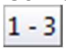
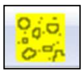
# TensarSoil® program for design of reinforced soil structures - 2-part wedge slope example

## TTV_103 training video - example for 2-part wedge slope design method (this is based on the withdrawn HA68/94 method, but adjusted to use partial material factors, as well as seismic loading)

| STEP | ACTION | COMMENTS |
|---|---|---|
| **Start TensarSoil program and input initial design parameters** | | |
| 1 | Start TensarSoil<br>√ **Seismic loading,** then **Make a new file**<br><br>**OK** to conditions of use<br>This opens the "Facing system and design method" window, which gives access to design method and facing system | |
| 2 | Select **Tensar 2-Part Wedge Slope Design** from drop-down list | **Seismic loading** is already selected<br>Note: the only facings remaining available are those suitable for slope design, ie with a facing angle less than 70° |
| 3 | Tensar **Standard Facings** are available by default.<br>In the central panel click on **Wraparound**, select **Bagwork** using the radio button and then on the right:<br>Change **Face angle** to 65°<br>Change **Total face height** to 12m<br>Change **Spacings to be multiple of** to 0.25m<br>Change **Minimum** to ×2<br>All other parameters default<br>Then √ **SET** and √ **OK** | May need re-sizing to see options fully<br>Values which are fixed are "greyed" and cannot be changed.<br>For values which can be changed, hint gives range as cursor is passed over the value:<br>Hint: <br>You may be asked "Do you want to set all grid coverage to the default for this facing", click **Yes** |
| 4 | The **Fill and foundation properties** form opens<br><br>Peak parameters are used by default:<br>$c' = 2$ kPa, $\phi' = 30°$, $\gamma = 19$ kN/m$^3$, Maximum particle size = 2mm<br>√ **SET** and **OK** to the message re the use of c′ | Fixed as drained for fill, so greyed. Note:<br>(1) Warning is given concerning the use of c′ which has been defined in this case.<br>(2) The Tensar 2-part wedge slope design method only checks the stability of the reinforced soil slope, and does not include a foundation check, which should be done separately. |
| 5 | The **Secondary Grids** form opens<br>√ **SET** default arrangement using TX150 | Secondary geogrids help to prevent local instability at the facing, grade and spacing may be adjusted |
| 6 | **The Earthquake Accelerations** input form opens, so check:<br>**Apply earthquake accelerations** √<br>Set Horizontal = 0.2g<br>Set Vertical = 0.1g<br>√ **OK** | **Calculate** opens and gives access to the full input.<br>√ **OK** makes changes and closes the form.<br>**Change to user defined seismic design parameters** permits change of all "greyed values".<br>Warnings are given if outside normal limits. |
| 7 | Now ready to finalise program input and carry out the design | There may be a warning: "Reinforcement costs have not been entered – please click on cost button to enter prices", also a warning about the limitations of the 2-part wedge slope design method. Press **OK** both times, the program will then open showing the basic operating desktop. |
| 8 | : Check interaction factors, then √ **OK** | Use default values. |

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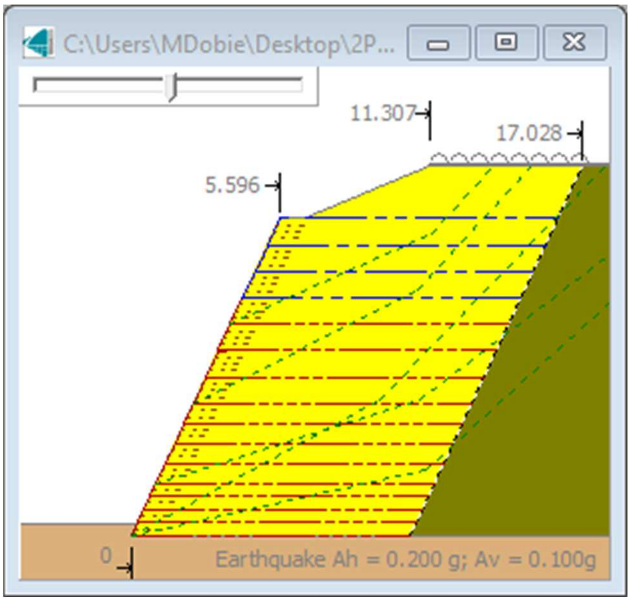
| 9 | Top slope: Complete the geometry by adding top slope, 2m high at 23° and 1m berm, then √ **SET** | Each time a dimension is adjusted, it must be **SET** for the change to take place.<br>Warnings are given re: maximum top slope angle. |
| 10 | : Set surcharge (x from crest of top slope)<br>**Load 1**: **Left end** = 0m, **Right end** = 100m, **Load** = 12 kPa, **TEMP** and then √ **SET** | Note:<br>(1) methods of measuring "x" values.<br>(2) importance of temporary (live load) or permanent (dead load). |
| 11 | : Check reinforcement properties<br>Use defaults: 60 years design life, 20°C soil temp<br>Set 2mm **Maximum particle size**<br>**Review design parameters**: shows all factors<br>√ **OK** | Factors are safety factors, so values are ≥ 1.00<br>Following current nomenclature, $f_s$ takes account of extrapolation of data, $RF_{ID}$ is the installation damage factor, $RF_W$ is for weathering and $RF_{CH}$ for chemical end environmental effects. |
| 12 | : Partial factors<br>Review values<br>Click **Default values** | Default values are material partial factors on soil strength and geogrid strength of 1.3 for static and 1.1 for seismic. These values are user adjustable. |

| STEP | ACTION | COMMENTS |
|---|---|---|
| **Run the design procedure**<br>All input is complete, so now ready to start the design procedure in the **HA68/94 Design** form | | |
| 13 | In the **Tensar 2-Part Wedge Slope Design** form<br>√ **Keep grid lengths equal** | This keeps the back and front of the reinforced soil block at the same angle |
| 14 | GO Proceed 1st click | Text tells the user what stage the calculation has reached, preparing for the $T_{ob}$ check |
| 15 | GO Proceed 2nd click | $T_{ob}$ = 9.5m for static, 8.5m for seismic down and 8.5m for seismic up, preparing for $T_{max}$ check |
| 16 | GO Proceed 3rd click | Provides results and dimensions from $T_{max}$ check for both static and seismic cases |
| 17 | GO Proceed 4th click | Provides default dimensions of the reinforced soil block, giving $L_B$ = 10.5m with back of reinforced soil block angle = 65°.<br>Alternative customised dimensions may be set, but they must stay within the requirements determined from the $T_{ob}$ and $T_{max}$ mechanisms. |
| 18 | GO Proceed 5th click | The **Tensar 2-Part Wedge Slope Design** form now changes to a spacing curve, and the **Modify Grid Layout** form opens.<br>**GO Proceed** has become greyed and will only become active again once an adequate grid layout has been arranged. |
| 19 | Using the **Modify Grid Layout controls**, adjust the geogrid grades and spacing until all plotted points fall on the left-hand side of the spacing curve for the grade being used.<br>Use option to add RE540 at the top of the slope | Layout resulting is:<br>RE570 at base, then 4 RE570 @ 0.5m spacing:<br>4 RE570 @ 0.75m spacing<br>3 RE570 @ 1.0m spacing<br>3 RE540 @ 1.0m spacing with extra at top |
| 20 | GO Proceed 6th click | Warning that a full wedge check will be carried out |
| 21 | GO Proceed 7th click | Wedges flash on the section showing where checks are being carried out. |
| 22 | On completion, the **Tensar 2-Part Wedge Slope Design** form gives results for wedges starting at different levels in terms of the "Highest proportion of reinforcement strength used", plus the $T_{max}$ mechanism<br>The form indicates **Design is satisfactory** if all results are < 1.00 | Cost index = 129.7 units |
| 23 | Save file as **2PWslope Example 65.WAL** | Save to preferred location |




65° slope section showing critical wedges (Step 22)

| STEP | ACTION | COMMENTS |
|---|---|---|
| **Investigate higher accelerations** | | |
| 24 | Press [GO Start again] to activate input | Input is not active during the design process. |
| 25 | Investigate the effect of higher ground accelerations on the design<br>: Earthquake accelerations<br>Use horizontal = 0.3g and vertical = 0.3g | The upper limits currently permitted are 0.5g |
| 26 | [GO Proceed] 1st click | Preparing for the $T_{ob}$ check |
| 27 | [GO Proceed] 2nd click | $T_{ob}$ = 9.5m for static, 9.0m for seismic down and 10.0m for seismic up, preparing for $T_{max}$ check |
| 28 | [GO Proceed] 3rd click | Provides results and dimensions from $T_{max}$ check for both static and seismic cases |
| 29 | [GO Proceed] 4th click | Provides default dimensions of the reinforced soil block, now giving $L_B$ = 13.0m. |
| 30 | [GO Proceed] 5th click | The **Tensar 2-Part Wedge Slope Design** form now changes to a spacing curve, and the **Modify Grid Layout** form opens. |
| 31 | Using the same geogrid layout as before, which was determined by the static case, so remains the most efficient | Layout resulting is:<br>RE570 at base, then 4 RE570 @ 0.5m spacing:<br>4 RE570 @ 0.75m spacing<br>3 RE570 @ 1.0m spacing<br>3 RE540 @ 1.0m spacing with extra at top |
| 32 | [GO Proceed] 6th click | Warning that a full wedge check will be carried out |
| 33 | [GO Proceed] 7th click | Wedges flash on the section showing where checks are being carried out. |
| 34 | On completion, the **Tensar 2-Part Wedge Slope Design** form gives results for wedges starting at different levels in terms of the "Highest proportion of reinforcement strength used", plus the $T_{max}$ mechanism<br>The form indicates **Design is satisfactory** if all results are < 1.00 | Cost index = 156.3 units<br><br>**NOTE**: the result of higher acceleration is an increase in geogrid length, but the layout remains the same as the previous case |

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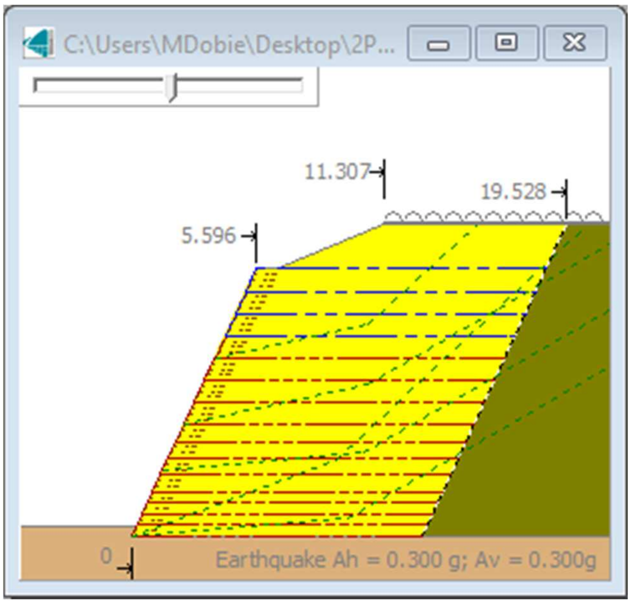
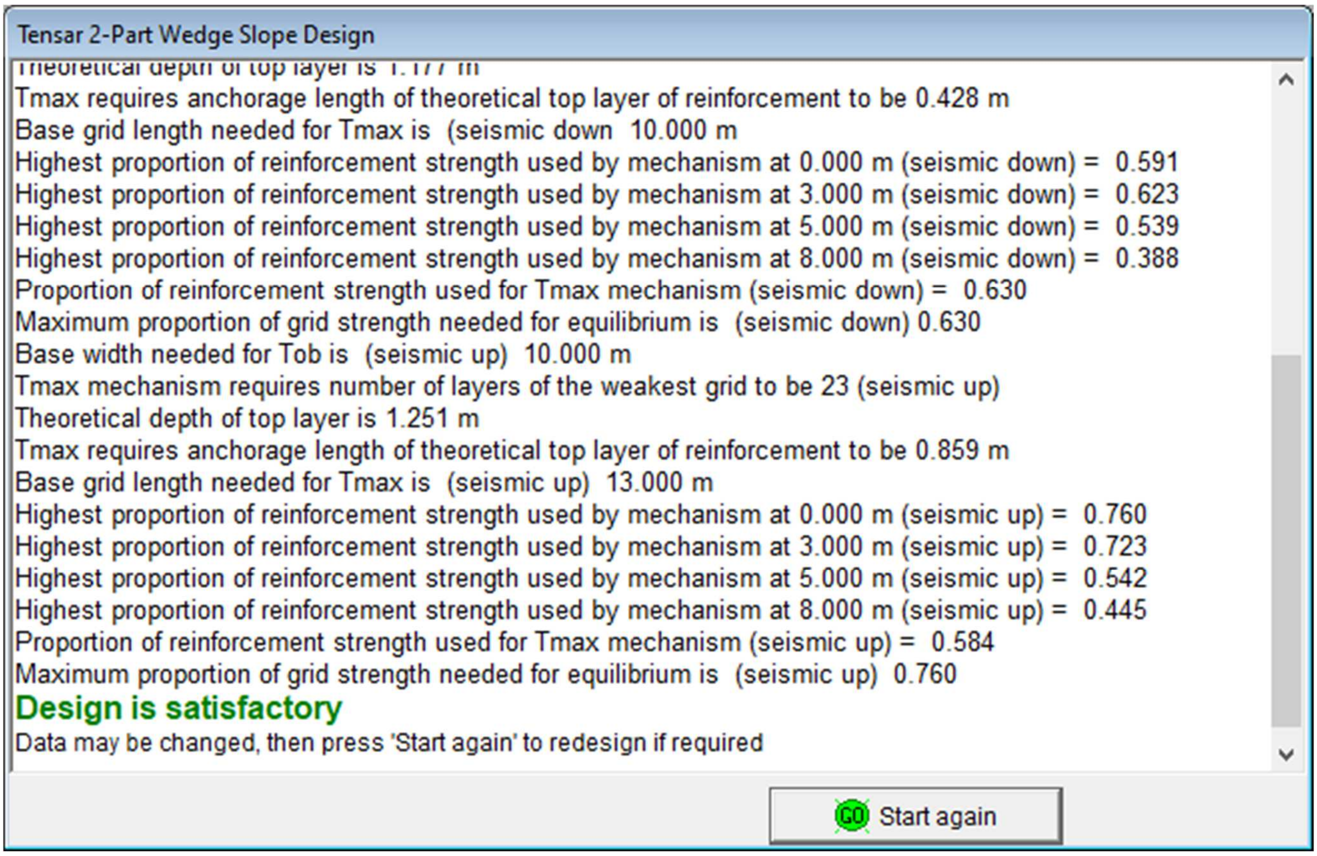
| 35 | In this case the design is satisfactory, however in different situations it is possible that the result of the final 2-part wedge check is a message that: **Design is NOT satisfactory**. This can generally be improved by increasing the geogrid length, see Step 29. | Solving **Design is NOT satisfactory** cases may be assisted by examining the locations of red wedges in the slope cross section following completion of the final 2-part wedge search. This issue may be seen by using $A_h$ = 0.5g and $A_v$ = 0. |

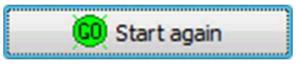
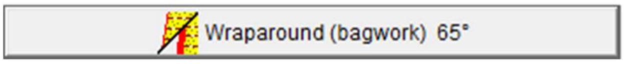
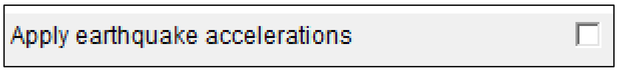
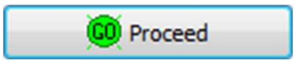


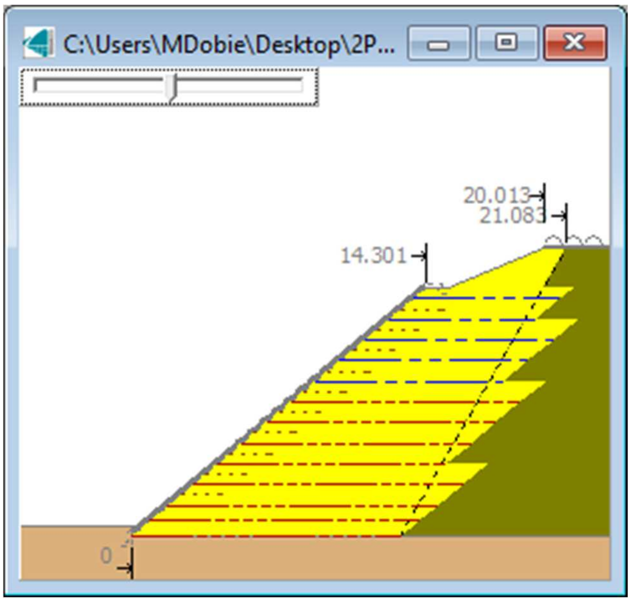


Tensar 2-Part Wedge Slope Design

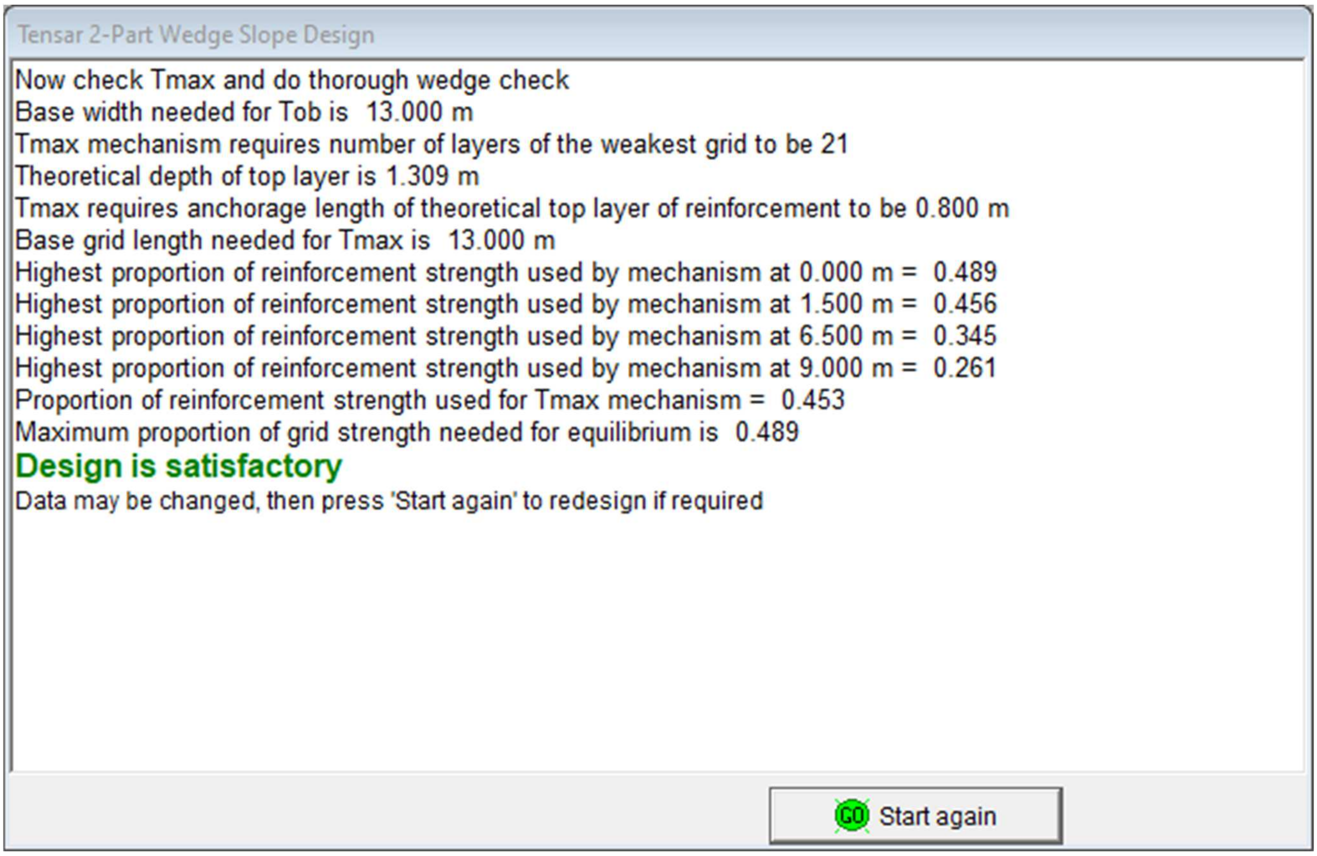
Theoretical depth of top layer is 1.177 m
Tmax requires anchorage length of theoretical top layer of reinforcement to be 0.428 m
Base grid length needed for Tmax is (seismic down 10.000 m
Highest proportion of reinforcement strength used by mechanism at 0.000 m (seismic down) = 0.591
Highest proportion of reinforcement strength used by mechanism at 3.000 m (seismic down) = 0.623
Highest proportion of reinforcement strength used by mechanism at 5.000 m (seismic down) = 0.539
Highest proportion of reinforcement strength used by mechanism at 8.000 m (seismic down) = 0.388
Proportion of reinforcement strength used for Tmax mechanism (seismic down) = 0.630
Maximum proportion of grid strength needed for equilibrium is (seismic down) 0.630
Base width needed for Tob is (seismic up) 10.000 m
Tmax mechanism requires number of layers of the weakest grid to be 23 (seismic up)
Theoretical depth of top layer is 1.251 m
Tmax requires anchorage length of theoretical top layer of reinforcement to be 0.859 m
Base grid length needed for Tmax is (seismic up) 13.000 m
Highest proportion of reinforcement strength used by mechanism at 0.000 m (seismic up) = 0.760
Highest proportion of reinforcement strength used by mechanism at 3.000 m (seismic up) = 0.723
Highest proportion of reinforcement strength used by mechanism at 5.000 m (seismic up) = 0.542
Highest proportion of reinforcement strength used by mechanism at 8.000 m (seismic up) = 0.445
Proportion of reinforcement strength used for Tmax mechanism (seismic up) = 0.584
Maximum proportion of grid strength needed for equilibrium is (seismic up) 0.760
**Design is satisfactory**
Data may be changed, then press 'Start again' to redesign if required

Start again

65° slope section showing critical wedges (Step 34) with information provided in the **Tensar 2-Part Wedge Slope Design** form

| STEP | ACTION | COMMENTS |
|---|---|---|
| **Adjust to lower angle slope with variable geogrid length and without earthquake loading** | | |
| 36 | Press   to activate input | Input is not active during the design process. |
| 37 | Click   to open the **Facing system and design method** form and select **Standard Facings** from drop-down list top left:<br>Select **Low angle slope**<br>Keep **Face angle** as 40°<br>Keep **Total face height** as 12m<br>Keep **Maximum** spacing set to 1.0m<br>All other parameters as default, √ **SET** and √ **OK** | Low angle facing does not use facing units.<br>You are asked "Do you want to set all grid coverage to the default for this facing", click **Yes** |
| 38 | By default the **Secondary grids** form opens<br>Use default TX150 at 0.5m spacing, √ **SET** | Also set **Maximum spacing without a secondary grid** to 0.5m |
| 39 | : Grid lengths<br>**Step grid lengths** √ **Set Length 2m,** √ **OK** | This will result in the geogrids being in groups of differing length |
| 40 | : Earthquake accelerations<br> <br>which sets horizontal and vertical acceleration to 0 | Removes earthquake design case |
| 41 | In the **Tensar 2-Part Wedge Slope Design** form ☐ **Keep grid lengths equal** | This permits face and back angle to be different. |
| 42 |   5 times accept all defaults | |
| 43 | Using the **Modify Grid Layout controls**, adjust the geogrid grades and spacing until all plotted points fall on the left-hand side of the spacing curve for the grade being used. | Layout resulting is:<br>RE570 at base<br>2 RE570 @ 0.75m spacing<br>5 RE570 @ 1.0m spacing<br>5 RE540 @ 1.0m spacing |
| 44 |   2 times | Carries out wedge check<br>**Design is satisfactory**<br>Cost index is 93.5 units |
| 45 | Final section has stepped lengths | When designing low angle slopes, it is often more cost effective to reduce geogrid length towards the top of the structure |
| 46 | Save file as **2PWslope Example 40.WAL** | Save to preferred location |




40° slope section showing critical wedges and four geogrid lengths (end of Step 45) with information provided in the **Tensar 2-Part Wedge Slope Design** form



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