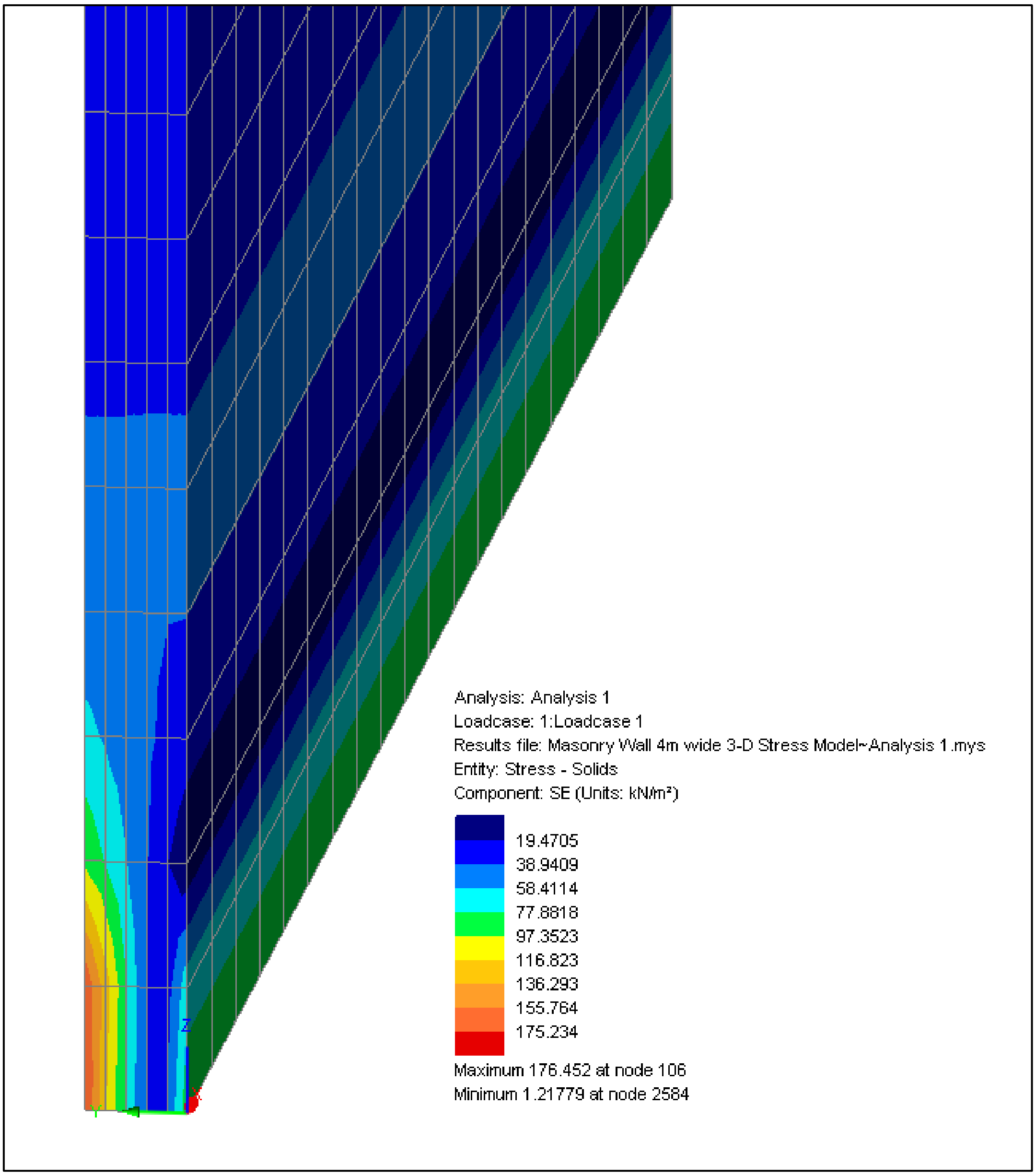
$\sigma = 60000/400000 = 0.15 N/mm^2$

$0.15 > 0.125 \therefore$ Fail.

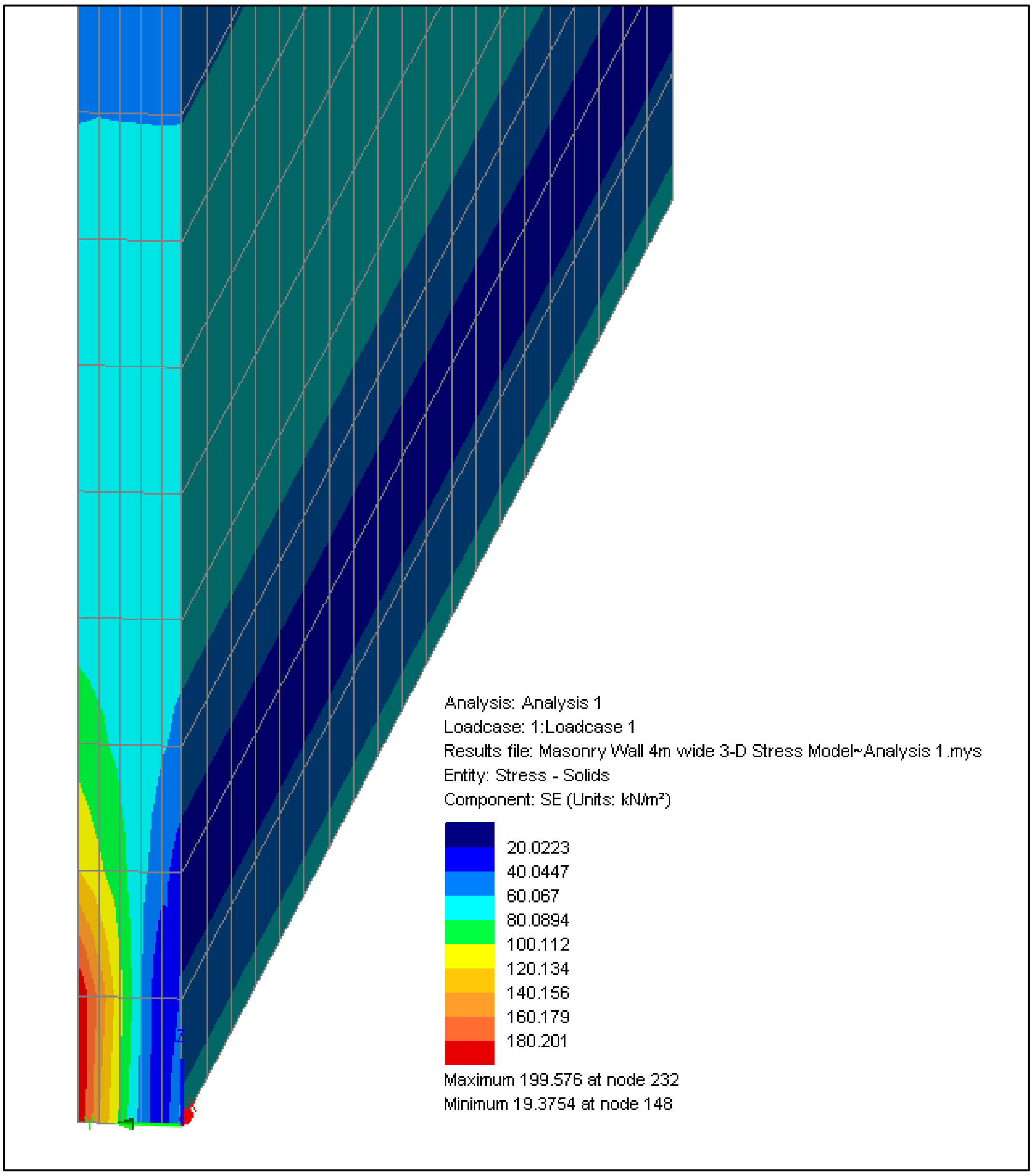
Appendix N - Tabulated design moment of resistance results for varied vertical loading (applied as a floor loading to $12m^2$)

Floor loading on per m^2 on $12m^2$ area (kN/m^2)	**Design moment of resistance parallel to the bed joints (kNm/m)**
0	0.333
1	0.433
2	0.533
3	0.633
4	0.733
5	Beyond masonry compression limit (see calculations in Appendix M)

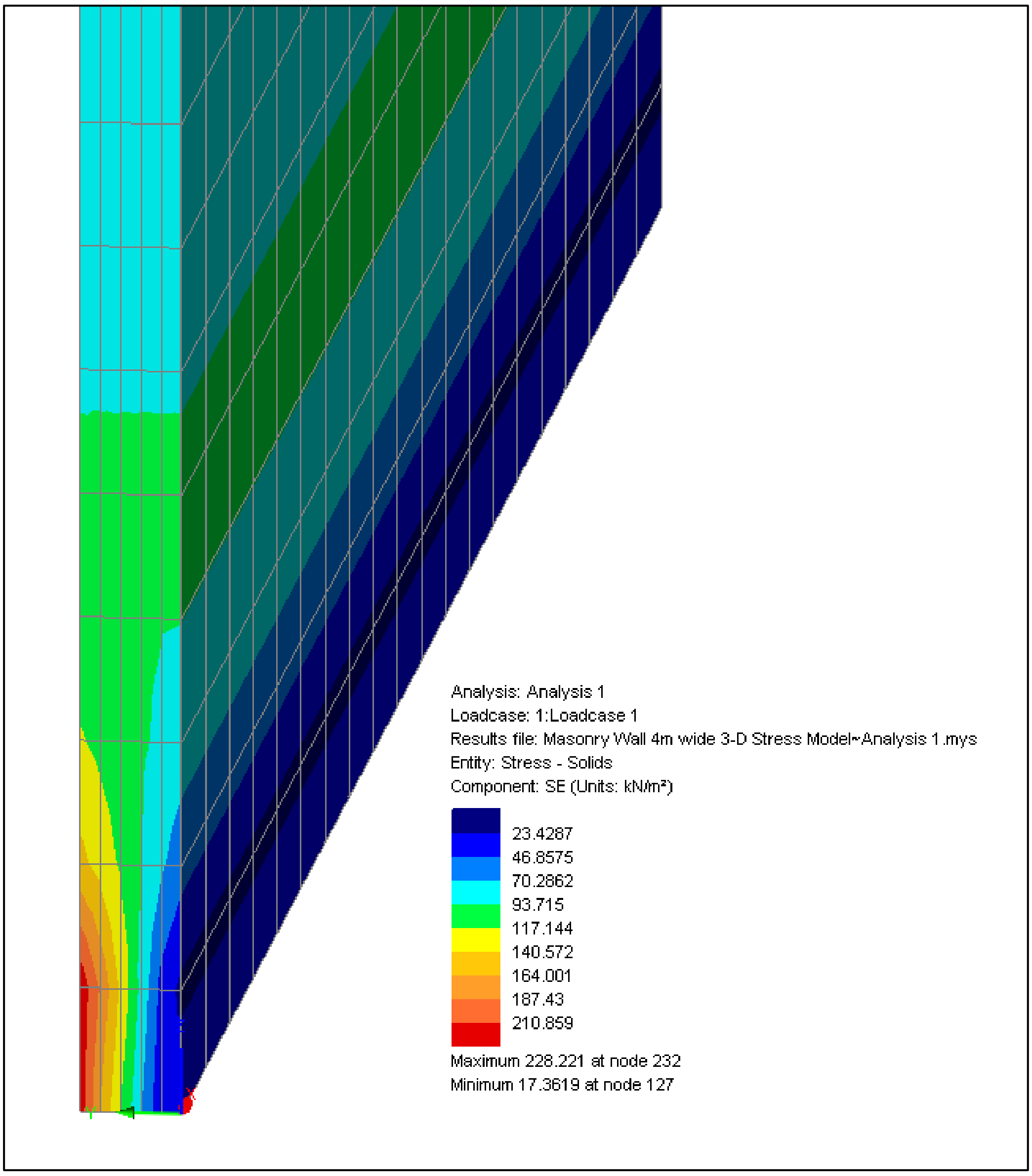
Appendix O1 - Resultant stress contour of the original panel under applied vertical loading from 12m^2 with a loading of 0kN/m^2



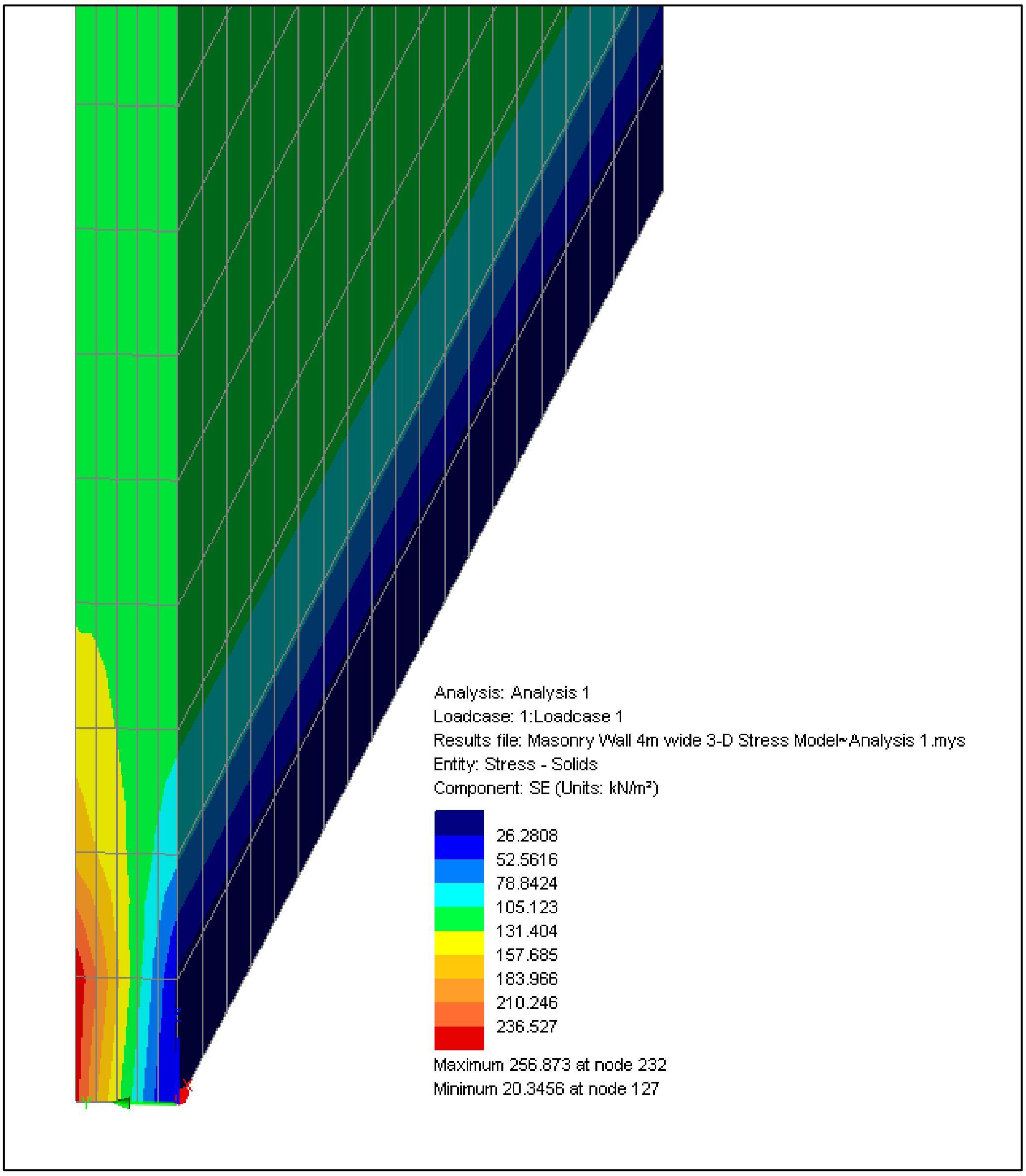
Appendix O2 - Resultant stress contour of the original panel under applied vertical loading from 12m² with a loading of 1kN/m²



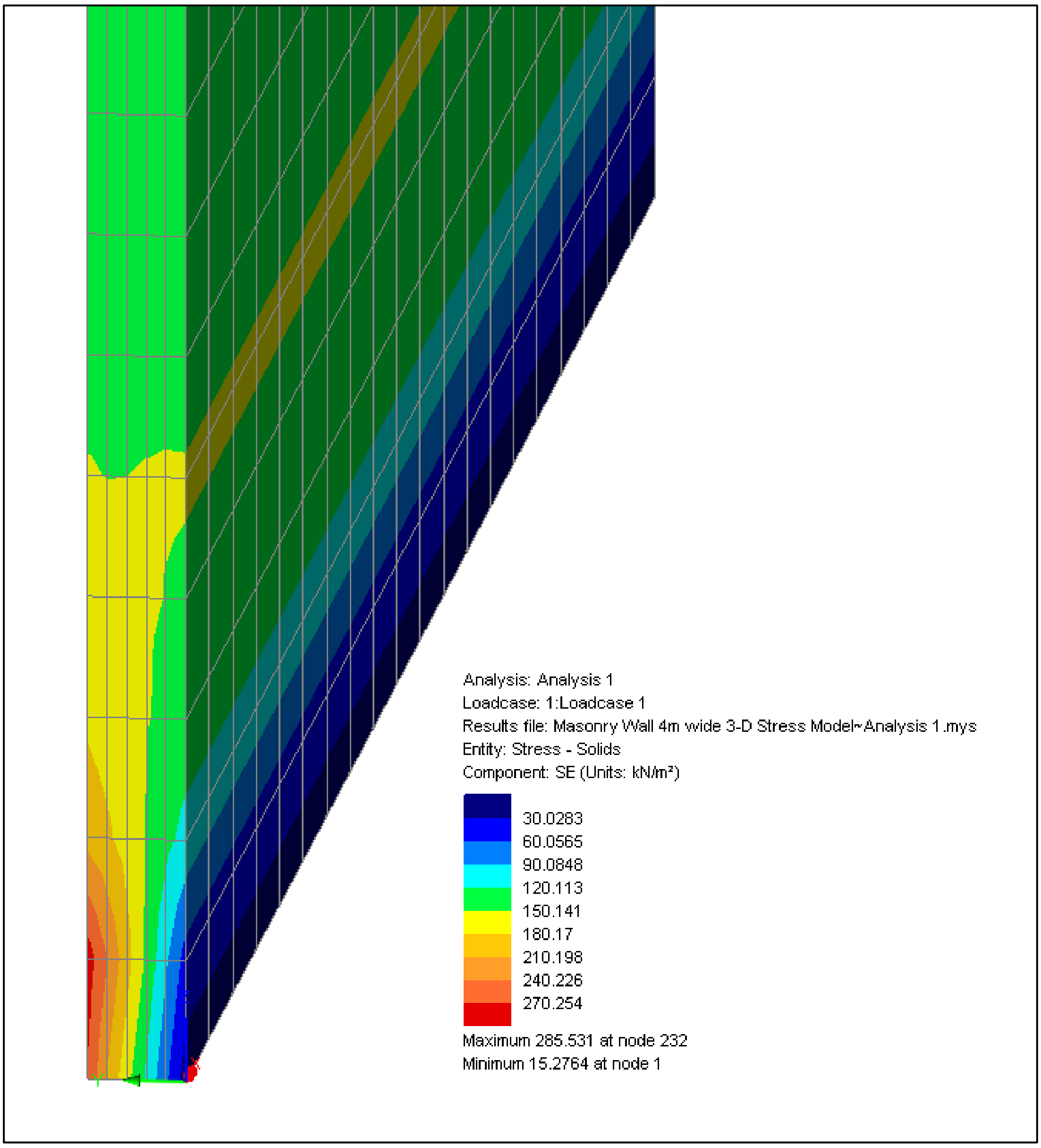
Appendix O3 - Resultant stress contour of the original panel under applied vertical loading from $12m^2$ with a loading of $2kN/m^2$



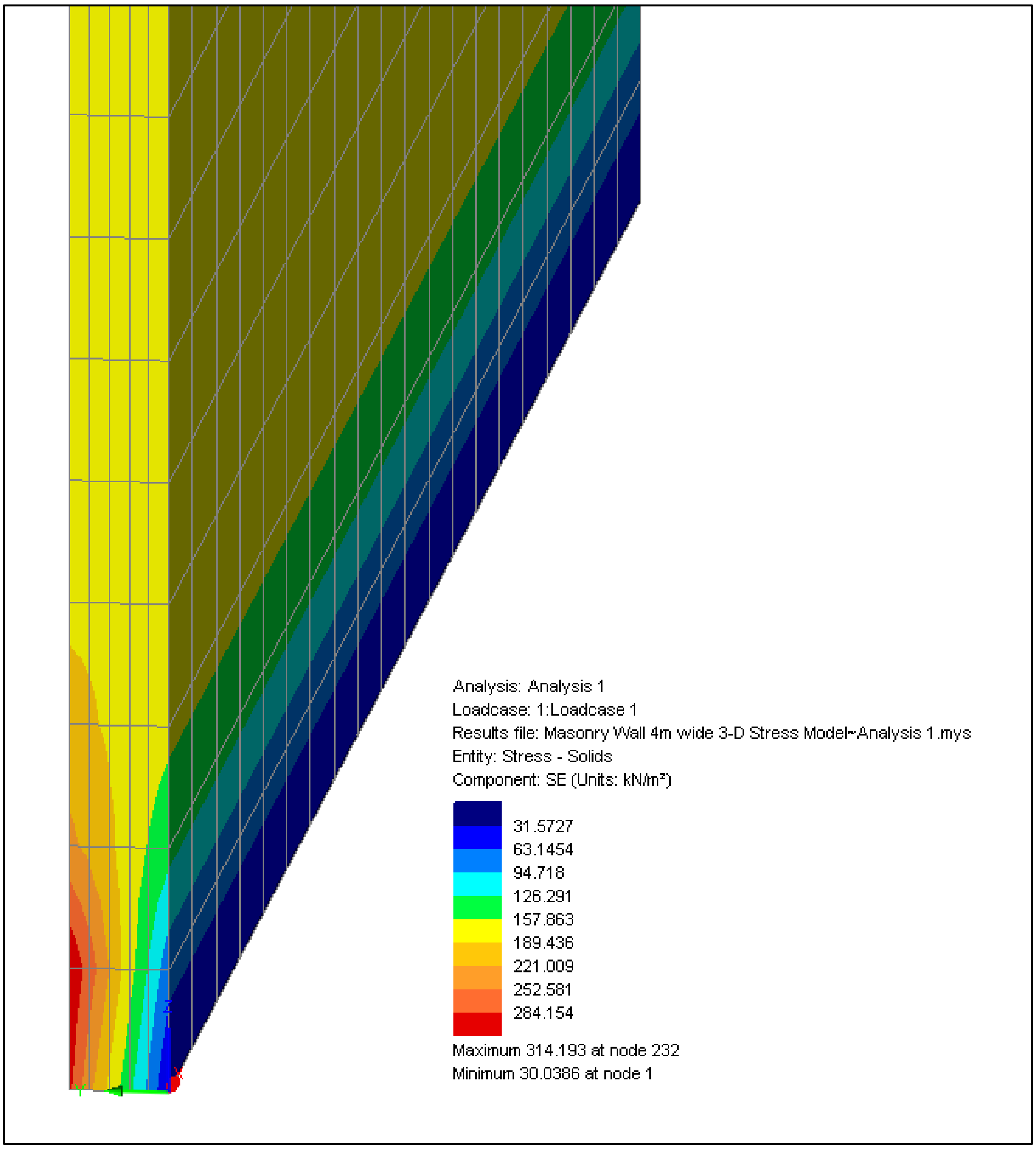
Appendix O4 - Resultant stress contour of the original panel under applied vertical loading from 12m² with a loading of 3kN/m²



Appendix O5 - Resultant stress contour of the original panel under applied vertical loading from $12m^2$ with a loading of $4kN/m^2$



Appendix O6 - Resultant stress contour of the original panel under applied vertical loading from 12m^2 with a loading of 5kN/m^2



Appendix P - Flood water hazard matrix

Table 4 – Hazard to People Classification using Hazard Rating *(HR= d x (v + 0.5) + DF)* for (Source Table 13.1 of FD2320/TR2 - Extended version)

HR	Depth of flooding - d (m)												
	DF = 0.5				DF = 1								
Velocity v (m/s)	0.05	0.10	0.20	0.25	0.30	0.40	0.50	0.60	0.80	1.00	1.50	2.00	2.50
0.0	0.03 + 0.5 = 0.53	0.05 + 0.5 = 0.55	0.10 + 0.5 = 0.60	0.13 + 0.5 = 0.63	0.15 + 1.0 = 1.15	0.20 + 1.0 = 1.20	0.25 + 1.0 = 1.25	0.30 + 1.0 = 1.30	0.40 + 1.0 = 1.40	0.50 + 1.0 = 1.50	0.75 + 1.0 = 1.75	1.00 + 1.0 = 2.00	1.25 + 1.0 = 2.25
0.1	0.03 + 0.5 = 0.53	0.06 + 0.5 = 0.56	0.12 + 0.5 = 0.62	0.15 + 0.5 = 0.65	0.18 + 1.0 = 1.18	0.24 + 1.0 = 1.24	0.30 + 1.0 = 1.30	0.36 + 1.0 = 1.36	0.48 + 1.0 = 1.48	0.60 + 1.0 = 1.60	0.90 + 1.0 = 1.90	1.20 + 1.0 = 2.20	1.50 + 1.0 = 2.55
0.3	0.04 + 0.5 = 0.54	0.08 + 0.5 = 0.58	0.15 + 0.5 = 0.65	0.19 + 0.5 = 0.69	0.23 + 1.0 = 1.23	0.30 + 1.0 = 1.30	0.38 + 1.0 = 1.38	0.45 + 1.0 = 1.45	0.60 + 1.0 = 1.60	0.75 + 1.0 = 1.75	1.13 + 1.0 = 2.13	1.50 + 1.0 = 2.50	1.88 + 1.0 = 2.88
0.5	0.05 + 0.5 = 0.55	0.10 + 0.5 = 0.60	0.20 + 0.5 = 0.70	0.25 + 0.5 = 0.75	0.30 + 1.0 = 1.30	0.40 + 1.0 = 1.40	0.50 + 1.0 = 1.50	0.60 + 1.0 = 1.60	0.80 + 1.0 = 1.80	1.00 + 1.0 = 2.00	1.50 + 1.0 = 2.50	2.00 + 1.0 = 3.00	2.50 + 1.0 = 3.50
1.0	0.08 + 0.5 = 0.58	0.15 + 0.5 = 0.65	0.30 + 0.5 = 0.80	0.38 + 0.5 = 0.88	0.45 + 1.0 = 1.45	0.60 + 1.0 = 1.60	0.75 + 1.0 = 1.75	0.90 + 1.0 = 1.90	1.20 + 1.0 = 2.20	1.50 + 1.0 = 2.50	2.25 + 1.0 = 3.25	3.00 + 1.0 = 4.00	3.75 + 1.0 = 4.75
1.5	0.10 + 0.5 = 0.60	0.20 + 0.5 = 0.70	0.40 + 0.5 = 0.90	0.50 + 0.5 = 1.00	0.60 + 1.0 = 1.60	0.80 + 1.0 = 1.80	1.00 + 1.0 = 2.00	1.20 + 1.0 = 2.20	1.60 + 1.0 = 2.60	2.00 + 1.0 = 3.00	3.00 + 1.0 = 4.00	4.00 + 1.0 = 5.00	5.00 + 1.0 = 6.00
2.0	0.13 + 0.5 = 0.63	0.25 + 0.5 = 0.75	0.50 + 0.5 = 1.00	0.63 + 0.5 = 1.13	0.75 + 1.0 = 1.75	1.00 + 1.0 = 2.00	1.25 + 1.0 = 2.25	1.50 + 1.0 = 2.50	2.00 + 1.0 = 3.00	3.50	4.75	6.00	7.25
2.5	0.15 + 0.5 = 0.65	0.30 + 0.5 = 0.80	0.60 + 0.5 = 1.10	0.75 + 0.5 = 1.25	0.90 + 1.0 = 1.90	1.20 + 1.0 = 2.20	1.50 + 1.0 = 2.50	1.80 + 1.0 = 2.80	3.40	4.00	5.50	7.00	8.50
3.0	0.18 + 0.5 = 0.68	0.35 + 0.5 = 0.85	0.70 + 0.5 = 1.20	0.88 + 0.5 = 1.38	1.05 + 1.0 = 2.05	1.40 + 1.0 = 2.40	1.75 + 1.0 = 2.75	3.10	3.80	4.50	6.25	8.00	9.75
3.5	0.20 + 0.5 = 0.70	0.40 + 0.5 = 0.90	0.80 + 0.5 = 1.30	1.00 + 0.5 = 1.50	1.20 + 1.0 = 2.20	1.60 + 1.0 = 2.60	3.00	3.40	4.20	5.00	7.00	9.00	11.00
4.0	0.23 + 0.5 = 0.73	0.45 + 0.5 = 0.95	0.90 + 0.5 = 1.40	1.13 + 0.5 = 1.63	1.35 + 1.0 = 2.35	1.80 + 1.0 = 2.80	3.25	3.70	4.60	5.50	7.75	10.00	12.25
4.5	0.25 + 0.5 = 0.75	0.50 + 0.5 = 1.00	1.00 + 0.5 = 1.50	1.25 + 0.5 = 1.75	1.50 + 1.0 = 2.50	2.00 + 1.0 = 3.00	3.50	4.00	5.00	6.00	8.50	11.00	13.50
5.0	0.28 + 0.5 = 0.78	0.60 + 0.5 = 1.10	1.10 + 0.5 = 1.60	1.38 + 0.5 = 1.88	1.65 + 1.0 = 2.65	3.20	3.75	4.30	5.40	6.50	9.25	12.00	14.75

Flood Hazard Rating (HR)	Colour Code	Hazard to People Classification
Less than 0.75		Very low hazard - Caution
0.75 to 1.25		Danger for some – includes children, the elderly and the infirm
1.25 to 2.0		Danger for most – includes the general public
More than 2.0		Danger for all – includes the emergency services

(Suresh *et al.*, 2008)

Appendix Q - Hydrodynamic loading results

Drag coefficient	Hazard rating	Velocity component orthogonal to the wall panel (m/s)	Hydrodynamic load per unit length (kN/m)	Factor of hydrostatic load
2	1.3	0	0.000	0.000
2	1.36	0.1	1.177	0.667
2	1.45	0.3	10.595	5.999
2	1.6	0.5	29.430	16.665
2	1.9	1	117.720	66.659
2	2.2	1.5	264.870	149.983
2	2.5	2	470.880	266.636
2	2.8	2.5	735.750	416.619
2	3.1	3	1059.480	599.932
2	3.4	3.5	1442.070	816.574
2	3.7	4	1883.520	1066.546
2	4	4.5	2383.830	1349.847
2	4.3	5	2943.000	1666.478
2.3	1.3	0	0.000	0.000
2.3	1.36	0.1	1.354	0.767
2.3	1.45	0.3	12.184	6.899
2.3	1.6	0.5	33.845	19.164
2.3	1.9	1	135.378	76.658
2.3	2.2	1.5	304.601	172.480
2.3	2.5	2	541.512	306.632
2.3	2.8	2.5	846.113	479.112
2.3	3.1	3	1218.402	689.922
2.3	3.4	3.5	1658.381	939.060
2.3	3.7	4	2166.048	1226.528
2.3	4	4.5	2741.405	1552.324
2.3	4.3	5	3384.450	1916.450

Appendix R - Maximum bending moment for varying velocities orthagonal to the wall panel calculations

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Project: Dissertation - PRCE 507 Project 2

Element: Hydrodynamic load yield line analysis calculations

0 m/s: $M_p = 0.219$ kNm/m

0.3 m/s: A factor of the increase in loading on the panel in comparison to hydrostatic loading, calculated as: $12.184 \div 1.766 = 6.899$

(12.184: hydrodynamic load per meter of exposed length) (1.766: hydrostatic load per meter of exposed length)

$\therefore M_p = 0.219 \times 6.899 = 1.511$ kNm/m

1.0 m/s: Factor $= 135.378 \div 1.766 = 76.658$

$\therefore M_p = 0.219 \times 76.658 = 16.788$ kNm/m

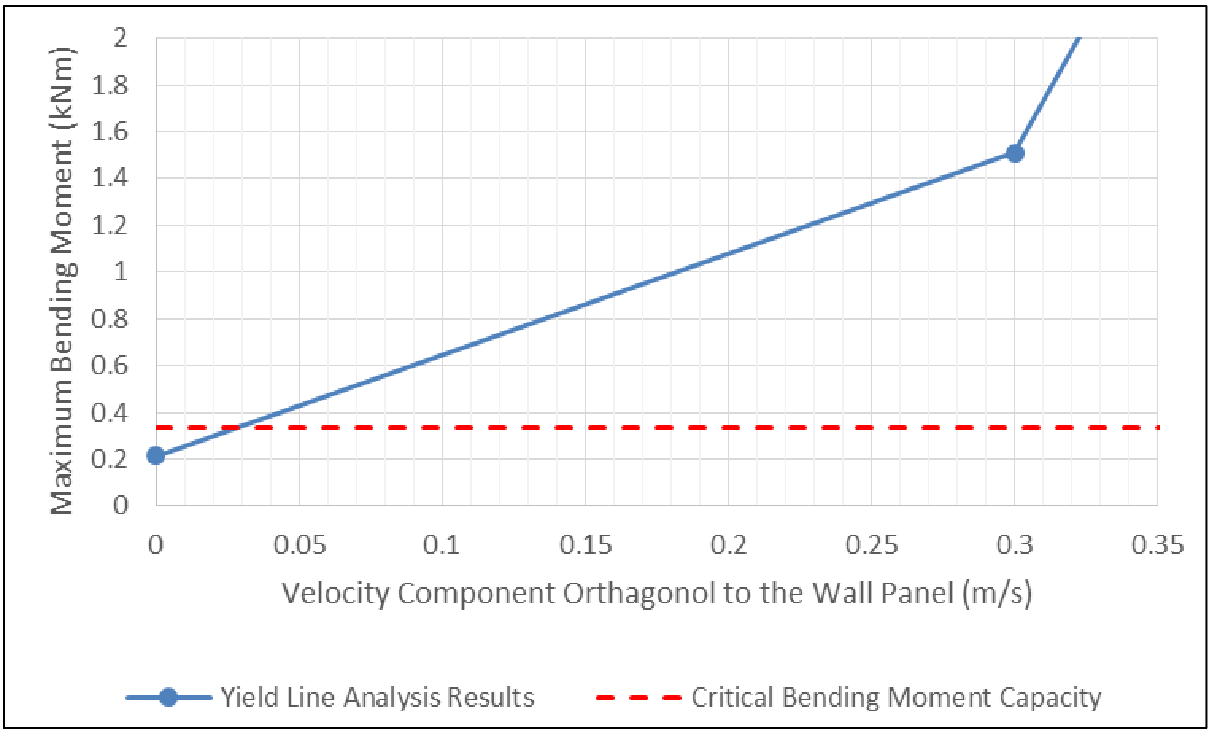
2.0 m/s: Factor $= 541.512 \div 1.766 = 306.632$

$\therefore M_p = 0.219 \times 306.632 = 67.152$ kNm/m

3.0 m/s: Factor $= 1218.402 \div 1.766 = 689.922$

$\therefore M_p = 0.219 \times 689.922 = 151.093$ kNm/m

Appendix S - Velocity component orthagonal to the wall panel verses maximum bending moment for slower velocities observed



Appendix T - Check sheet to assist in determining whether a protection height of 0.6 meters is appropriate for a wall panel

	Yes	No
Section modulus less than that from inner and outer leafs 100 mm thick ($3.333*10^6$ mm^3)?		
Notable velocity of flood water in previous events?		
Presence of large opening for large sliding doors (or similar)?		
Walls in a less than fair condition upon visual inspection?		
Total:		