Latest April 2018 – Updates/Upgrades to Vespa MSE Design

Software. Item 1. Design Methodology

Vespa now includes AASHTO 2010 LRFD and AASHTO 2015 LRFD Design Methodologies. (Jan 2016)

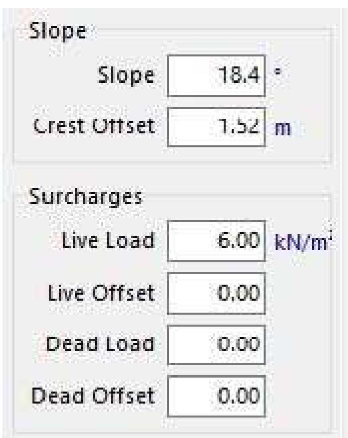
1.1 AASHTO 2010 LRFD - Update/Upgrades:

1.1.1 Static Analysis:

1.1.1.1 Live/Dead Loads

The original version of AASHTO 2010 LRFD included with Vespa treated Live Loads as an "equivalent height of soil" in accordance with 11.10.10.2 (i.e. 600mm of soil depth).

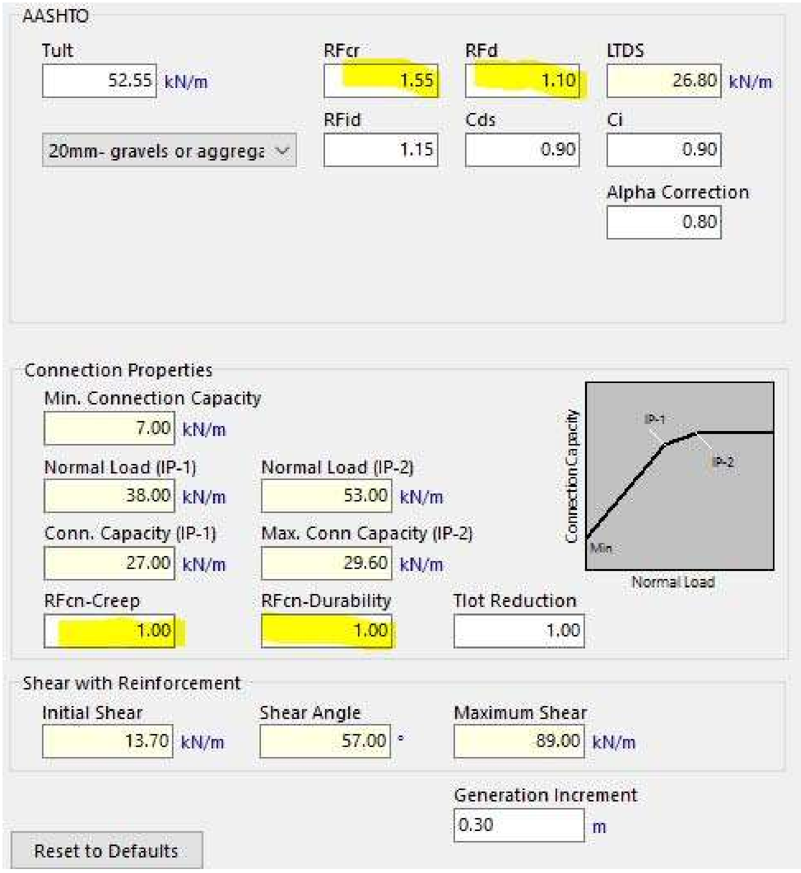
In an effort to model loads more explicitly, this method was replaced with the ability to set the actual surcharge load (kN/sq.m or lbf/sq.ft), load type (Live/Dead), and offset from the face of the Wall.



When loading older Vespa files, the equivalent Live Load will be automatically calculated based on the previous input equivalent soil height. The other result of this change is the load factor applied to the Live Load. Modelled as a soil surcharge (previous version), a Load Factor of 1.5 (ES)was applied. When modelled as an actual Live Load Surcharge (current version), a Load Factor 1.75 is applied.

1.1.1.2 Block/Grid Connection Factors

Previously, Reduction Factors for Creep (RFcr) and Durability (RFd) at the Block/Grid Connection were defaulted to be those provided by the Geogrid manufacturer for Creep and Durability of the Geogrid Reinforcement. These were editable, however, if they were changed, they would alter the Geogrid Reinforcement properties as well as the Connection Properties. New fields have been provided to separate these Reduction Factors for a) Reinforcement and b) Connection.



1.1.1.3 Seismic

Previous AASHTO 2010 did not include Live Load in the Seismic analysis. It is now included with the 0.5 combined Load Factor.

1.2 AASHTO 2015-LRFD

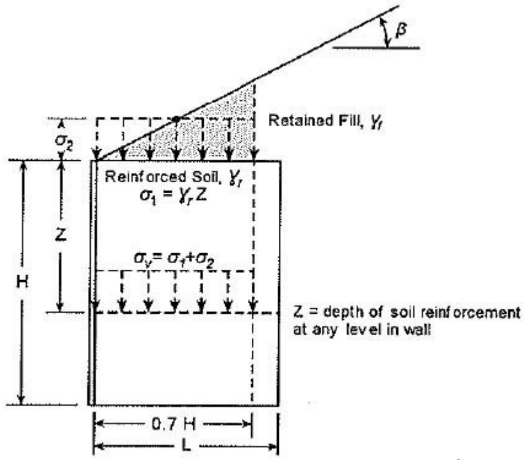
1.2.1 Static Analysis

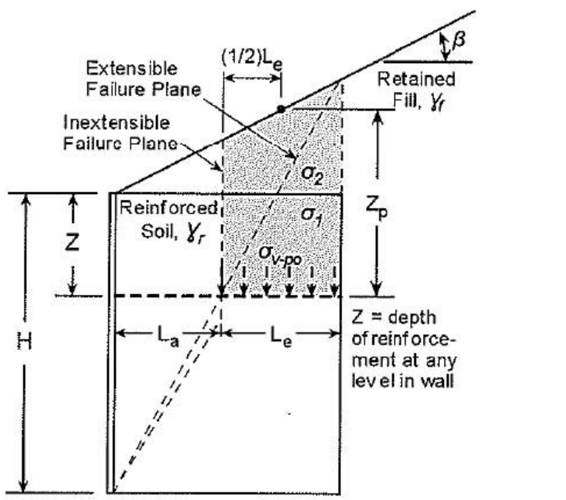
1.2.1.1 Tmax Calculation

Per Figure 11.10.6.2.1.2, for calculating the Vertical Pressure on reinforcements in sloping situations, the extent of the triangular weight above the reinforced zone is limited to 0.7H as shown. This was previously (2010) modeled as the full depth of reinforcement (L). The 0.7H limitation is more conservative but better reflects the actual vertical stress applied to the reinforcement.

1.2.1.2Pullout Resistance

2015 provides a more detailed explanation of the calculation of Vertical Confining Pressure and Zp depth in the anchorage zone beneath sloping backfill. Refer to Figure 11.10.6.3.2-1.





Nominal Vertical Confining Pressure:

$\sigma_1 = \gamma_r Z$

$\sigma_2 = \gamma_f (Z_p - Z)$ for sloping backfill

$\sigma_{v-po} = \gamma_r Z + \gamma_f (Z_p - Z)$

$Z_p = Z + (L_a + (1/2) L_e) \tan \beta$ for sloping backfill

1.2.1.32 Crest Toppling

Previously (2010), as the option was not provided to offset Live Loads from the back of the Wall, the Crest Toppling Calculation always included the Live Load surcharge.

With the provision for Live Load and Dead Load offsets, the Crest Toppling calculation now checks if the Load is outside of the zone of influence, assumed to be 1H:1V from the back of the Coping Unit.

1.2.2 Seismic Analysis

1.2.2.1 Calculation of Seismic Horizontal Acceleration Coefficient

Previously, the Seismic Horizontal Acceleration Coefficient, kh, was calculated as a function of the PGA and a specified allowable displacement. In 2015, the displacement criteria has been simplified to either allow it, or not, rather than specifying a specific amount of displacement. If displacement is allowed, the Seismic Horizontal Acceleration Coefficient, kh, is reducedto half of As. Refer to 11.10.7 for full Seismic Calculation.

1.2.2.2 Total Factored Horizontal Thrust (C 11.6.5.1)

As an additional check for the Total Horizontal Thrust, two potential scenarios are compared. Check 1 is 100% of Dynamic Horizontal Thrust due to Earth Pressure/Live/Dead Loads with 50% of the Inertial Force of the Reinforced Mass. Check 2 is 50% of the Pae/Paell/Paedl with 100% of the Inertial Force.

1.2.2.3 –Factored Increment Dynamic Inertia Force at Each Layer of Geogrid.

For 2015, Internal Stability, the total Inertial Force of the active wedge is evenly distributed to all reinforcements by simply dividing the Inertial Force, Pi, by the total number of Layers of Reinforcement. This is a change from 2010, where the distribution of the load to the Reinforcements was based on the Reinforcements relative contribution to total Anchorage Length.

1.2.2.4 – Pullout Calculations (Jan 2016 -end)

Previously, the Tmax was recalculated for Pullout in order to remove the Live Loads per 11.10.6.3.2-1 as the Live Load was not considered in the Pullout Resistance. In discussion with Designers and Vespa users, the concern was highlighted that for high walls, the case may occur when a live load (traffic lane) could exist in the “active” part of the wall, without necessarily have the same load above the anchorage zone. For conservatism, we have there used the same Tmax for Tensile Overstress and Pullout calculations.

1.2.2.5 – Dead Load Default Factors (Jan 2017)

For Dead Loads, Vespa always used the Default Load Factor value of 1.25 based on Table 3.4.1-2, where DC is described as Component and Attachments. The assumption here was that Dead Loads would typically be a footing for a structure nearby, or even an abutment footing. It has been suggested by user that the default for Dead Loads should be the more conservative ES: Earth Surcharge of 1.5, and let people reduce as they see fit, rather than the other way around. To be conservative, we now have the Dead Load default as 1.5.

Item 2. Project Tab

2.1 Creation of Project Folder Path

Previously, when the user entered the Client Name and Project Name, Vespa automatically created a File Folder Path using these names in the directory. Vespa users indicated that in most cases, they had already created their own Project Folder with related projects documents (CAD files, PDFs, emails, etc), so this automated process was not efficient. This process has been changed as follows:

- Prior to “Creating a Wall” the user must select “Set/Change” in the Folder Path to identify the Project Folder Path. Using this method, an existing Project Directory can be selected and set to the directory that Vespa uses to send files. If your Project files are usually found in the same place, you can set your starting pointing "Settings / Options / Project File Location". By setting your Project File location here (Settings), when you are in the Project Tab and select "Set/Change", it will automatically start you in the main directory.

- Once the Project Folder Path has been selected, you can now "Create Wall" as before.

Item 3 – Design Criteria

3.1 – Load and Resistance Factors (LRFD Methodology).

The Load and Resistance factors are now being formatted in a table showing the Min. and Max. "default" values, as well as the Min. and Max. "Used" values. Previously, for each load or resistance factor, a separate variable was designated for each Min.and Max value. We now have a single variable (i.e.LFES – Earth Surcharge Load Factor), with a min. and max. value depending on where itis being used. This is more in line with how itis presented in AASHTO(applies to 2010 and 2015, Static and Seismic.) For AASHTO 2010 and 2015 greater flexibility has been added to the Seismic Resistance Factors, allowing individual variables for each of the Connection, Pullout, and Tensile (Combined Static/Seismic) as well Frictional Resistance Factors for Connection and Pullout (RFconn, RFpull). Note that for RFconn, the default value is 1.0, however AASHTO recommends for "frictional" connections this be reduced to 0.8.

Design Notes | Empirical Checks | Load & Resistance Factors | Design Inputs

○ Static ◉ Seismic

Term	Name	Min Def.	Max Def.	Min Used	Max Used
LFDC	Load - Dead Load (Structure)	0.90	1.25	0.90	1.25
LFEQDL	Load - Dead Load Seismic Factor	0.00	1.00	0.00	1.00
LFES	Load - Earth Surcharge Load	0.75	1.50	0.75	1.50
LFEQ	Load - Earthquake Load	0.00	1.00	0.00	1.00
LFEH	Load - Horz. Pressure of earth fill	0.90	1.50	0.90	1.50
LFEQLL	Load - Live Load Seismic Factor	0.00	0.50	0.00	0.50
LFEV	Load - Vert. Pressure of earth fill	1.00	1.35	1.00	1.35
BEARING	Resistance - Bearing	1.00	n/a	1.00	n/a
COMBIMPCO	Resistance - Combined Static/EQ Connection	1.20	n/a	1.20	n/a
COMBIMPPO	Resistance - Combined Static/EQ Pullout	1.20	n/a	1.20	n/a
COMBIMPTO	Resistance - Combined Static/EQ Tensile	1.20	n/a	1.20	n/a
RFconn	Resistance - Seismic Frictional Connection Factor	0.80	n/a	0.80	n/a
RFpull	Resistance - Seismic Frictional Pullout Factor	0.80	n/a	0.80	n/a
SLIDING	Resistance - Sliding	1.00	n/a	1.00	n/a

Item 4 – Wall System

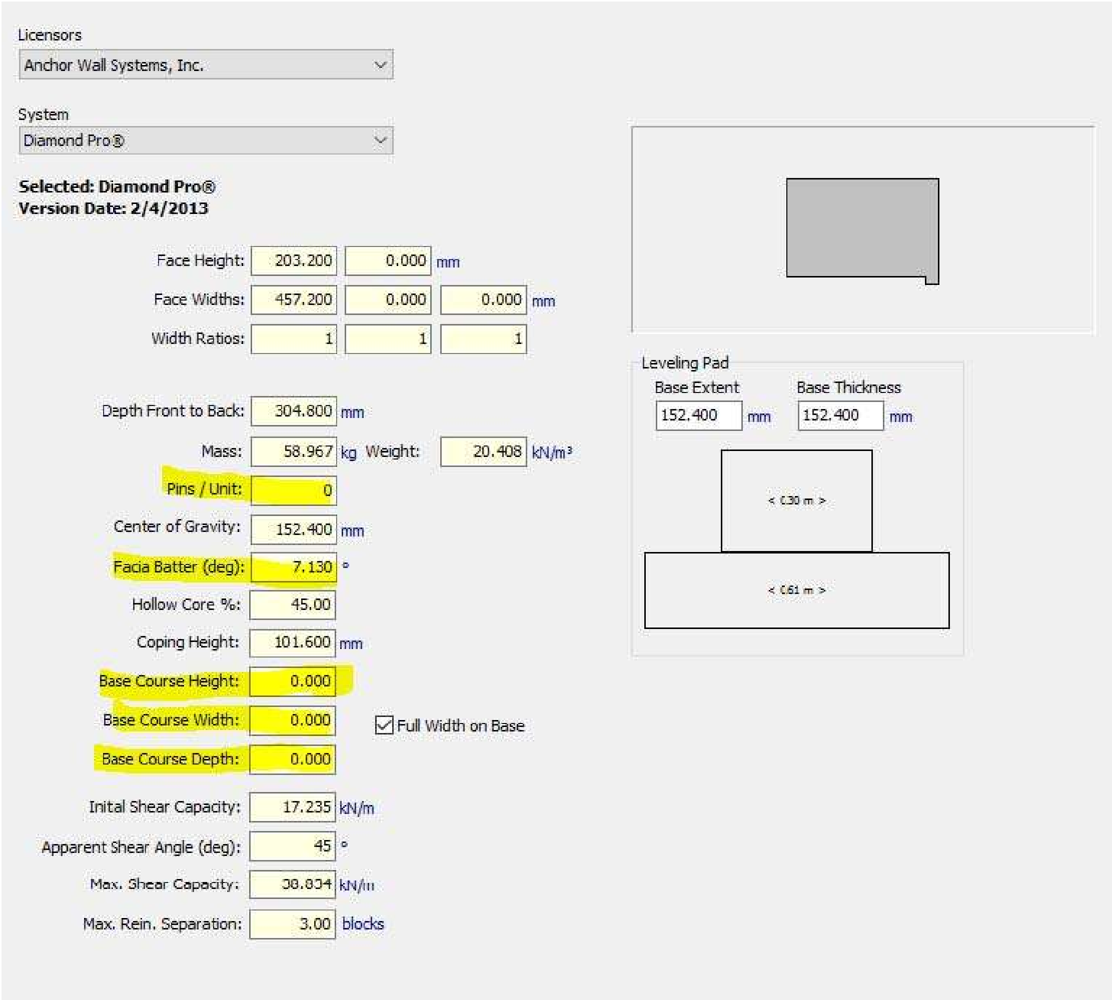
4.1 – Additional Wall System Characteristics

Additional fields have been incorporated to allow greater control over quantity calculation, panelization of units, etc.

4.1.1 Pins/Unit – For systems that require pins or connectors, this input will calculate the total quantity required for the project. If the manufacturer has not yet updated this field, it will be editable and the user can input a value as required.

4.1.2 Facia Batter – As a number of different systems have 2 or 3 possible facia batters for the same system, we have incorporated the ability to select just a single block, then select the facia batter from a drop down menu (if multiple batters exist). This is a change from the previous method where there existeda separate block for each wall batter(i.e. Block A ,8 degree, Block A,Vertical, etc).

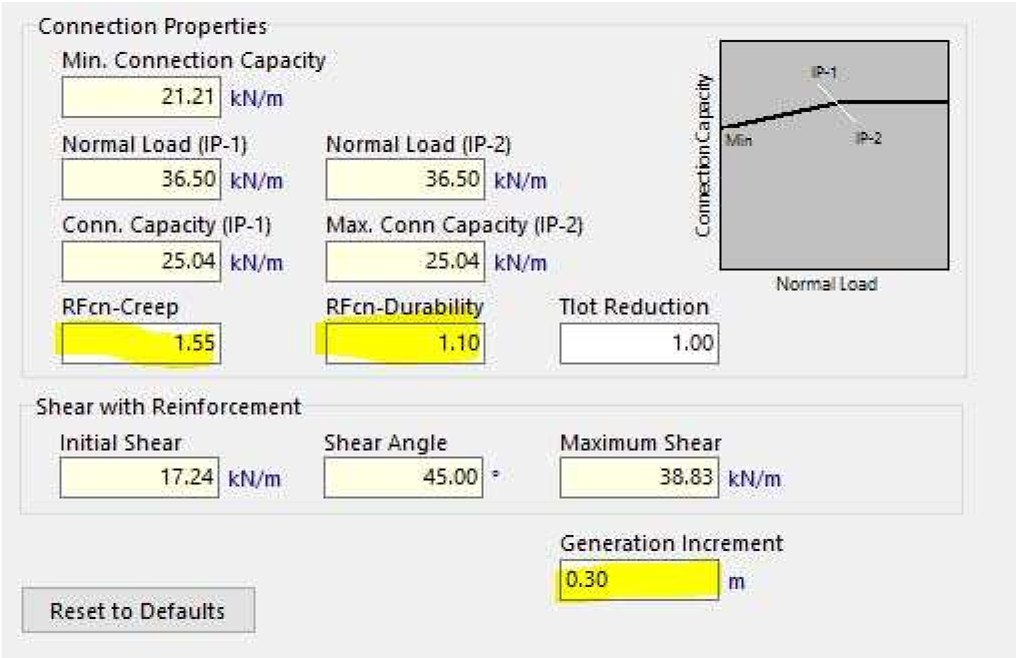
4.1.3 Base Course – Some systems include a special base block, or base course, which is used exclusively on the first course of the Wall. This unit can now be defined and used in the panelization, quantity estimate, and analysis.



Item 5 – Reinforcement Tab

5.1 – RFcn-Creep and RFcn-Durablity

As discussed above, for AASHTO Design Methodologies, 2 additional inputs have been included to separate values for RFcn-Creep and Durablity. These reduction values relate to the Creep and Durability reduction at the Block/Grid connection.

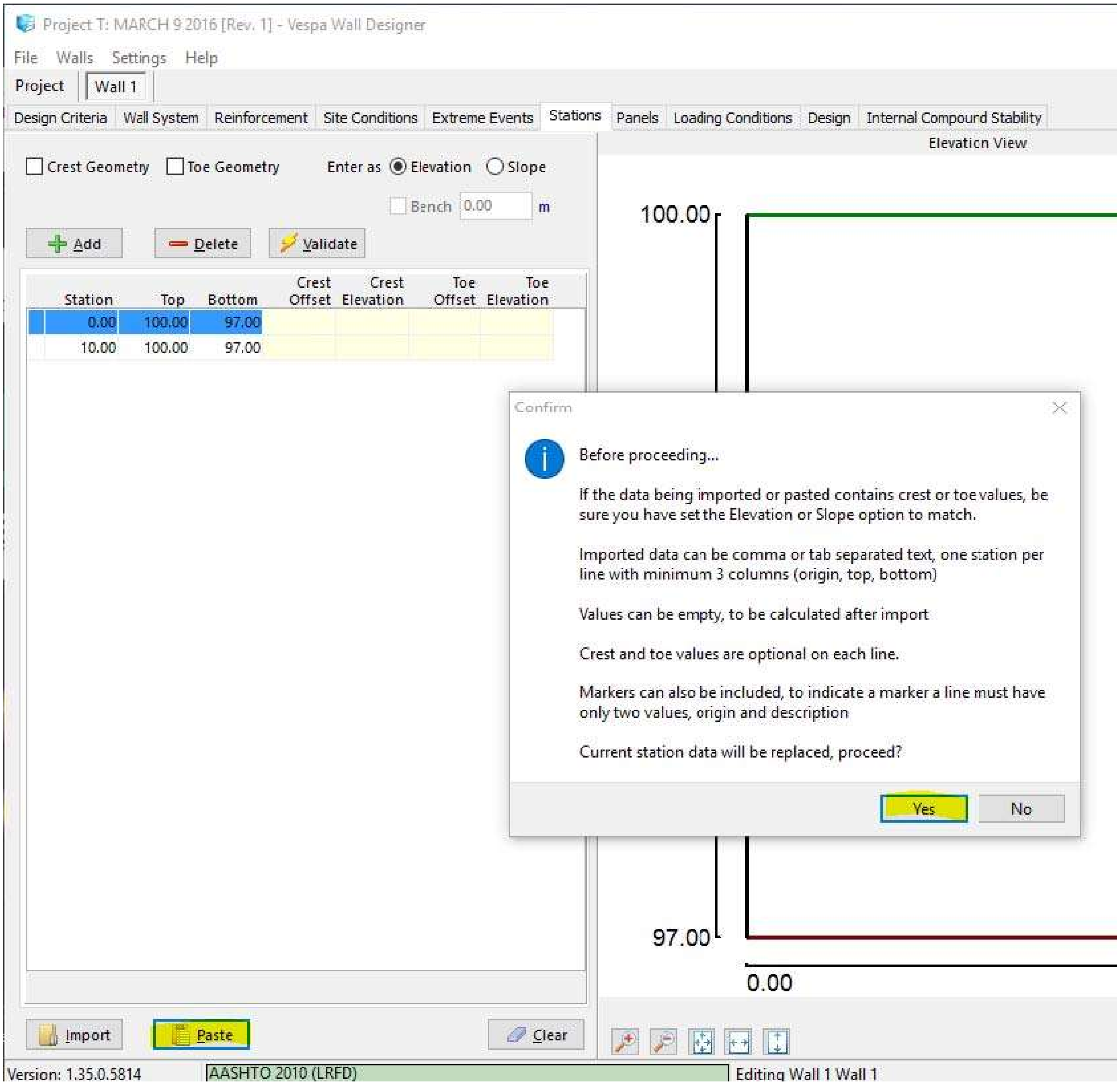


5.2 –Generation Increment

The generation increment is a new feature that allows the Designer to set the Geogrid Length increment at which the "Generate"function (Design Tab) steps through a Trial Design. For example, if the Generation Increment was set to 1.0ft, the Generate function would step through possible Designs starting at the min. base to height ratio (i.e. 6.0ft on a 10.ft high Wall for NCMA), then keep stepping up by 1.0ft (7.0ft, 8.0ft, etc), until the Design met all required F.S. or CDR values.

Item 6 – Stations Tab

6.1 Paste Function. As some users create the Wall Stations in Excel or some other spreadsheet, we now have the ability to paste cells from a spreadsheet directly into the Stations Table.



Item 7 – Panels Tab

A new feature has been added to allow the user to align either the Top of Wall or the Bottom of Wall better with a set or existing grade. The "Grade Alignment" feature sets either the Top or Bottom of Wall as the starting point for the Generate Routine. For example, if "Top" is selected, the Panelization routine begins panelizing the Wall by first matching the top block (or Coping if the "Include Coping in Height" is turned on) with the Top of Wall Grade. If your TW grade at Station 1 is set to 100, then the Panelization routine would set the Top of Coping to 100 and build the Wall from the Top –Down. In this case, the Top would be the "Set" or "Existing" grade that would have to be adhered to. Alternatively, if you needed to minimize embedment as much as possible, you could set the Grade Alignment from the

“Bottom” and the bottom block would be set to the minimum embedment elevation, then build the Wall from the Bottom-Up.

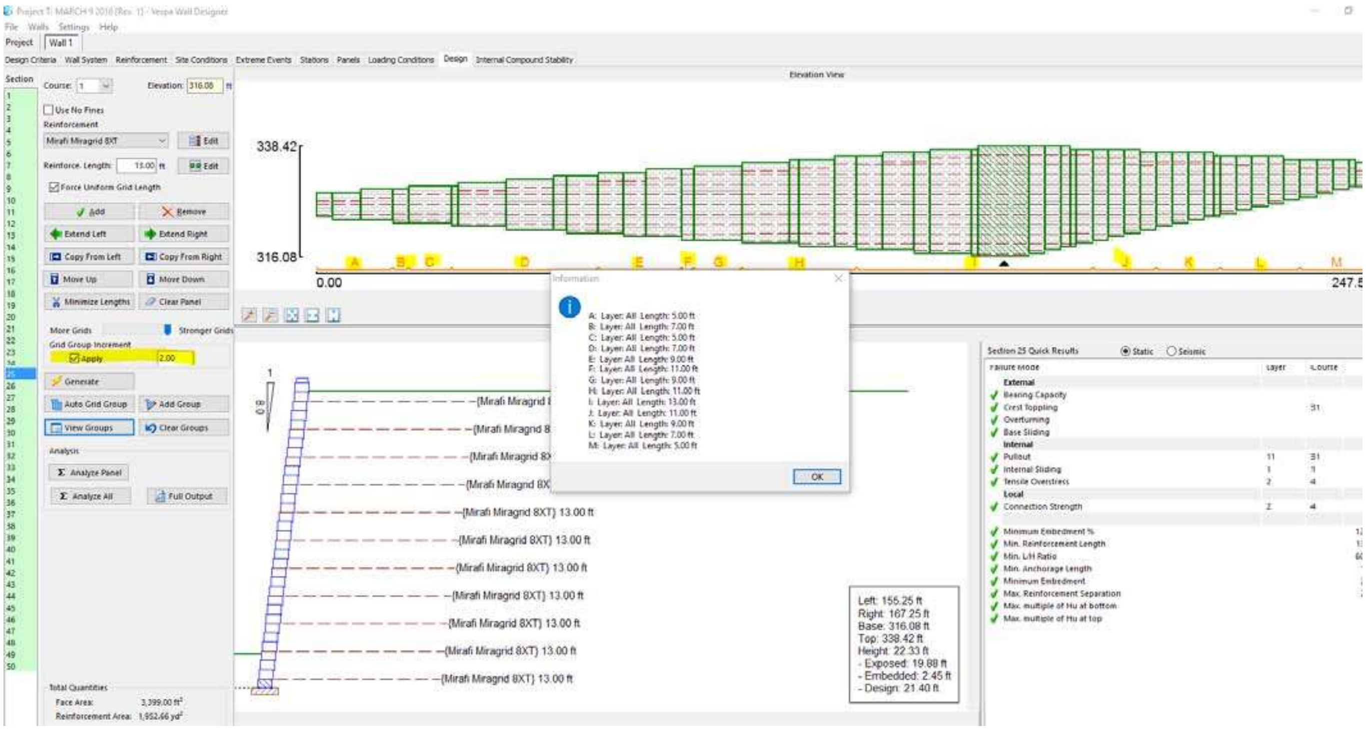
As noted above, the normal Panelization routine always starts at the first Station. However, if there was some Datum or grade in the middle of the wall for example that had to be matched (i.e.the TW grade in the middle of the Wall has to hit 110ft), you could select the “Datum” toggle and the Drop Down menu would give you all of the potential TW grades (based on the input Stations) or BW grades to have the Panelization start working from.

Item 8 – Design Tab (April 2017)

8.1 Grid Group Increment

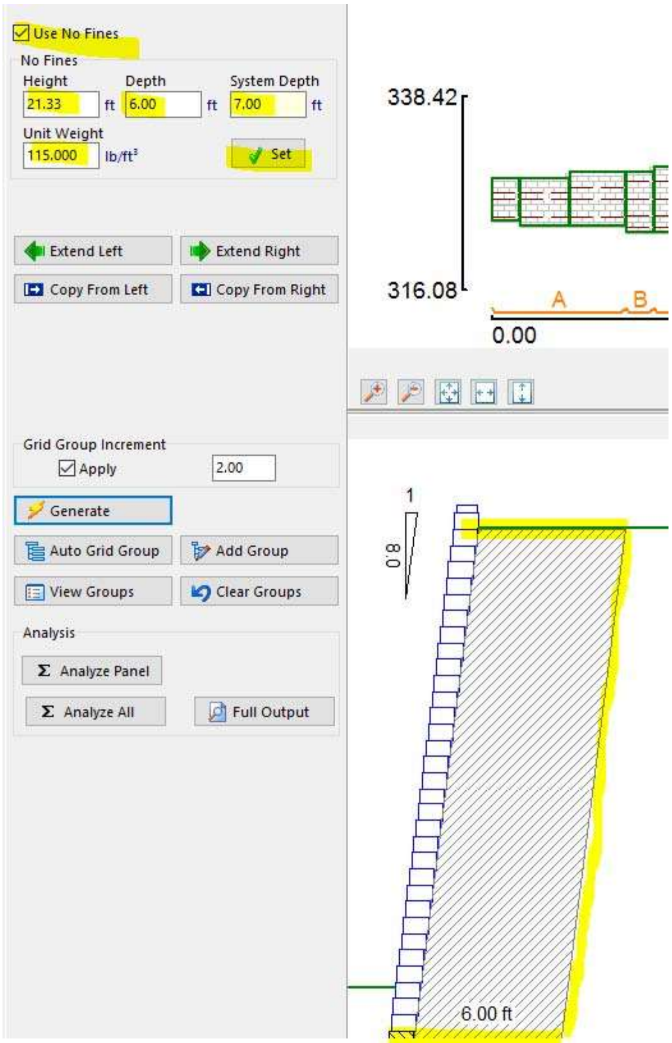
Expanding on the current automatic “Generate” functionality, the Grid Group Increment feature runs an algorithm that attempts to produce a Trial Design for the entire Wall. The algorithm takes into consideration the fact that Geogrid Reinforcement layers generally should be kept at constant elevations (for ease of installation) wherever possible, while still adhering to all Design and Empirical limitations (i.e. Max Crest Height, max reinforcement spacing, etc). Also, the reinforcement lengths should be changed at a reasonable interval along the length of theWall. The Grid Group Increment is the value at which the Reinforcement Length changes from one Group of Panels to the other. For example, if the Grid Group Increment is set at 2.0ft, the Reinforcement Length will step in intervals of 2.0ft from one group of Panels to the next (Note – this is different from the Generation Increment described above, which sets the Trial Design Length for an individual Panel).

By right clicking on the Elevation portion of the Design Tab and selecting “Select All” or by holding down the SHIFT keyand selecting any number of Panels, you can highlight all the Panels you want Designed. After you have these panels selected, click the “Apply” toggle in the Grid Group Increment area and then input the desired increment that you want the Geogrid to change length along the Wall. For example, if I select all panels, click “Apply”, then input 2.0ft , then hit Generate, the algorithm Designs the entire Wall with all layers in horizontal alignment, and the Grid Groups already defined and labelled (Grid Lengths in this example are 5.0ft, 7.0ft, 9.0ft, up to 13.0ft at 2.0ft increments.



8.2 No Fines Concrete (April 2017)

A practice gaining in popularity is the use of a No-Fines concrete backfill material to create composite gravity Walls. Vespa allows the user to select “Use No Fines” to Generate or define manually a depth of Free Draining Concrete behind the Wall. By selecting “Use No Fines” and hitting “Generate”, the algorithm calculates the necessary Wall Depth to resist the standard Conventional Modes of Failure (Base Sliding, Overturning, Bearing Capacity). The user can set the Unit Weight, as this will vary, or the Depth if required.



8.3 – Internal Compound Stability (April 2017)

This tab has been moved outside of the Design Tab to provide more space for results to be shown and greater flexibility of input parameters.

Item 9 – File Menu

9.1Export to AutoCAD

The DXF output has been upgraded to be more user friendly to the CAD Designer. The Facing Units are now drawn as individual blocks with a pline, so the user can move them, manipulate them,etc. Note that these Facing Units are just shown as a representation of how they would appear in the Wall and are not meant to exactly show the position and location of every unit. In some cases, corner units and other specialized units are used which are not shown and which would change the layout of standard units.

Also, if a Wall has a lean or batter, this would distort the actual arrangement of the bond pattern (i.e. bottom of Wall length is actually longer than top of Wall length).

9.2 PDF Output

A number of upgrades have been made to the PDF Report. The Summary Reports, which summarize either the entire Project (Project Materials Summary), or a Single Cross Section (Section Analysis Summary) have been expanded to include more detail and better arrange information.

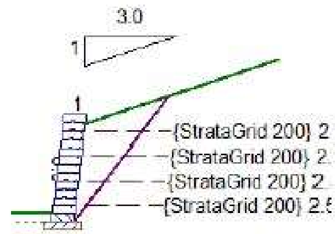
Section Analysis Summary

The Section Analysis Summary includes all relevant input and output values for the selected Cross Section, which would typically be required by a local Municipal Engineer for review, DOT, etc.

Project Materials Summary

This Summary Report details all quantities for an entire Project and has been formatted to contain multiple wall systems, includes pins or connectors as required, all infill, drainage, and core fill quantities, as well as reinforcements. Note that the Total Wall Area noted is the sum-total of the facing, coping, and embedded Wall area. The Facing area is the total Wall Area minus the Coping Area.

Section	#5 at Station 2.40
Report Date	June 28, 2016
Design Standard	National Concrete Masonry Association 3rd Edition
Design	Static
Unit of Measure	S.I.
Selected Facing Unit	Siena Stone 500
Seismic As	N/A



Soil Parameters

Soil Zone	Soil Type	Friction Angle φ	In Situ Density γ [kN/m³]	Friction Factor μ	Cohesion Cf [kN/m²]
Infill (i)	GW	35°	22.00	n/a	n/a
Retained (r)	CL	28°	19.95	n/a	n/a
Foundation (f)	CL	28°	19.95	0.55	0.00
Base (b)	GW	35°	22.00	0.70	n/a

Section Details

Section Height	2.41	Back Slope	18.40	LL Surcharge	0.00	DL Surcharge	0.00
Design Height	2.19	Crest Offset	0.00	LL Offset	0.00	DL Offset	0.00
Embedment	0.20	Wall Batter	7.12	Toe Slope	0.00	Toe Offset	0.00

Minimum Factors of Safety

Reinforced

External		Value	Internal		Value	Facing		Value
FSsl	Base Sliding	1.50	FSsl	Internal Sliding	1.50	FScs	Connection Strength	1.50
FSbc	Bearing Capacity	2.00	FSpo	Pullout	1.50	FSsc	Facing Shear	1.50
FSct	Crest Toppling	1.50	FSto	Tensile Overstress	1.50			
FSot	Overturning	2.00						

Reinforcements

SG200 - StrataGrid 200 — **Supplier: Strata Systems, Inc., Fill Type: 20mm- gravels or aggregate**

Tult	52.55	RFcr	1.55	RFd	1.10	LTDS	26.80
RFid	1.15	Cds	0.90	Ci	0.90		

Connection Properties

αcs1	13.70	IP-1	17.50	αcs2	22.60	IP-2	17.50	αcs max	22.60
au	42.00	λu	80.00	Vu(max)	147.00				

Analysis Results

* Analysis Includes Vertical Forces
* Embedment Included In Bearing Capacity

External Static	FS
Bearing Capacity	8.11
Overturning	8.21
Base Sliding	2.72
Crest Toppling	237.28

Internal Static

Layer	Elevation	Rein	Length	Internal Sliding	Pullout	Tensile Overstress
1	0.23	SG200	2.50	9.75	16.30	4.22
2	0.78	SG200	2.50	12.97	17.38	7.26
3	1.34	SG200	2.50	17.42	16.48	12.92
4	1.89	SG200	2.50	26.45	27.27	54.11

Facing Static

Layer	Elevation	Rein.	Length	Connection Strength
1	0.23	SG200	2.50	3.56
2	0.78	SG200	2.50	5.70
3	1.34	SG200	2.50	8.59
4	1.89	SG200	2.50	29.50

NOTE: THESE CALCULATIONS, QUANTITIES, AND LAYOUTS ARE FOR PRELIMINARY DESIGN ONLY AND SHOULD NOT BE USED FOR CONSTRUCTION WITHOUT REVIEW BY A QUALIFIED ENGINEER

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Item 10 – Walls Menu

The Walls Menu has been enhanced to include a more flexible way to “Copy Wall”. In the previous version, beside the “Create Wall” button was an option to “Copy Soil Conditions, Wall System and Reinforcement Type” so that when you Create a new Wall in a Project, these variables are already set and do not need to be entered in again. This option always copied the “First” wall in the Project. Some users wanted the ability to Copy the properties from a different Wall in their Project (i.e the fourth Wall, for example) when creating the next(fifth) Wall. Our new "Copy Wall" feature in the Walls menu copies the properties from the Current Wall you have selected.

Additional options have been added to Options/Analysis tab.

Item 11 – Settings Menu

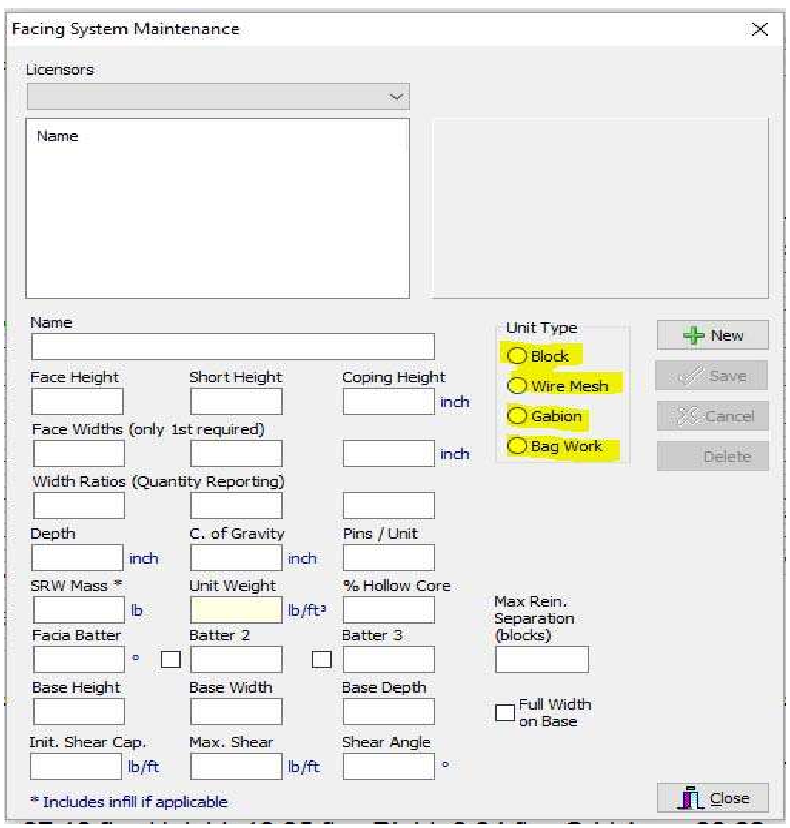
Vespa now allows the user to create various different Facings in addition to standard"Block" (SRW) type units.

Item 12 – Additional Facing Types

As the Geogrid Reinforcement arrangement can differ depending on the Facing Type, options have been provided to allow the user to detail how the Reinforcement is being configured. For example, if a Wire Mesh type facing is used, the Reinforcement tab changes to provide 4 different options for Reinforcement configuration.

With the Wire Mesh, the user can opt to use "No wrap", Face wrap with secondary wrap only, Face wrap with primary reinforcement and secondary wrap, and Facewrap with primary wrap only. The associated Primary Wrap, Secondary Top Length, and Secondary bottom length input fields are provided as well.

Note that these are provided for Quantity calculation and detailing only, and are not accounted for in the analysis. The chosen methodology is applied, however, for Facings other than SRW Blocks, Facing/Geogrid Connection is not checked.



Item 13 NCMA Design Methodology

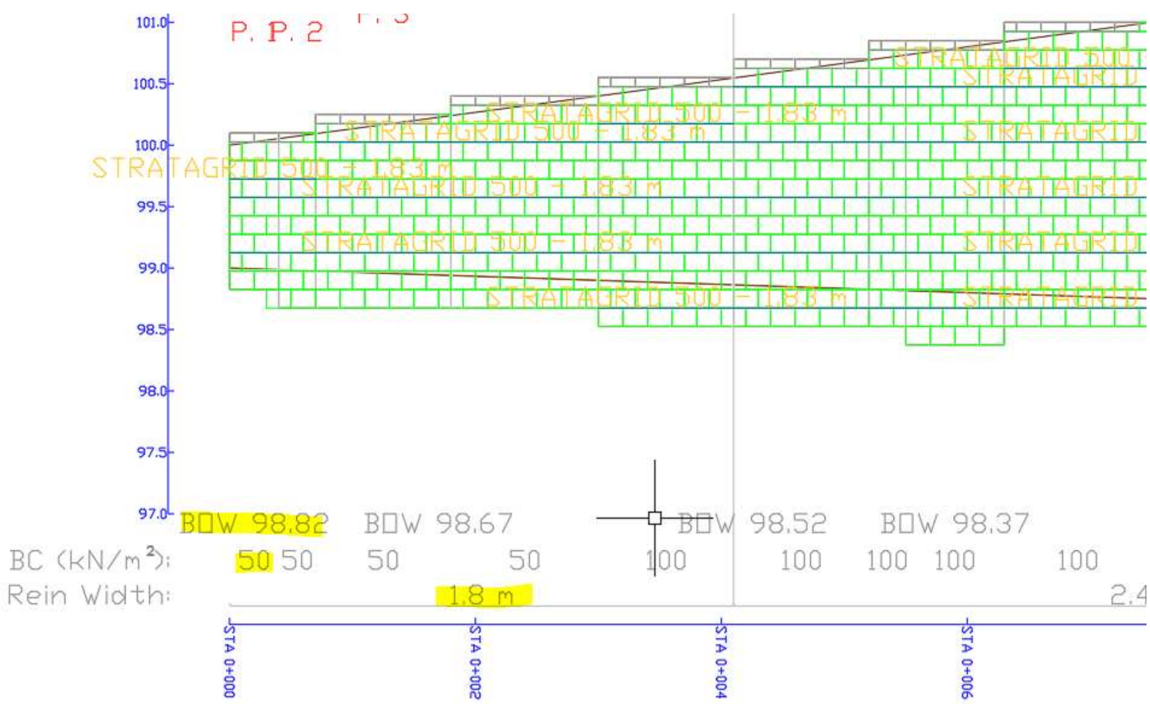
(April 2017)

A change has been made to the way Vespa handles the vertical component of the Dead Load forces for use as a “Resisting Force”. Per Section 7.4.1.2 of the NCMA DMFSRW 3rd Edition, the vertical component of the exterior Dead Load is to be neglected as a resisting force if the Dead Load offset is outside of the internal influence distance (dint) or the reinforced zone, defined by Lbeta. In Vespa, As the Dead Load was still being applied to the exterior of the Reinforced Mass as a destabilizing force, the vertical component of that load was also still included as a stabilizing force (Pqdv). Although accurate, this was a deviation from the NCMA recommendation so the Pqdv has been removed as a stabilizing force if outside of the reinforced zone, despite the fact that these vertical forces do exist. This is a conservative change and only applies when the “include vertical forces” is turned on in the Settings/Options.

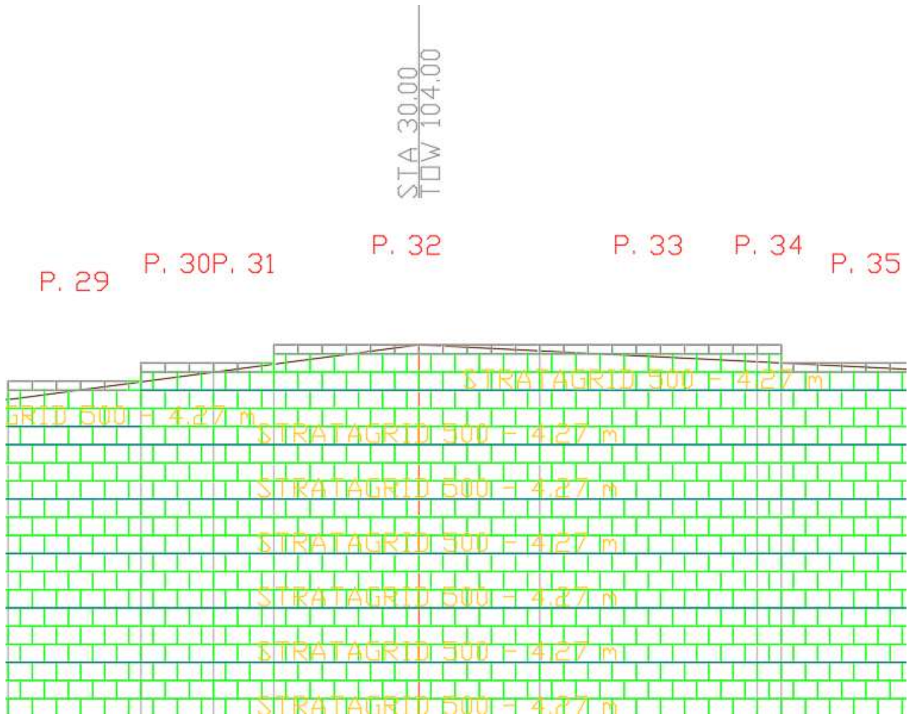
Item 14 DXF Updates

In order to make the DXF output more “print ready” and useful in the field, we have added a few upgrades.

We have added 3 rows under the Wall that show the BOW grade, Min. Applied Bearing Capacity, and Reinforcement Requirements for each Panel.



We have also added the Station Data (Station and TOW Grade) to the elevation view so the user can reference the original Grades Input. As well, these have been added to another table in the DXF, along with the Crest/Toe inputs.



All of these elements are on independent layers so they can be easily turned off if the user does not want them.

Item 15 – Bug Fix (April 2017)

In the last (April) build, for NCMA Methodology, for the calculation of applied Bearing Load the Dead Load was being used in place of the Live Load. Therefore, for very large Dead Loads, the Dead Load would be essentially applied twice and results would be conservative for applied bearing load. This has been fixed.

Item 16 – April 2017

For AASHTO 2010 and 2015, for calculation of Bearing Capacity (Bearing Resistance), we had originally adopted the convention of using “L” as the width of the Wall, as opposed to B (which includes the facing). The AASHTO direction on this was that either L or B could be used, depending on the thickness of the face (i.e. if the face was “thick”, then it should be B). As this is a vague term and likely relative to the MSE type walls, we erred on the conservative side and used “L”, thereby ignoring the facing. The consensus of users is that B is more widely accepted as most block facings are at least 1ft thick or larger and there is also a base to consider. This change has been made.

Item 17 – April 2017

Previously, in AASHTO 2010 and 2015, the "Overturning" check is a comparison of the calculated base eccentricity to the maximum allowable eccentricity. A ratio of e/emax was used to express the fact that the emax was not being exceeded. This check was the only method AASHTO provided for looking at overturning. We have expanded the Overturning check to be more in line with a classic overturning analysis, with Mresisting/Moverturning being the actual Overturning check. We have moved the current eccentricity check to the "empirical checks" portion of the analysis, allowing the user to specify the max eccentricity in the Design Criteria.

Item 18 (Bug Fix). (April 2017)

For AASHTO 2010, the Pae, Paell, and Paedl were being calculated using the full Kae value as they are in 2015. In 2010, however, the Static loads are still being applied, so a reduced value for Kae (reduced for the static portion) should be used and is now changed. In short, the previous build overestimated applied Seismic loads and was therefore overly conservative.

Item 19 (May 2017)

Two items were identified which, when changed, no longer wipe out the existing Design. Vespa allows you to change the Crest Offset and Crest Elevation without causing a repanelization and/or wipe out the Geogrid Design that is in there. The other variable is the Block. If a Block that has the identical face height and width is substituted for the block in the current Design, the Panelization will not occur again.

Item 20 (May 2017)

NCMA, Conventional, Seismic, Bearing Capacity

On page 129 of the NCMA Design Manual, Third Edition, the following equation is given for the Seismic Eccentricity, eseismic.

9.7.1.3: Bearing Pressure (Refer to Section 6.4.5)

pplied bearing stress at the base of the leveling pad is calculated as:

$$Q_{a\text{-}seismic} = \frac{[W_{w} + P_{sV} + P_{qV} + 0.5\Delta P_{dynV}]}{B'_c} \qquad \text{[Eq. 9-42]}$$

;

$$B'_c = W_u + h_{lp} - 2e_{seismic} \qquad \text{[Eq. 9-43]}$$

$$e_{seismic} = \frac{\left[k_{base}W_w\left(\frac{H}{2}\right) + P_{sH}\left(\frac{H}{3}\right) + P_{qdH}\left(\frac{H}{2}\right) + 0.5\Delta P_{dynH}\left(\frac{H}{2}\right)\right] - W_w X_w}{W_w} \qquad \text{[Eq. 9-44]}$$

The moment arm shown for the resisting moment is Xw, which is the distance from the toe of the wall to the center of gravity. This is contrary to the Conventional Static version of the same equation, where the moment arm is correctly shown as ew, which is the moment arm from the center of the block. Vespa followed equation 9-44 due to this misprint, but has been changed to reflect the ew requirement shown in Static.

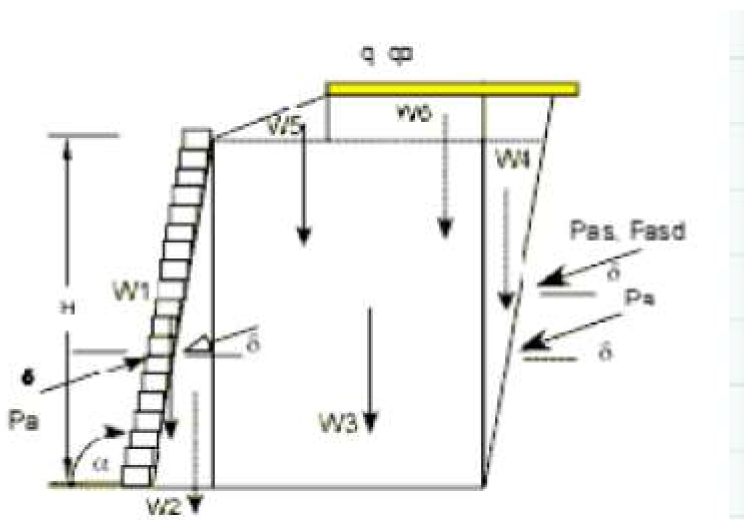
Item 21 (Bug Fix) (May 2017)

NCMA, Reinforced

In the case where a Dead Load was applied to the top of the wall, and the Dead Load Offset was beyond the Reinforcement Zone (DLoffset>L), an error in logic was causing the Dead Load to still be included as part of the Resistance for some of the calculations. Specifically, the contributing effect was being applied to the Overturning Resistance (which would overestimate the overturning resistance) and the applied Bearing Capacity (which would produce a conservative result) in the Static calculations. It did not affect the Base Sliding Calculation, which is typically the critical mode of failure in External Stability analysis. In Seismic, the Dead Load contribution was being applied to Overturning, Sliding, and Bearing Capacity. The error only occurred when the Dead Load Offset was outside of the Reinforced Zone and inside of the influence zone (L+H+h).

Item 22 AASHTO -Inclusion of Wall Batter (August 2017)

AASHTO 2010 and 2015 state that for a Wall Batter less than 10 degrees, the Wall is assumed to be vertical. Based on discussions with Designers, we have concluded that while we can apply this principle to the calculation of Ka (and Kae), the model is more accurate if we include the Wall Batter in the Geometry when calculating Wall weights, moment arms, etc. As a result, we will now use the actual wall batter, even if it is under 10 degrees, to more accurately model the Walls with respect to Geometry as shown in the figure below. The applied external forces will still act on the vertical interface. Note that the weight W4 is not included as it lies outside of the vertical interface. This is not consistent with the NCMA approach, which simply approximates Wri as a rectangular shape with height (H) and depth (L). Not including W4 may therefore give an overly conservative result. To check this, you can set your Wall batter to zero and compare.



Item 23 AASHTO 2015, Seismic (August 2017)

One of the main changes to AASHTO for 2015 was the calculation of total Horizontal Thrust (Seismic). Thf had to be checked for three conditions to get the maximum value. The three conditions (per C11.6.5.1) included: 1) 100%Pae+50%Pir, 2) 50% Pae +Pir, and 3) Unfactored Static Loads+Pir. This was incorporated when 2015 was included in Vespa. The max of these was used where dictated by AASHTO

(Base Sliding Calculation). Upon reviewing this again recently, it was determined that if the intent was to always look at these combinations, they should also be applied to the new Overturning Moment calculation that was added in April of 2017 (on top of the existing eccentricity check that was already in place). As such, the load combinations are used to determine the maximum overturning moment and bearing eccentricity. This is not explicitly defined in AASHTO, however, we believe it is in line with the intent of C11.6.5.1.

Item 24 – AASHTO Load Factors (August 2017)

When AASHTO 2015 was introduced to Vespa, the Load Factors/Resistance Factors were separated from being a single variable that was either set to a Min or Max value (depending on the use), to what we have now, which is a separate variable for the Minimum Load/Resistance Factor and another one for the Maximum Load/Resistance Factor. This made the coding clearer and also allowed us to format the Design Criteria table better. There was one case reported where upon updating the database, a duplicate value for the Live Load Factor (Max.) was created and it was a corrupt value (set to 0 instead of 1.75). Additional checks have been added to ensure duplicate values are not created, however, for older files, ensure to check Load/Resistance factors are not duplicated or have incorrect values.

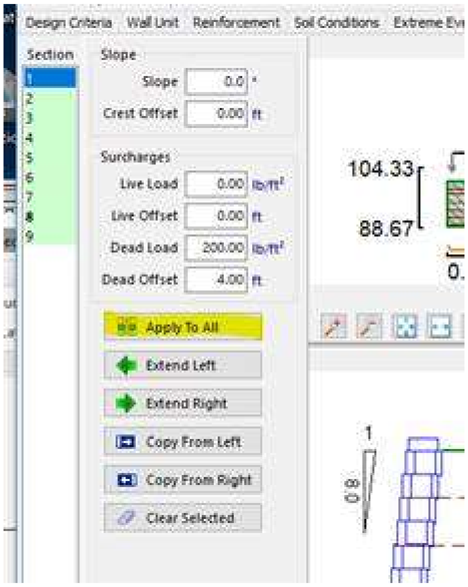
Item 25 – Changing Blocks/Geogrids on Existing Designs (August 2017)

Some users wanted the ability to change the SRW units/Facing in a Wall, without wiping out their Geogrid Reinforcement Design. We have now added the ability to do this. If you select a new Facing, different from the current one being used in the Design, as long as it has the same face dimensions (Block Height and Block Length) AND it has connection testing with the existing Geogrids, the Facing will be replaced. Keep in mind, this does not automatically mean it will pass all criteria the previous facing may have (as connection properties may change), so you have to run the analyze all routine again.

Updates – September 2017-December 2017

Item 26. Significant performance improvement when generating or analyzing, or copying left/right

Item 27. Apply All added to Loadings screen. This makes it quicker to apply loading to all panels instead of extend left and right.



Item 28. Panelization improvement – In some situations, previous panelization routine could create ½ block width wider than it needed to.

Item 29. Change to never consider coping in calculating needed embedment (now includes in % of height).

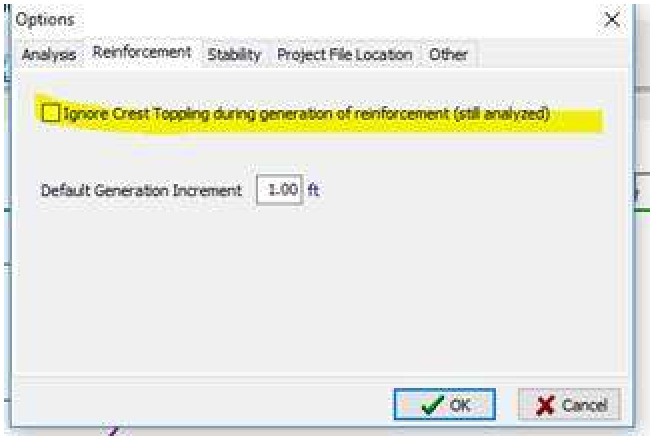
Item 30. Improved handling of RsTop/Bottom during generation, and in conjunction with a block's max. separation

Item 31. Better handling of potential pullout errors on a grid too close to grade

Item 32. Improved handling of uniform grid lengths

Item 33. Soil type on reinforcement screen now applies to all selected reinforcements, no longer allows diff. settings for each

Item 34. Option to ignore crest toppling during generation. Sometimes this is useful if you know you will be putting a small secondary layer of grid at the top, but do not want to have your top layer of grid 1ft from the top (and get crazy lengths).



Item 35. AU (Australian) Code: structure importance classification now on project screen and better PDF output.

Item 36. Can edit file names for DXF export

Item 37. Improvement on how NCMA and AASHTO handle load offsets. For External Stability, AASHTO and NCMA do not really provide a graduated way of reducing surcharge loads if they are offset beyond the back of the reinforced zone. We have implemented a simple approach where the load would be reduced according to the offset distance. For example, in NCMA, a factor (called a qdfactor) would be applied to the Live/Dead load according to the following:

Pq = q • Hext • Kaext • qfactor

where qfactor equals:

IF qoffset ≤ Lb then qfactor = 1.00

IF qoffset > (Lb + Hext) then qfactor = 0.00

Else qfactor = [(Lb + Hext - qoffset] / Hext

For AASHTO it would be:

Pq = q • Hext • Kaext • qfactor

where qfactor equals:

IF qoffset ≤ Lb then qfactor = 1.00

IF qoffset > 2H then qfactor = 0.00

Else qfactor = (2H - qoffset) / (2H - Lb)

Item 38. NCMA Seismic Analysis

For situations where the values entered for phi angle, back slope and Seismic Kh are incompatible with the M-O analysis, Vespa previously brought up the warning (which the user had to agree to) which stated that an “Alternate Seismic Method” was used. This Alternate Seismic method was the “Trial Wedge” approach, which analyzed potential failure planes behind the reinforced zone on 1 degree increments to solve for the maximum thrust (more information available upon request). In the latest version of Vespa, we are requiring that the user more explicitly agree to this approach by selecting it as an option in the Settings/Options/Analysis. When the option is turned “ON”, the Trial Wedge Approach is automatically run when the condition exists:

$$\phi_r - \beta_{ext} - \Theta_{ext} < 0$$

If the option is not on, the industry standard “stop-gap” method of setting this term = 0 when it is negative.

January 2018

Item 39. Offset Loads and Reduction Factors - Option

As noted in Item 37, we have provided a way to reduce Live and Dead loads based on Offset Distances.

However, we have updated Vespa to have this as an Option the user selects for NCMA, rather than just automatically utilizing it, as this is not explicitly discussed in the NCMA Design Methodology.

As well, we have included a further method to reduce loads for internal stability based on offset as described below.

To review, for AASHTO, External Stability, a Factor for the Live and Dead load is calculated as follows:

$$q_{lFACTOR} := \begin{Vmatrix} \text{if } q_{loffset} \le L_\beta \\ \quad \Vert\, 1 \\ \text{else if } q_{loffset} \ge 2 \cdot H \\ \quad \Vert\, 0 \\ \text{else} \\ \quad \Vert\, \dfrac{(2 \cdot H - q_{loffset})}{2 \cdot H - L_\beta} \end{Vmatrix} = 1$$

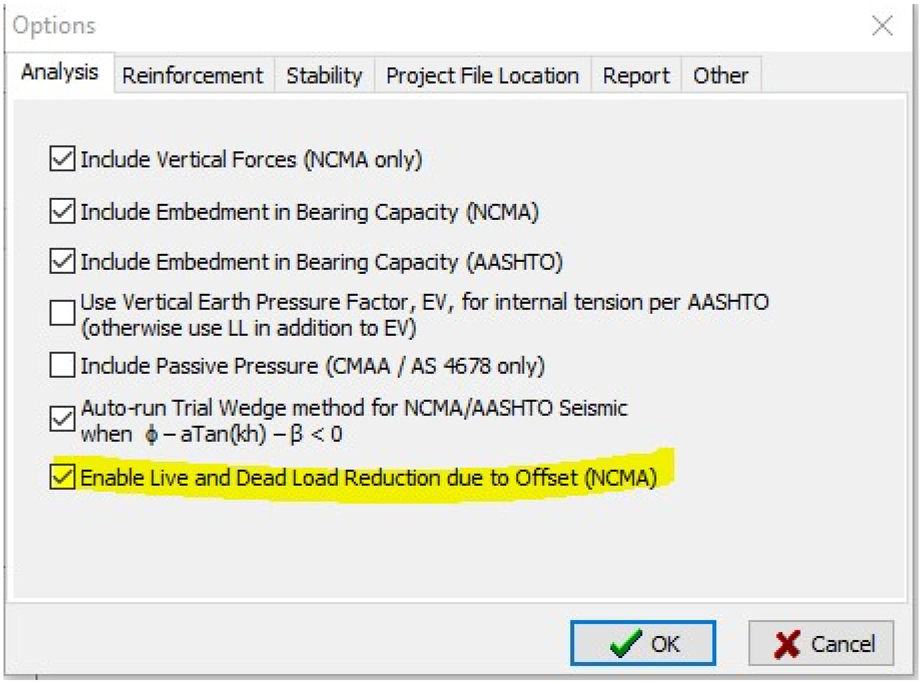
$$q_{dFACTOR} := \begin{Vmatrix} \text{if } q_{doffset} \le L_\beta \\ \quad \Vert\, 1 \\ \text{else if } q_{doffset} \ge 2 \cdot H \\ \quad \Vert\, 0 \\ \text{else} \\ \quad \Vert\, \dfrac{(2 \cdot H - q_{doffset})}{2 \cdot H - L_\beta} \end{Vmatrix} = 1$$

This factor is then applied to the Driving Live and Dead forces, F2 and F3. Because AASHTO is silent on how the offset load can be gradually reduced, we have made the conservative assumption that the maximum influence distance from the back of the Wall is equal to 2H. This factor is automatically utilized during the analysis.

For AASHTO Internal Stability, the result is not graduated and basically applies the full Live or Dead Load if the Offset is within the Reinforced Zone.

$$q_{lAPP} := \begin{Vmatrix} \text{if } q_{loffset} > L \wedge q_{loffset} > d_{int} \\ \quad \Vert\, 0 \, \dfrac{lbf}{ft^2} \\ \text{else} \\ \quad \Vert\, q_l \end{Vmatrix} = 0 \, \frac{lbf}{ft^2}$$

For NCMA, the user is given the option to either run “Standard” NCMA handling of offset loads as described in the NCMA Manual (3rd Edition), OR, choose to more accurately reflect the load offsets according to the following calculations. The Option to choose this is in the Settings:



For External Stability, the Qdfactor and Qlfactor are calculated as follows:

$$Q_{dfactor} := \begin{cases} 1 & \text{if } q_{doffset} \le L_\beta \\ 0 & \text{else if } q_{doffset} > L_\beta + H_{ext} \\ \left(\dfrac{L_\beta + H_{ext} - q_{doffset}}{H_{ext}}\right) & \text{else} \end{cases} = 0.848$$

$$Q_{lfactor} := \begin{cases} 1 & \text{if } q_{loffset} \le L_\beta \\ 0 & \text{else if } q_{loffset} > L_\beta + H_{ext} \\ \left(\dfrac{L_\beta + H_{ext} - q_{loffset}}{H_{ext}}\right) & \text{else} \end{cases} = 0.848$$

For Internal Stability, a similar approach to the NCMA method is used, however, instead of the 2V:1H influence line assumed by NCMA, a more conservative 1H:1V influence line is used. However, although we are more conservative from the distribution point of view, we then apply this reduction to all internal modes of failure (Tensile Overstress, Pullout, Connection), as opposed to the NCMA, which just applies it to Connection.

As with NCMA, the intercept height on the back of the Wall facing is calculated (assuming a 1H:1V distribution.

Live Load

$$E_{qLinfl2} := \begin{cases} 0\ ft & \text{if } q_{loffset} \ge q_{offsetmax} \\ H - \left(\dfrac{q_{loffset} - h_s}{1 - \tan(\omega)}\right) & \text{else} \end{cases} = 5.1\ ft$$

Dead Load

$$E_{qDinfl2} := \begin{cases} 0\ ft & \text{if } q_{doffset} \ge q_{offsetmax} \\ H - \left(\dfrac{q_{loffset} - h_s}{1 - \tan(\omega)}\right) & \text{else} \end{cases} = 5.1\ ft$$

An individual Load Reduction Factor is then calculated for each layer of Geogrid as follows:

$$
qlf_n := \left\|
\begin{array}{l}
\text{if } E_{qLinft2} = 0\ ft \\
\quad \| \ 0 \\
\text{else if } n = 1 \\
\quad \left\| \begin{array}{l}
\text{if } E_{qLinft2} \geq \dfrac{\left(E_{n+1} + E_n\right)}{2} \\
\quad \| \ 1 \\
\text{else} \\
\quad \left\| \ \dfrac{E_{qLinft2}}{\dfrac{\left(E_{n+1} + E_n\right)}{2}} \right.
\end{array} \right. \\
\text{else if } n = Nl \\
\quad \left\| \begin{array}{l}
\text{if } E_{qLinft2} \geq H \\
\quad \| \ 1 \\
\text{else} \\
\quad \left\| \ \max\left(0, \dfrac{\left(E_{qLinft2} - \dfrac{\left(E_n + E_{n-1}\right)}{2}\right)}{H - \dfrac{\left(E_n + E_{n-1}\right)}{2}}\right) \right.
\end{array} \right. \\
\text{else} \\
\quad \left\| \begin{array}{l}
\text{if } E_{qLinft2} \geq \dfrac{\left(E_n + E_{n+1}\right)}{2} \\
\quad \| \ 1 \\
\text{else} \\
\quad \left\| \ \max\left(0, \dfrac{\left(E_{qLinft2} - \dfrac{\left(E_n + E_{n-1}\right)}{2}\right)}{\dfrac{\left(E_n + E_{n+1}\right)}{2}}\right) \right.
\end{array} \right.
\end{array} \right.
$$

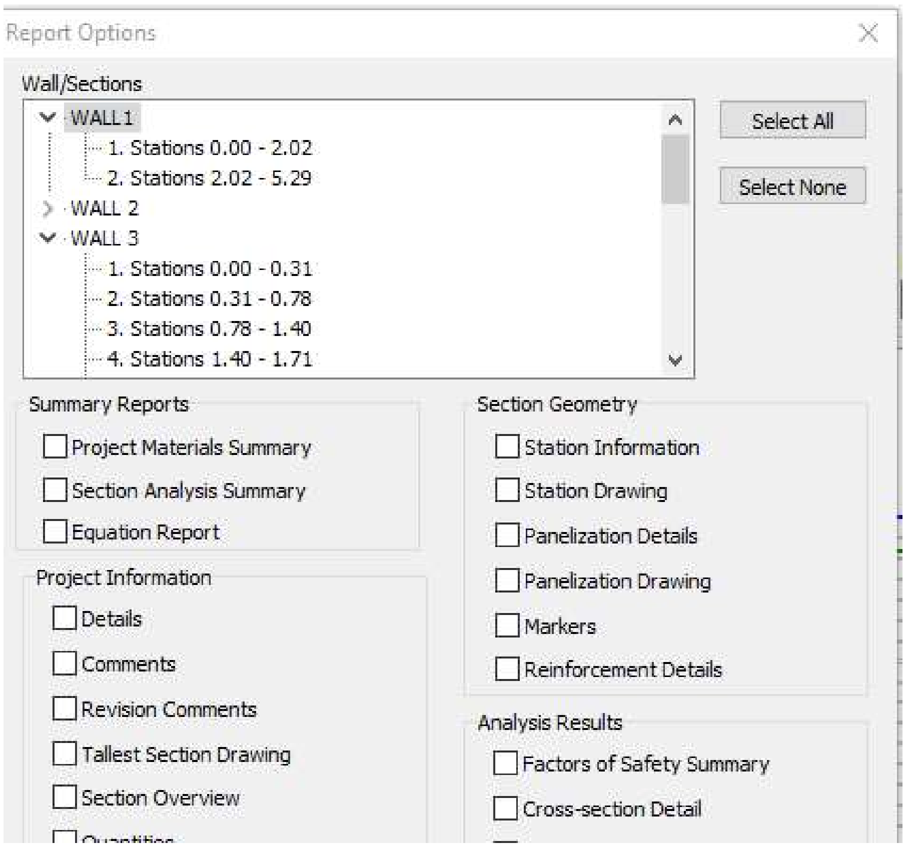
Bottom Layer (n+1 = 2, n = 1)

Top Layer

Intermediate Layer

Item 40 – New PDF Output Options

In the PDF output dialogue box, you can now select multiple Panels from any Wall within a given Project. For example, if you wanted to print out the detailed calculations for Panel 5 in Wall 1, Panel 3 in Wall 2, and Panel 10 in Wall 3, you can select each of these Panels in the new selection box and they will be compiled in a single report.



Item 41 – March 2018 - Improvement when Switching between Methodologies

In a given Project, if the user was switching between different Design Methodologies, such as NCMA to AASHTO, the user would have been required to go to the Reinforcement Tab to reset the related Connection Data. New coding has been added to ensure the user can move directly to the Design/Analysis without first going to the Reinforcement Tab to get the AASHTO Connection Creep and Durability values.

Item 42 – March 2018 – NCMA Crest Toppling

Some Vespa users noted that the NCMA Seismic Crest Toppling calculation yielded a different result than the “same” Overturning calculation when analyzing an independent conventional Wall of the same height and loading conditions. This is due to some inconsistencies in the NCMA Design Methodology. For Static Crest Toppling, NCMA currently uses Beta(int) and Ka(int) in the analysis. Calculation of Beta(int) is based on the full Wall height, but should be based on only the smaller Crest (gravity) height of the Wall. As such to be more accurate, we need to create a couple of new variables to account for this.

First, for Static Crest Toppling, we create a new variable called hmaxCREST

$$h_{maxCREST} := H_{unreinf} \cdot \tan(\beta)$$

This variable is then used to calculate a new Beta value (just for Crest Toppling)

$$\beta_{crest} := \begin{cases} \text{if } h_s < h_{maxCREST} \wedge \beta_{offset} > 0\ ft \\ \quad \operatorname{atan}\left(\dfrac{h_s}{H_{unreinf}}\right) \\ \text{else} \\ \quad \beta \end{cases} = 18.4\ deg$$

Based on the new variables, a new Kaint(CREST) is calculated. Note that we are still using the infill friction angle instead of the Retained friction angle as it is assumed the “reinforced” material extends to close to the top of the Wall.

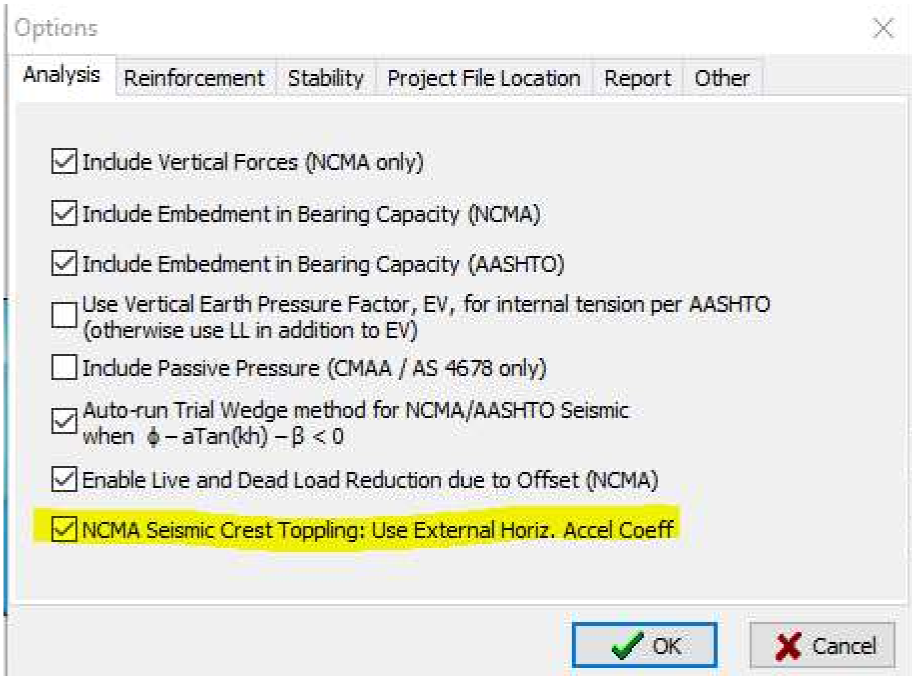
$$Ka_{intCREST} := \frac{\cos(\phi_i + \omega) \cdot \cos(\phi_i + \omega)}{\cos(\omega) \cdot \cos(\omega) \cdot \cos(\omega - \delta_i) \cdot \left(1 + \sqrt{\dfrac{\sin(\phi_i + \delta_i) \cdot \sin(\phi_i - \beta_{crest})}{\cos(\omega - \delta_i) \cdot \cos(\omega + \beta_{crest})}}\right)^2} = 0.3$$

We assess the effect of offsets on applied Live and Dead Loads as follows (if this option is ON)

$$Q_{lfactorCREST} := \begin{cases} \text{if } q_{loffset} > H_{unreinf} \\ \quad 0 \\ \text{else} \\ \quad \left(\dfrac{H_{unreinf} - q_{loffset}}{H_{unreinf}}\right) \end{cases} = 0 \qquad Q_{dfactorCREST} := \begin{cases} \text{if } q_{doffset} > H_{unreinf} \\ \quad 0 \\ \text{else} \\ \quad \left(\dfrac{H_{unreinf} - q_{doffset}}{H_{unreinf}}\right) \end{cases} = 0$$

Crest Toppling calculations continue per NCMA based on the above new variables.

For Seismic Crest Toppling, the major difference here is the assumption that the Internal Inertial Angle should be applied to the Kae (int) equation. However, if this small (Crest) Wall was considered as an independent gravity wall, the External Inertial Angle would apply, which we allow deflection to apply. As a result, the current Seismic Crest toppling often results in higher seismic loads than the equivalent Gravity Wall. To balance this, we have included the Option in Settings to allow the khext to be used in the Crest Toppling analysis.



The new Kae(int) CREST would then be:

$$K_{AE.intCRESText} := \frac{\dfrac{\cos\left(\phi_i+\omega-\Theta_{ext}\right)\cdot\cos\left(\phi_i+\omega-\Theta_{ext}\right)}{\cos\left(\Theta_{ext}\right)\cdot\cos\left(\omega\right)\cdot\cos\left(\omega\right)\cdot\cos\left(\delta_i-\omega+\Theta_{ext}\right)}}{\left(1+\sqrt{\dfrac{\sin\left(\phi_i+\delta_i\right)\cdot\sin\left(\phi_i-\beta_{crest}-\Theta_{ext}\right)}{\cos\left(\delta_i-\omega+\Theta_{ext}\right)\cdot\cos\left(\omega+\beta_{crest}\right)}}\right)^2} = 0.3$$

(Note – because the new approach does not strictly follow NCMA, although it is more correct, the user will have to select the Option in Settings).

Item 43 – Reformat PDF Output

The detailed calculation output tables have been reformatted to be more consistent from Methodology to Methodology, particularly for gravity structures, highlighting the applied loads, then resisting loads, followed by the associated FS or CDR value.