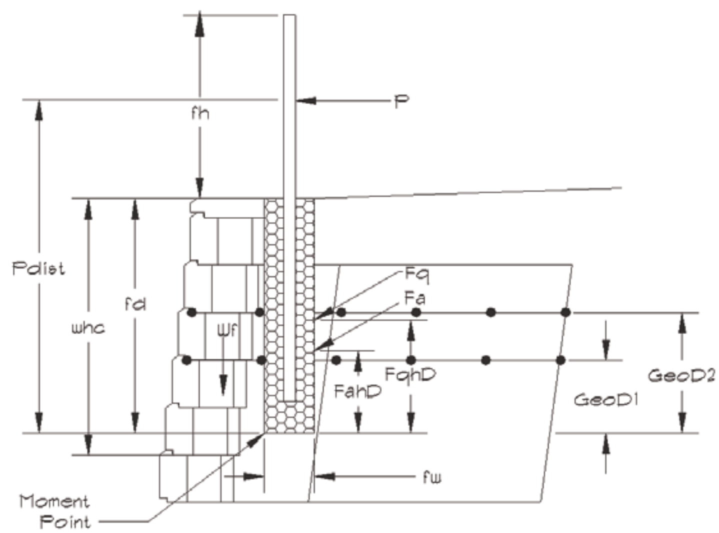
Top of Wall Fence Overturning

Localized top of wall overturning is typically investigated when a fence or railing is to be placed above and behind a retaining wall. In order to properly design the top of wall to resist the overturning force you need to know a few things about the wall, fence, and site conditions.

- What is the fence height and desired post spacing?
- What are the lateral wind loads and/or pedestrian loads?
- What is the friction angle of the soils used in the wall design?
- Are there any additional surcharges such as a roadway or slope above the wall?
- What is the geogrid type, length, spacing between layers, and position in the top portion of the wall?

Determining these five bullet points will allow the engineer to calculate an overturning moment that can be used for the design of the post depth and be used to specify the final geogrid position, strength and length. Please note that the resistance to overturning comes from the wall facing setback and self-weight as well as the residual geogrid capacity above and beyond what is required for the wall stability alone.



From the free body diagram, the bottom of the fence or railing post becomes the rotational pivot point for the summation of resisting and applied forces.

Wind or Pedestrian Loads

If the fence will withstand wind loads then the design will need to incorporate the wind speed and exposure coefficients in order to calculate the wind pressure.

Once the design wind pressure is determined then the resultant force for each panel of fence is calculated by multiplying the design wind pressure by the tributary area (fence post spacing and height). The percent of area that the fence obstructs (around 3% for a chain link fence or 100% for a solid wood fence) will also need to be considered. The applied wind force is concentrated at the mid-height of post so the overturning moment is equal to the post depth plus half the height of the post.

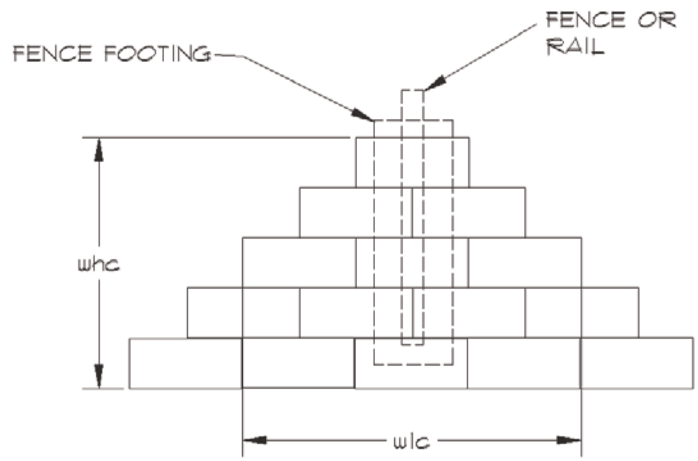
For pedestrian loads the designer should check with their local building codes to determine the force. A common applied force is 50 pounds per linear foot (74.4 kg/m) or a minimum of 200 pounds (90.7 kg) at each post. Typically these loads are placed at the top of the railing.

Surcharge and soil forces

Often overlooked in fence overturning calculations are forces from surcharges placed close to the back of the wall and these are the lateral earth pressure along the side of the footing. The driving surcharge force is the surcharge force (lb/ft^2 or N/m^2) multiplied by the active earth coefficient (K_a) and the fence post depth (fd). $[f_q = Q * K_a * F_d]$. The driving active earth force is one half of the active earth coefficient (K_a) multiplied by the unit weight of the soil and the depth of the fence post (f_d^2) .
$[f_a = ½ K_a * y * f_d^2]$ The moment distance for the active earth force (F_{ahD}) is equal to 1/3 of the fence post depth (f_d) and the moment distance for the surcharge force (F_{qhD}) is equal to ½ of the fence post depth.

Resisting Forces

As stated above, the resistance comes from the weight of the effected courses of facing and the relative strength and position of the effected geogrid layers. Choosing a post depth is an iterative process. By choosing a post depth you are also choosing the number of wall courses affected by the rotating post. Thus, the self-weight of the wall and rotational moment can be determined. The wall height affected by the embedded post (*whc*) is equal to the fence post depth divided by the block height and rounded up to full units. If the block length is greater than the post width, then the wall length affected by the fence post (*wlc*) is equal to (whc+1)/2 otherwise it is equal to (whc+2)/2. This value is in full block quantities and thus it must be multiplied by the actual block length in order to determine the length in feet or meters.



Multiply the number of units by their unit weight and by half the block to determine, the wall portion of the resisting moment.

Geogrid provides the most resistance to overturning. In a standard wall design, the strength of each geogrid layer is calculated in three different ways: block pullout, soil pullout and overstress. It is recommended that these values are obtained from AB Walls 10 software as the calculations required to determine these values is not covered in this document. For each layer chose the one that has the lowest factor of safety and use its excess capacity as the resisting force for the overturning calculations. The grid position, or moment arm, is based on counting courses up from the bottom affected course to each grid layer. The deeper the post is the more grid layers that are affected and more resisting force is available.

Now that all of the resisting and overturning moments have been calculated, the safety factor for overturning can be determined by dividing resisting moments by the applied moments. A minimum factor of safety of 1.1 to 1.3 is common, but local code requirements may call for higher values. If the factor of safety is lower than the required, lowering the bottom of post one more block course will greatly increase the resistance. Continue to iterate to determine the required post depth. Please see the Allan Block Engineering Manual for a full explanation of internal and external wall calculations.