S. K. GHOSH ASSOCIATES LLC
Seismic and Building Code Consulting

RTWall

Version 1.7.0

User Manual

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DISCLAIMER

Every attempt has been made to ensure correctness in implementing code provisions as well as the accuracy of the calculations in RTWall. In using the program, however, the user accepts and understands that no warranty is expressed or implied by SKGA as to the accuracy or the reliability of the program. The user must carefully read this manual and thoroughly understand the assumptions of the program and must independently verify the results. In addition, in no event shall SKGA, or its employees or affiliates be liable for any indirect, incidental, consequential, or punitive damages whatsoever relating to the use of RTWall.

REVISION HISTORY

Version 1.1.0 (Release Date: April 7, 2016)

1. Design of CMU cantilever retaining walls based on both Allowable Stress Design and Strength Design requirements of MSJC has been added.
2. A new option for user-defined lateral pressure on the shear key has been added.
3. Program interface has been graphically improved.

Version 1.1.1 (Release Date: June 13, 2016)

1. An option to specify embedment type (into the footing) for stem's vertical bars has been provided.

Version 1.2.0 (Release Date: June 20, 2016)

1. Design of restrained (basement) walls with up to five restraints along the height of the stem has been added.

Version 1.2.1 (Release Date: September 27, 2016)

1. An error has been fixed where the design shear force and bending moment in the stem due to adjacent strip, line and point loads were not being initialized properly.

Version 1.3.0 (Release Date: February 1, 2017)

1. Support for the 2015 IBC, ACI 318-14 and 2013 TMS 402 is added.

Version 1.4.0 (Release Date: August 30, 2017)

1. Major revisions incorporated in the way the program handles restrained walls.
2. Some errors are corrected in the calculation of shear and bending moments in the stem from an adjacent strip, line and point loading.
3. Output is now generated in PDF format for easy navigation and file handling.
4. A feature is added for easy renewal of program license.

Version 1.5.0 (Release Date: July 30, 2018)

1. An error was corrected where the program was not calculating the correct restraint reactions for seismic force when the seismic force was entered directly from a geotechnical report.

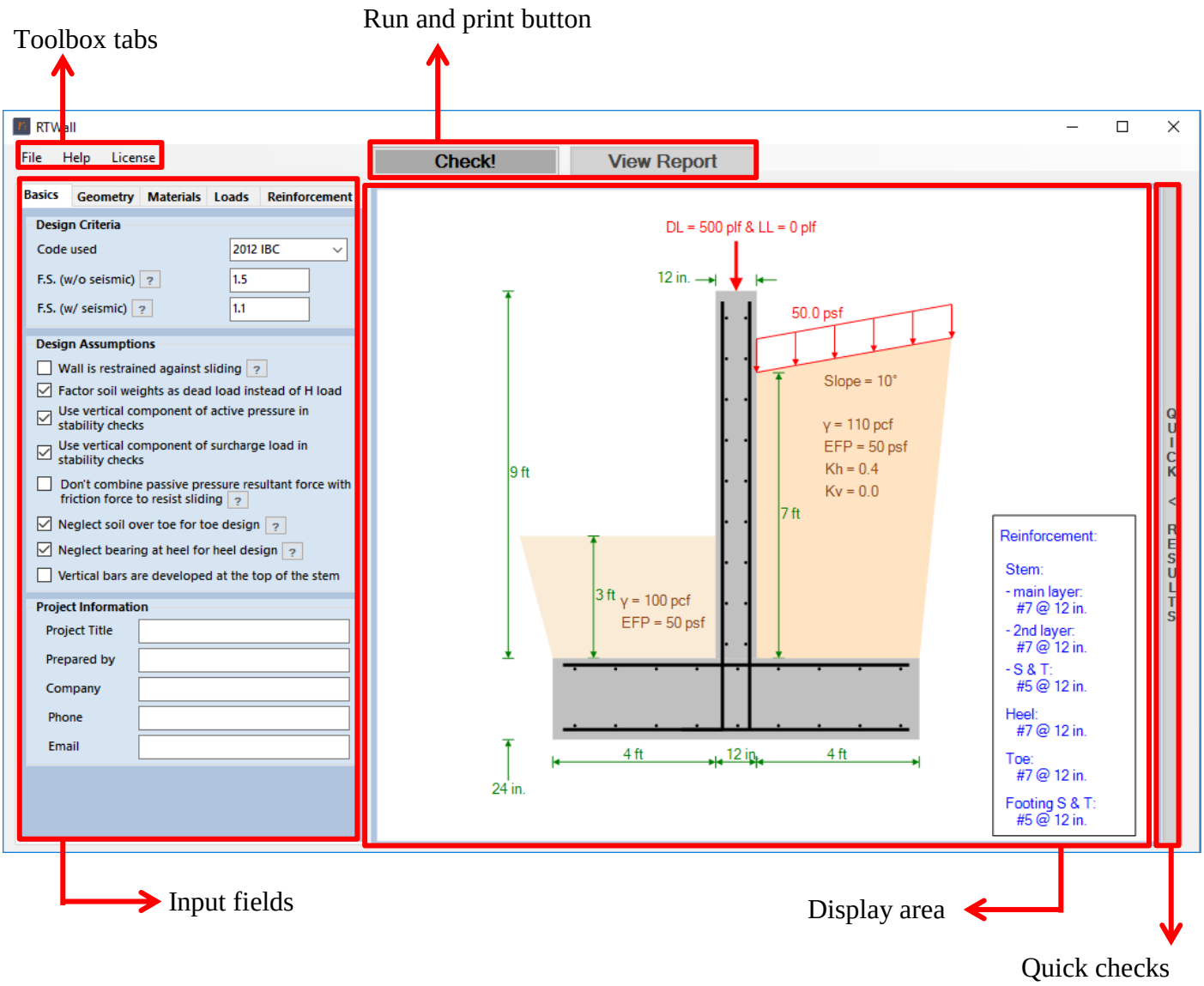
Version 1.6.0 (Release Date: October 7, 2020)

1. Support for the 2018 IBC and 2016 TMS 402 is added.

Version 1.7.0 (Release Date: May 12, 2022)

1. An error is corrected in the way the moment and shear strengths of a tapered RC stem were being calculated.
2. An error message is addressed that came up while opening an input file in certain conditions.

USER INTERFACE AT A GLANCE



INPUT FIELDS

The input fields in the RTWall interface are mostly self-explanatory. However, a short description of each input field is provided below for better clarity. Different input fields are marked by item numbers, as shown below in Figure 1. Units used in this program are as follows:

BASICS

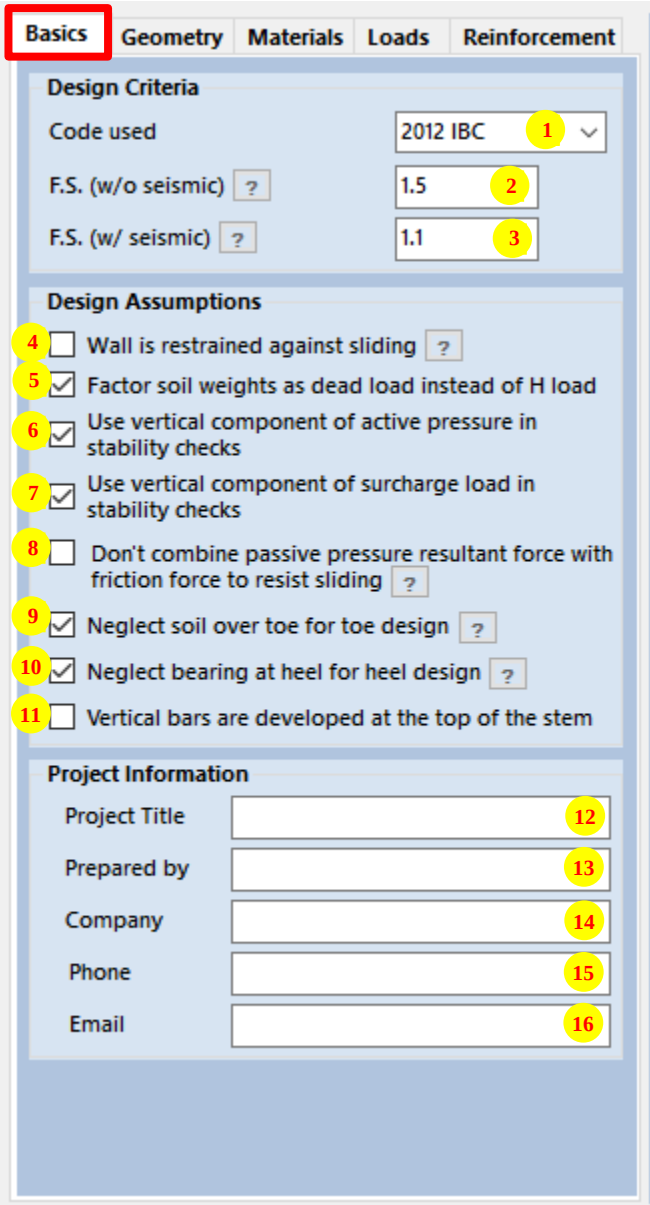


Figure 1. BASICS input page of RTWall

Item 1: Select the code version to follow. Options are: 2009 IBC and 2012 IBC.

Item 2: Safety factor for retaining wall sliding and overturning when earthquake loads are not included. Minimum code prescribed value is 1.5.

Item 3: Safety factor for retaining wall sliding and overturning when earthquake loads are included. Minimum code prescribed value is 1.1.

Item 4: Select if wall is restrained against sliding. If selected, the program will skip the sliding calculations.

Item 5: Select if soil weights must be factored as dead load (D). If not selected, the program will factor soil weights as earth loads (H).

Item 6: Select if vertical component of active pressure can contribute to wall's stability.

Item 7: Select if vertical component of surcharge load can contribute to wall's stability.

Item 8: Select if only the larger of passive pressure resultant force and friction force is used to resist sliding. If not selected, the combination of both forces will be used.

Item 9: Select if weight of the soil over toe must be neglected in structural design of the toe.

Item 10: Select if upward bearing pressure below heel must be neglected in structural design of the heel.

Item 11: Select if vertical bars are developed at the top of the stem. If not selected, concentrated shear and moment cannot be applied at the top of the stem.

Items 12 through 16: *Project Info* fields can be used to enter the details of the anchor design project. These details show up on the header of the output reports.

GEOMETRY

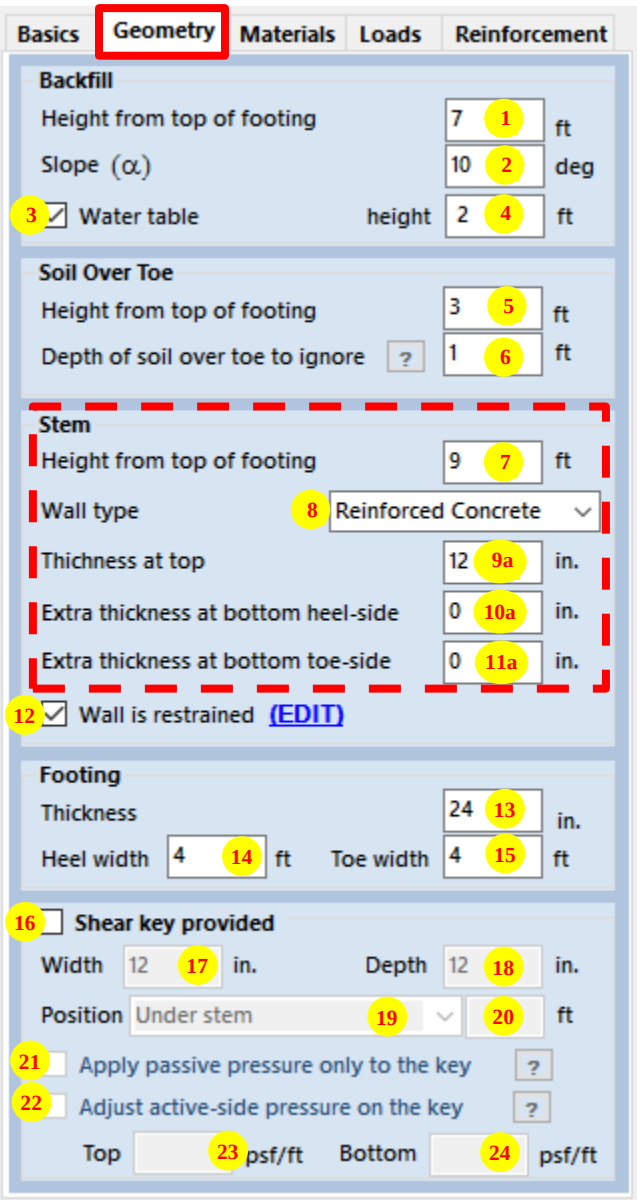


Figure 2. GEOMETRY input page of RTWall

Item 1: Height of the backfill soil (ft) measured from top of footing.

Item 2: Slope of the backfill soil (degree).

Item 3: Select if water table exists in the backfill soil.

Item 4: height of the water table (ft) measured from top of footing.

Item 5: Height of the passive soil (ft) measured from top of footing.

Item 6: Height of the top layer (ft) of the passive soil to be ignored.

Item 7: Height of the stem (ft) measured from top of footing.

Item 8: Type of the stem. Options are: Reinforced Concrete and Reinforced Masonry (see Figure 3 as well).

Item 9a: Thickness of the RC stem (in.) at the top of the wall.

Item 10a: Extra thickness of the RC stem (in.) on the heel side of the wall at its base.

Item 11a: Extra thickness of the RC stem (in.) on the toe side of the wall at its base.

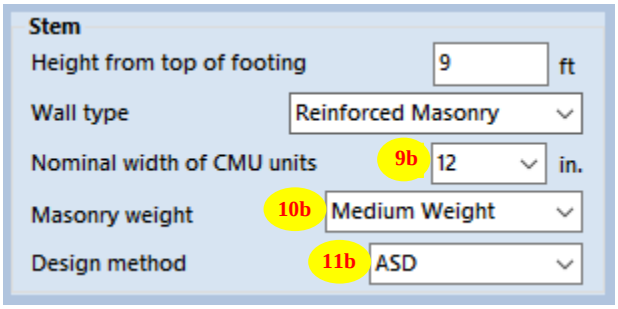


Figure 3. Stem GEOMETRY input panel for Reinforced Masonry Walls

Item 9b: nominal width of the units for the CMU stem (in.). Options are: 6, 8, 10, 12, 14, and 16 inches wide units.

Item 10b: Weight class for the CMU stem (in.). Options are: Normal Weight, Medium weight, and Light Weight.

Item 11b: Design method for the CMU stem (in.). Options are: Allowable Stress Design (ASD) and Strength Design.

Item 12: Select if the wall is restrained.

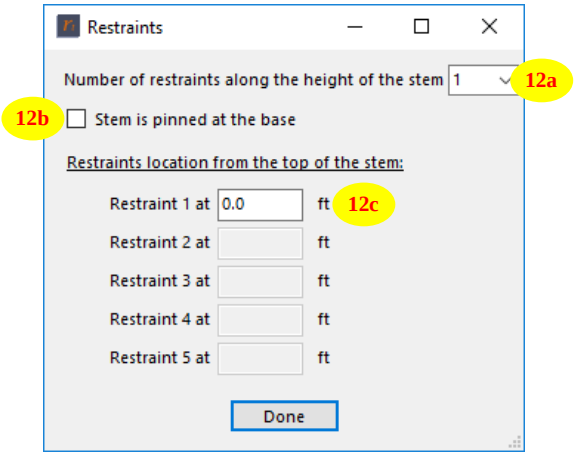


Figure 4. Restraints input window

Item 12a: determine number of restraints along the height of the stem.

Item 12b: Select if the stem is pinned at the base.

Item 12c: determine the location of restraint point(s) measured from the top of the stem.

Item 13: Thickness of the footing (in.).

Item 14: Width of the heel (ft).

Item 15: Width of the toe (ft).

Item 16: Select if shear key is provided.

Item 17: Width of the shear key (in.).

Item 18: Depth of the shear key (in.).

Item 19: The shear key's position. Options are: Under the stem, Heel side, Toe side, and Other. If Other is selected, the shear key's location must be determined in item 18.

Item 20: Location (distance) of the shear key from the tip of the toe (ft).

Item 21: Select if passive pressure applies on the shear key only (neglecting passive pressure on the side of the footing).

Item 22: Select to adjust active-side pressure on the shear key (overriding program-calculated pressure).

Item 23: User-adjusted factored pressure at the top of the shear key (psf/ft).

Item 24: User-adjusted factored pressure at the bottom of the shear key (psf/ft).

MATERIALS

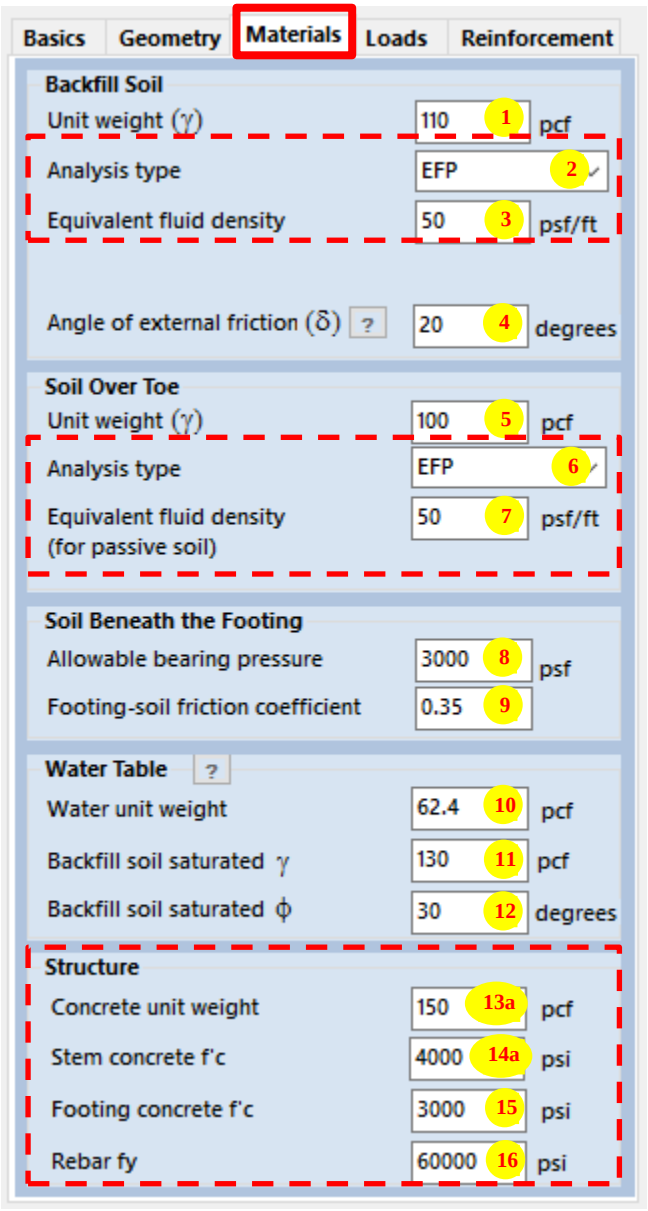


Figure 5. MATERIALS input page of RTWall

Item 1: Backfill soil's unit weight (pcf).

Item 2: Method of backfill pressure analysis. Options are: Rankine theory method (Rankine), Coulomb theory method (Coulomb), and Equivalent Fluid Pressure (EFP) method.

Item 3: Equivalent fluid density of the backfill soil (psf/ft) when EFP is selected for backfill pressure analysis.

Note: As shown in Figure 6, when Rankine or Coulomb method is selected for backfill pressure analysis, Item 3 will be replaced by **Item 3a**, angle of internal friction of the backfill soil (degrees), and for Rankine method only, **Item 3b**, backfill soil's cohesion (psf).

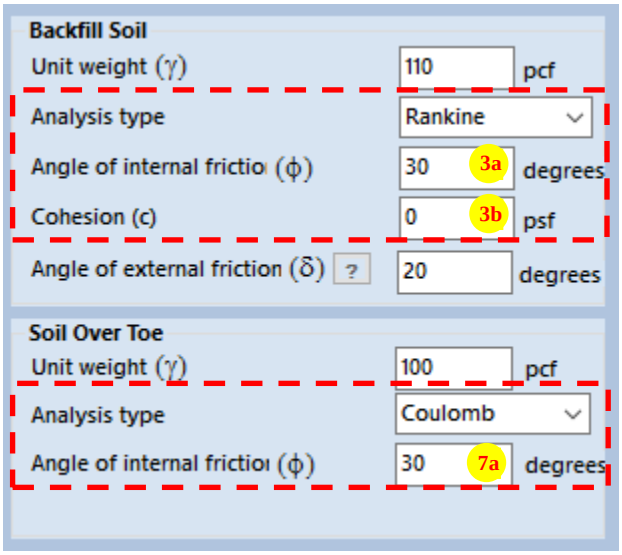


Figure 6. Different analysis type options

Item 4: Angle of external friction of the backfill soil (degrees).

Item 5: Passive soil's unit weight (pcf).

Item 6: Method of passive pressure analysis. Options are: Rankine theory method (Rankine), Coulomb theory method (Coulomb), and Equivalent Fluid Pressure (EFP) method.

Item 7: Equivalent fluid density of the passive soil (psf/ft) when EFP is selected for passive pressure analysis.

Note: As shown in Figure 6, when Rankine or Coulomb method is selected for passive pressure analysis, Item 7 will be replaced by **Item 7a**, angle of internal friction of the backfill soil (degrees), and for Rankine method only, another input field for backfill soil's cohesion (psf).

Item 8: Allowable bearing pressure of the soil beneath the footing (psf).

Item 9: Footing-soil friction coefficient.

Item 10: Water's unit weight (pcf).

Item 11: Backfill soil's saturated unit weight (pcf).

Item 12: Backfill soil's saturated angle of internal friction (degrees).

Item 13a: Concrete's unit weight (pcf).

Item 14a: Specified compressive strength of the RC stem concrete (psi).

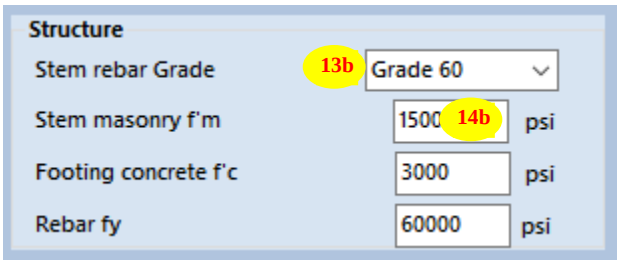


Figure 7. Structure MATERIALS input panel for Reinforced Masonry Walls

Item 13b: Rebar grade for the CMU stem. Options are: Grade 40, Grade 50, and Grade 60.

Item 14b: Specified compressive strength of the masonry material for the CMU stem (psi).

Item 15: Specified compressive strength of the footing concrete (psi).

Item 16: Yield strength of the structural steel rebar (psi).

LOADS

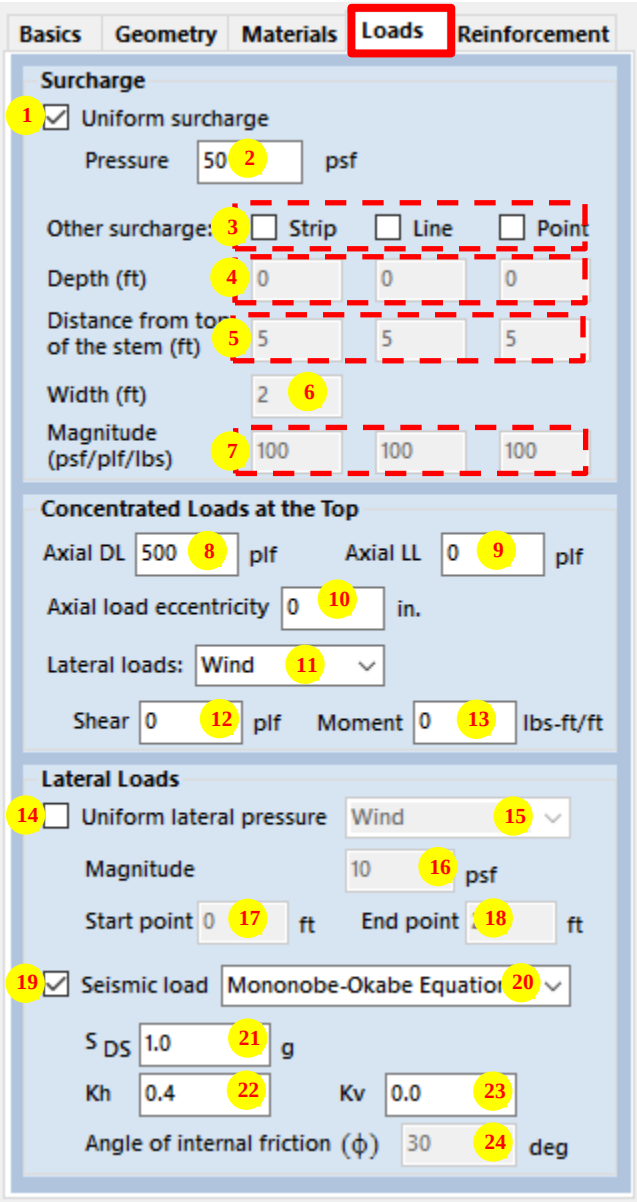


Figure 8. LOADS input page of RTWall

Item 1: Select if uniform surcharge (at the top of the backfill soil) exists.

Item 2: Magnitude of the uniform surcharge (psf).

Item 3: Select if strip, linear, and point surcharge (adjacent footings) exist, respectively.
Note: Applying a point (single) surcharge will result in designing the wall for the critical section along its length.

Item 4: Depth (distance from the top of the backfill) of the strip, linear, and point surcharge (ft), respectively.

Item 5: Distance from the top of the stem of the strip, linear, and point surcharge (ft), respectively.

Item 6: Width of the strip surcharge (ft).

Item 7: Magnitude of the strip, linear, and point surcharge (psf/plf/lbs), respectively.

Item 8: Concentrated axial dead load at the top of the stem (plf).

Item 9: Concentrated axial live load at the top of the stem (plf).

Item 10: Eccentricity of axial loads from the center line of the stem (in.).

> *Note:* Applying concentric moment (direct moment or eccentric axial loads) at the top of the stem requires vertical bars to be developed at the top – can be enabled under Basics settings.

Item 11: Source of concentrated lateral loads (shear and moment) at the top of the stem. Options are: wind and seismic.

Item 12: Concentrated shear at the top of the stem (plf).

Item 13: Concentrated moment at the top of the stem (lbs-ft/ft).

Item 14: Select if uniform lateral pressure applies on the stem.

Item 15: Source of uniform lateral pressure on the stem. Options are: live, fluid, earth, and wind.

Item 16: Magnitude of the uniform lateral pressure on the stem (psf).

Item 17: Start point (distance from the top) of the uniform lateral pressure (ft).

Item 18: End point (distance from the top) of the uniform lateral pressure (ft).

Item 19: Select if seismic load applies on the wall.

Item 20: Method of seismic analysis. Options are: Mononobe-Okabe (M-O) equation and geotechnical report values.

Item 21: Value of the design short period spectral response acceleration, S_{DS} (g) when M-O equation is used for seismic analysis.

Item 22: Horizontal seismic acceleration factor when M-O equation is used for seismic analysis.

Item 23: Vertical seismic acceleration factor when M-O equation is used for seismic analysis.

Item 24: Angle of internal friction of the backfill soil (degrees). Required only when EFP is selected for active pressure analysis.

Note: As shown in Figure 9, when using geotechnical report values is selected for seismic analysis, Items 21 through 25 will be replaced by **Item 21a**, strength-level seismic force (plf), and **Item 21b**, application point (distance from the top of the footing) of the seismic force (ft).

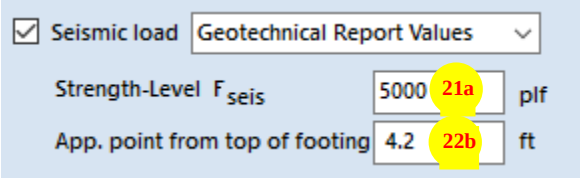


Figure 9 Simplified seismic load input option

REINFORCEMENT

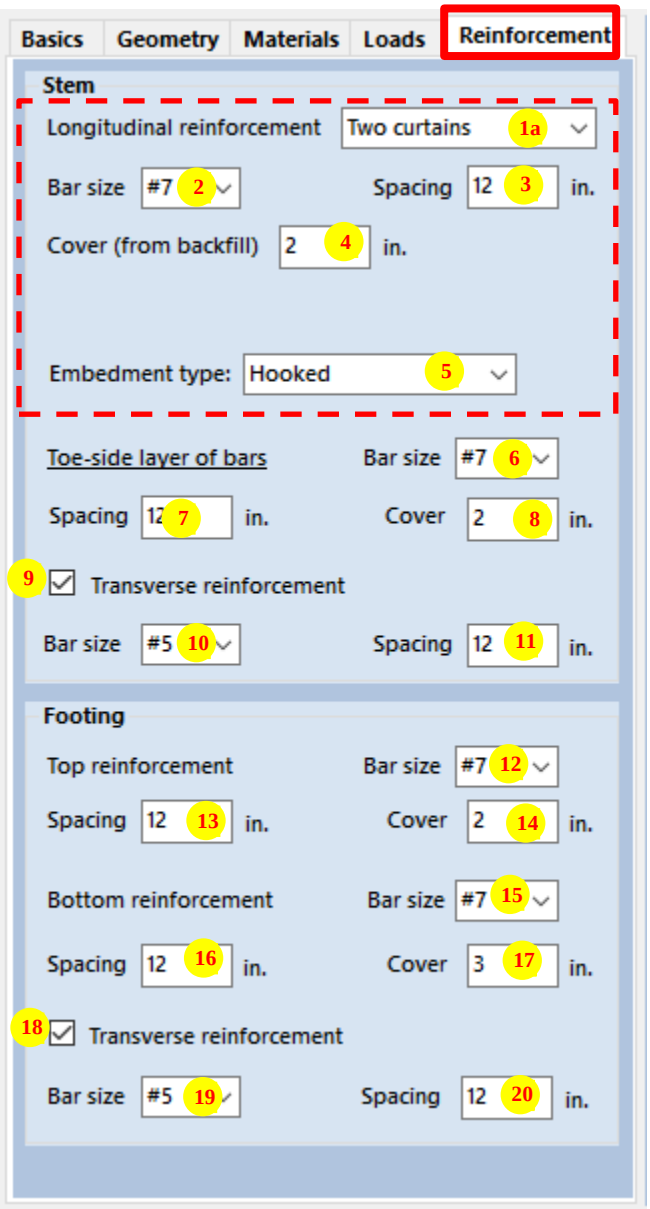


Figure 10. REINFORCEMENT input page of RTWall

Item 1a: Longitudinal reinforcement layout for RC stem. Options are: one curtain, centered layer

Item 2: Bar size for stem's first layer of longitudinal reinforcement. Options are: #3 through #18.

Item 3: Spacing for stem's first layer of longitudinal reinforcement (in.).

Item 4: Concrete cover for stem's first layer of longitudinal reinforcement (in.).

Item 5: Longitudinal reinforcement embedment type. Options are: straight, hooked, and check both.

Item 6: Bar size for stem's second layer of longitudinal reinforcement, if existed. Options are: #3 through #18.

Item 7 Spacing for stem's second layer of longitudinal reinforcement, if existed (in.).

Item 8: Concrete cover for stem's second layer of longitudinal reinforcement, if existed (in.).

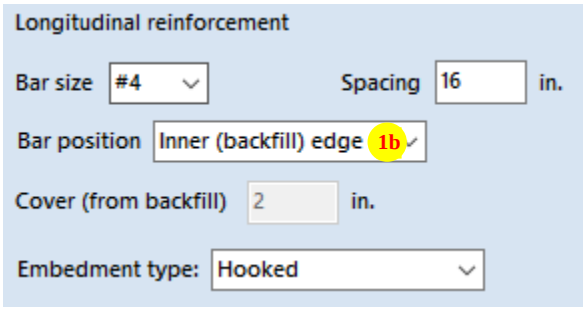


Figure 11. Stem's longitudinal bars REINFORCEMENT input panel for Reinforced Masonry Walls

Item 1b: Longitudinal reinforcement layout for RC stem. Options are: one curtain, centered layer

Item 9: Select if the stem has transverse (shrinkage and temperature) reinforcement.

Item 10: Bar size for stem's transverse reinforcement, if existed. Options are: #3 through #18.

Item 11: Spacing for stem's transverse reinforcement, if existed (in.).

Item 12: Bar size for footing's negative (heel) reinforcement. Options are: #3 through #18.

Item 13: Spacing for footing's negative (heel) reinforcement (in.).

Item 14: Concrete cover for footing's negative (heel) reinforcement (in.).

Item 15: Bar size for footing's positive (toe) reinforcement. Options are: #3 through #18.

Item 16 Spacing for footing's positive (toe) reinforcement (in.).

Item 17: Concrete cover for footing's positive (toe) reinforcement (in.).

Item 18: Select if the footing has transverse (shrinkage and temperature) reinforcement.

Item 19: Bar size for footing's transverse reinforcement, if existed. Options are: #3 through #18.

Item 20: Spacing for footing's transverse reinforcement, if existed (in.).

CHECK DESIGN AND QUICK RESULTS

Upon completing design details input, user can click on the “Check!” button to verify if the design meets code’s stability and structural requirements.

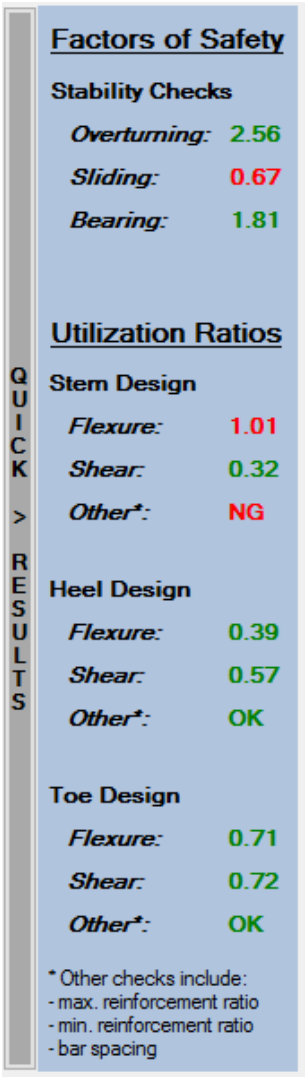
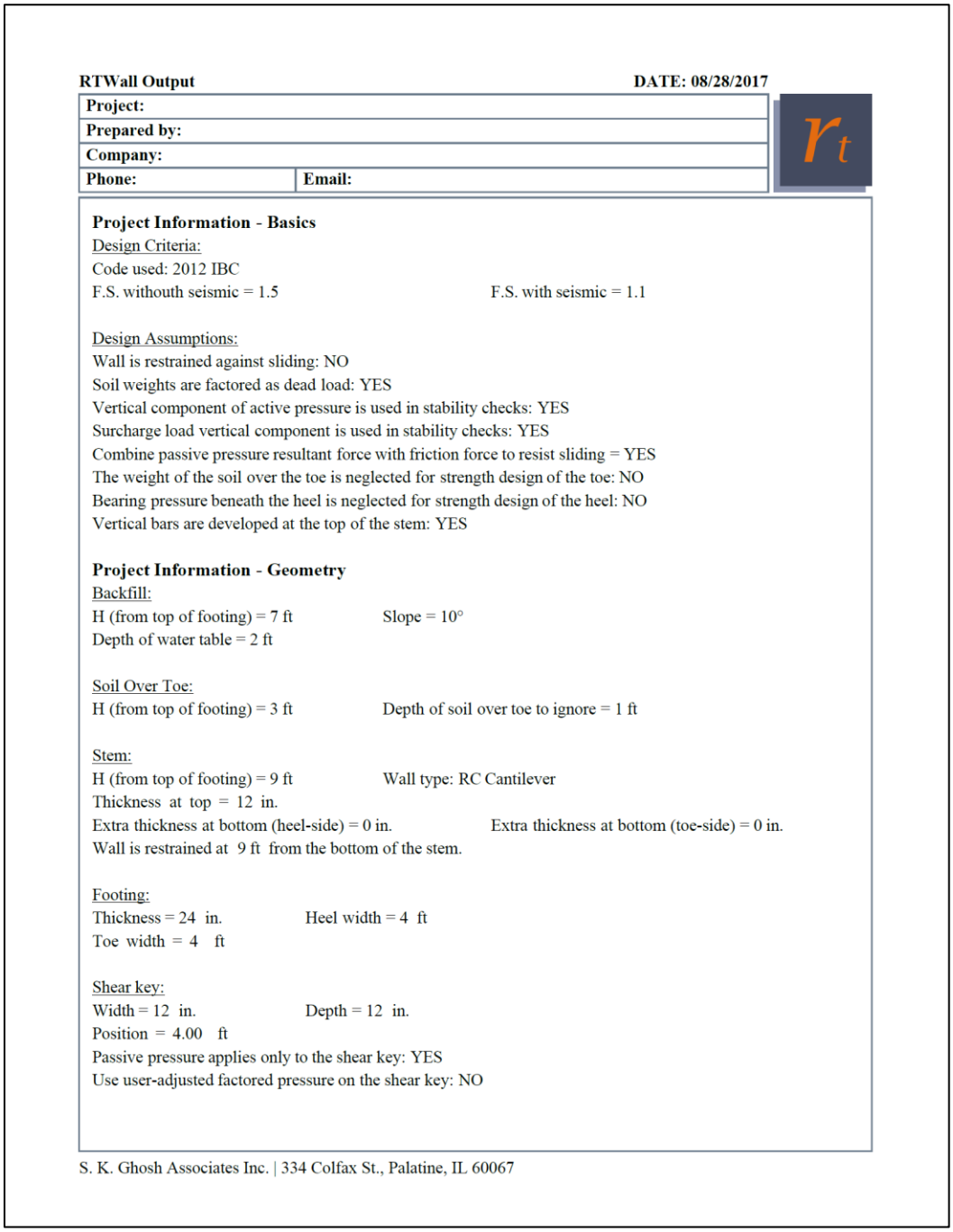


Figure 12. Results bar after running the design check

RTWall provides user with two output options. The first option is checking quick results shown in the results bar (Figure 12) that show whether the design complies with the code’s requirements for stability (overturning, sliding, and bearing) and structural design (stem, heel, and toe). The second option is checking the detailed output through using the “View Report” button.

OUTPUT INTERFACE

The detailed output report (Figure 13) can be displayed by clicking on the "View Report" button.



RTWall Output **DATE: 08/28/2017**

Project:	
Prepared by:	
Company:	
Phone:	**Email:**

Project Information - Basics

Design Criteria:

Code used: 2012 IBC

F.S. withouth seismic = 1.5 F.S. with seismic = 1.1

Design Assumptions:

Wall is restrained against sliding: NO

Soil weights are factored as dead load: YES

Vertical component of active pressure is used in stability checks: YES

Surcharge load vertical component is used in stability checks: YES

Combine passive pressure resultant force with friction force to resist sliding = YES

The weight of the soil over the toe is neglected for strength design of the toe: NO

Bearing pressure beneath the heel is neglected for strength design of the heel: NO

Vertical bars are developed at the top of the stem: YES

Project Information - Geometry

Backfill:

H (from top of footing) = 7 ft Slope = 10°

Depth of water table = 2 ft

Soil Over Toe:

H (from top of footing) = 3 ft Depth of soil over toe to ignore = 1 ft

Stem:

H (from top of footing) = 9 ft Wall type: RC Cantilever

Thickness at top = 12 in.

Extra thickness at bottom (heel-side) = 0 in. Extra thickness at bottom (toe-side) = 0 in.

Wall is restrained at 9 ft from the bottom of the stem.

Footing:

Thickness = 24 in. Heel width = 4 ft

Toe width = 4 ft

Shear key:

Width = 12 in. Depth = 12 in.

Position = 4.00 ft

Passive pressure applies only to the shear key: YES

Use user-adjusted factored pressure on the shear key: NO

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Figure 13. Output report