Technical Note - Use of the 'Cutoff' Material

Introduction

The 'Cutoff' model in LimitState:GEO has many uses in modelling geotechnical problems. This note introduces the use of this material type in two applications:

- the modelling of a tension crack behind a retaining wall
- modelling a propped retaining wall

All files used in this note are available in a zip file that can be downloaded from:
http://www.limitstate.com/files/technical-notes/LSGTN3/cutoff_material.zip

Modelling Tension Cracks

Consider the 8m high cantilever wall depicted in Figure 1. The wall is embedded 2m into a cohesive soil of undrained shear strength 35 kN/m^2, unit weight 20 kN/m^3 and a surcharge load of 10kN/m^2 is applied on the surface of the retained soil. For simplicity the soil/wall interfaces are modelled as smooth, and all analyses will be short term undrained. In this example the focus is on the external failure of the wall, and so the wall itself is simply modelled as a *Rigid* material of unit weight 24kN/m^3. In the results that follow all analyses were undertaken using a medium nodal resolution.

The problem was set up in LimitState:GEO with the **Adequacy factor** applied to the surcharge load. The question being asked is therefore how much larger does the surcharge load have to be to cause collapse (i.e. drive the system to its Ultimate Limit State). If the problem is modelled exactly as in the scenario described above, the analysis predicts an adequacy factor of 1.25 (i.e. collapse when the surface load reaches 12.5 kN/m^2) with the collapse mechanism predominantly involving sliding of the wall.

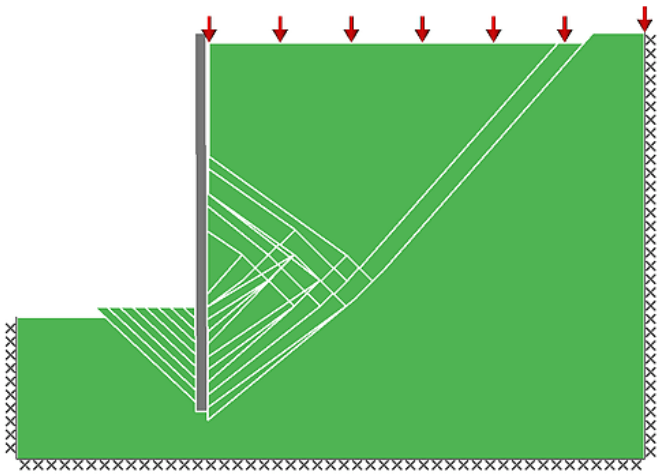

Figure 1: Retaining wall collapse mechanism showing formation of tension crack at the upper wall/soil interface

However since the soil is cohesive there are likely to be near surface tensile forces appearing in the retained soil. To eliminate this effect at the soil/wall interface, a tension cutoff material can be 'added' to the wall/soil boundary.

(This can be done in various ways e.g. drag and drop the system defined *No-Tension Cutoff* material, available in the **Materials Explorer**, onto the right hand soil/wall boundary, and click 'Add'). This allows this boundary to be both smooth and not allow any tensile forces to be transmitted across it. Solution of this problem produces a lower adequacy factor of 1.16 and a modified collapse mechanism involving sliding and rotation as depicted in Figure 1, where the tension crack can clearly be seen. (Note that by adding the **No-Tension Cutoff** material to the whole retained soil mass would also allow modelling of tension cracks within the soil and a further reduction of adequacy factor).

The complete wall model may be loaded by opening the file unpropped_wall_no_tension.geo.

Modelling Wall Rotations about a Prop

The margin of safety for the above wall is clearly very low. To increase this, a prop can be introduced located e.g. centred 1.0m from the top of the wall as depicted in Fig 2. In this case a *Rigid* material is used and is joined to the wall along a height of 0.2m. If the prop is connected directly to the wall, a 'fixed' joint will be modelled. In this case the failure mode that LimitState:GEO will find is of a base heave type failure with soil flowing around the rigid wall. To allow free rotation about the prop it is necessary to again utilise the *No-Tension Cutoff* material. In this case it should be added to the prop/wall interface. (As before drag and drop the built in *No-Tension Cutoff* material onto the 0.2m length of prop-wall interface). On solving, the wall is now allowed to rotate about the prop and the failure mechanism in Figure 2 is obtained together with a much increased adequacy factor of 5.28.

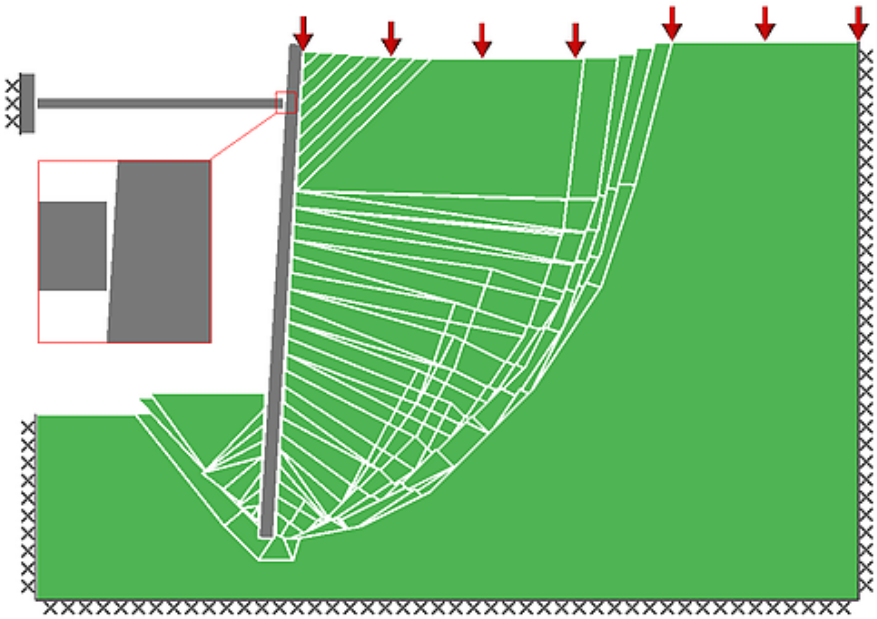

Figure 2: Propped wall collapse mechanism with free rotation about the prop.

If the wall/prop joint is zoomed into as shown in Figure 2, it will be seen that the wall is rotating about the lowest point of the wall/prop interface. It is able to do this because the interface now has zero tensile strength, but effectively an infinite compressive strength allowing it to rotate about an almost infinitesimal contact area.

More sophisticated use of the cutoff model can allow modelling of e.g. a plastic hinge in the prop or wall and compressive yield of the prop (e.g. representative of a buckling load). For more information see Technical Note: **Modelling Structural Resistance LS-G-TN4**.

The complete propped wall model may be loaded by opening the file propped_wall_no_tension.geo.

For more information: www.limitstate.com/geo