Elementary Analysis For Width/Height Ratio Of Retaining Masonary Structure

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In masonry construction, one of the key challenges is ensuring the stability of structures against lateral forces, such as those caused by wind, water, or soil pressure. Unlike materials like steel or reinforced concrete, masonry is inherently weak in resisting tensile forces. As a result, masonry structures rely primarily on their weight to counteract these lateral loads. To maintain stability and prevent failures such as overturning or sliding, the dimensions of masonry structures must be carefully proportioned.

In this article, we will explore the derivation of an expression for the width-to-height ratio of a simple rectangular masonry structure. This ratio is critical in ensuring that the structure can resist lateral forces purely through its weight. We will examine two scenarios—overturning and sliding—and determine the minimum base width-to-height ratio necessary for the structure's stability, taking into account both the material properties and the frictional resistance at the base.

Calculations

Let,

$$γ=density of water $$

$$ sm=specific gravity of masonry materia l$$

$$ sl=specific gravity of material giving lateral force (e.g. water, soil etc) $$

$$ h=height of the structure $$

$$ x=width of the structure $$

$$ W=weight of structure=h*x*s* γ $$

$$ μ= coefficient of friction $$

Case1: For overturning

Moment dut to lateral force=moment due to weight of the material

½* γ*sL*h^2*h/3 =W*x/2

$$ ½* γ*h^2*h/3*sl= γ *sm*h*x*x/2$$

$$ (x/h)^2=(sl/(3*sm)) $$

$$ x/h=sqrt(sL/(sm/3)) $$

For water (sL=1);for stone-masonry (sm=22/9.81=2.14):

Therefore,
$$ x/h=0.394≈0.4$$

Case2: For Sliding

Horizontal force=friction factor*weight of the structure

$$ ½* γ*sL*h^2= μ (γ*sm*h*x) $$

$$ x/h=sL/(2*sm* μ) $$

For water and stone masonry and using $$μ=0.65$$

$$ x/h=0.359≈0.4 $$

Thus from above derivation we see that the minimum base width/height ratio of the rectangular block to resist the lateral (triangular here) force with safety factor 1 is 0.4.

With safety factor of 1.5 the minimum width/height ratio becomes 1.5*0.4=0.6.

Other results