Example of Calculations applying the Middle Third Rule

A freestanding masonry wall is 7 m high and it is 0.6 m thick. The material density = 2000 kg/m^3. Calculate the maximum horizontal steady wind pressure for the condition of no tensile stress to be in the wall.

Solutions:

\[
p = 7000 \text{ N/m}^2
\]

Resultant load on the wall, \( P \) acting at the C of G (from the wind)

By inspection, the heel of the wall is the critical section with regard to the requirement for no tension to development in the wall. Consider unit length of the wall:

\[
W = \text{weight of the wall}
\]

\[
R = \text{the resultant of} \ P \ \text{and} \ W . \ \text{this must lie on the “core boundary” for the zero tensile stress condition to apply.}
\]
Taking moments about the position at which the resultant, $R$, intercepts the base of the wall:

\[
\frac{7}{2} P = \frac{0.6}{6} W \quad \text{(using metre units)}
\]

\[
3.5P = 0.1W
\]

\[
P = p*7*1 \text{ Newton (for } p \text{ in N/m}^2 \text{ units)}
\]

\[
W = 2000*9.81*0.6*1.0*7 \text{ N}
\]

Substituting,

\[
3.5(7p) = 0.1(2000*9.81*0.6*7) \Rightarrow p = 336.3 \text{ N/m}^2
\]

Alternative view of the solution:

Masonry wall moments (NTS):

Moments about the heel: $3.5P + 0.3W = 0.4W \Rightarrow 3.5P = 0.1W$
Alternatively: Using combined stresses theory.

\[
\frac{M}{Z} = \frac{F}{A} = \frac{W}{A}
\]

\[
\frac{3.5 \times 7 \times 1.0 \times p}{1.0 \times 0.6^2} = \frac{7 \times 1.0 \times 0.6 \times 2000 \times 9.81}{1 \times 0.6} \quad \Rightarrow \quad p = 336.3 \text{ N/m}^2
\]

If the wind speed increases so that the wind pressure is 450 N/m^2, calculate the new height of the wall for zero stress at the heel.

\[
\frac{M}{Z} = \frac{W}{A}
\]

\[
M = H/2 \times H \times 1.0 \times 450 = 225H^2 \quad \text{(N m)}
\]

\[
W = H \times 0.6 \times 1.0 \times 2000 \times 9.81 = 11772H \text{ Newton}
\]

\[
Z \text{ & } A \text{ are as before.}
\]

\[
225H^2 = 11772H \quad \Rightarrow \quad H = 5.232 \text{ metres}
\]

If the wall is constructed at the new height but with a base width of 900 mm, what steady wind pressure can be applied for the zero base pressure stress condition to be maintained?

\[
M = (5.232)^2 \times p \text{ N m}
\]

\[
W = 5.232 \times 0.9 \times 1.0 \times 2000 \times 9.81 = 92386.66 \text{ N}
\]

\[
Z = 1 \times 0.9^2/6 \text{ m}^3
\]

\[
A = 1 \times 0.9 \text{ m}^2
\]

Hence \( p = 1012.5 \text{ N/m}^2 \)