

Preface: The importance of good structural software can't be underestimated as a tool for today's structural engineer. During the last few years, the software options available to structural engineers for masonry design have grown and the use of masonry To support the engineering community, FORSE Consulting, LLC has created this manual.

RISA 3D v.21.0.0 for Masonry Design (from FORSE Consulting, LLC and IMI)

RISA 3D is one of the few commercially available, finite element analysis based, structural analysis and design programs that provides tools for effective modeling and design of masonry structures.

RISA 3D can be used to create an entire building that includes masonry or simply model and design an individual masonry wall panel. It provides code checks for masonry load bearing walls, masonry shear walls, masonry wall lintels, and masonry columns at the end of wall panels. The code check options are as follows:

- TMS 402-16 Strength
- TMS 402-16 ASD
- ACI 530-13 Strength
- ACI530-13 ASD
- ACI 530-11 Strength
- ACI 530-11 ASD
- ACI 530-08 Strength
- ACI 530-08 ASD
- ACI 530-05 Strength
- ACI 530-05 ASD
- ACI 530-02 Strength
- ACI 530-02 ASD
- ACI 530-99 ASD
- UBC 1997 Strength
- UBC 1997 ASD

It also can design hybrid masonry/frame structures and handles both reinforced and unreinforced masonry using concrete masonry units or clay brick units in a variety of compressive strengths and unit configurations. RISA 3D is one of the software packages recommended by the International Masonry Institute for masonry wall design.

About RISA 3D v21 (from RISA Technologies, LLC)

RISA 3D has the most current steel, concrete, cold-formed steel, masonry, aluminum, and timber design codes. RISA-3D gives you the tools to tackle multi-material projects with confidence.

About International Masonry Institute (IMI)

The International Masonry Institute offers quality training for craftworkers, professional education for masonry contractors, and free technical assistance to the design and construction communities. IMI is a strategic alliance between the International Union of Bricklayers and Allied Craftworkers (BAC) and their signatory contractors to promote quality masonry construction.

Team IMI consists of architects, engineers, construction managers, skilled craftworkers and instructors, offering what no other group can: expertise in training, craftsmanship, design, installation and marketing. That means buildings built by union craftworkers and contractors get built the right way.

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Disclaimer

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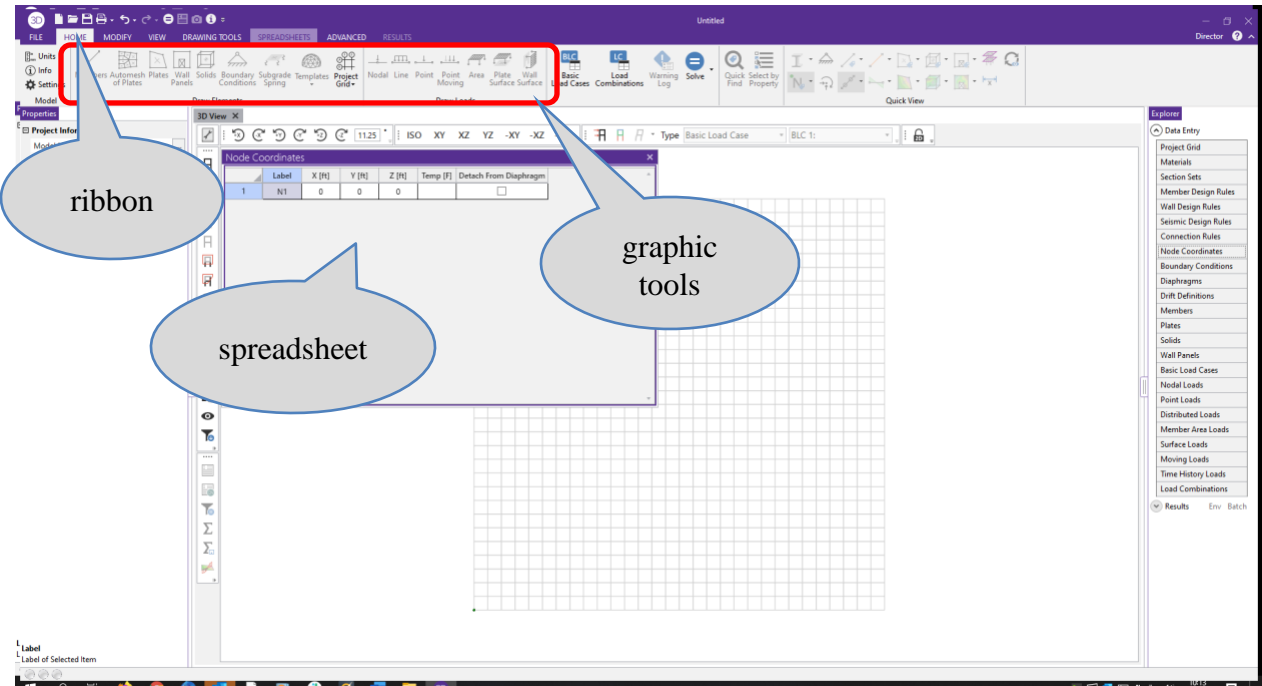
This document is intended for the use of industry professionals who are competent to evaluate the significance and limitations of the information provided herein. This publication should not be used as the sole guide for masonry design and construction.

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Section 1: Workflow for Masonry Buildings in RISA-3D v21

- 1. Open RISA-3D
- 2. Learn about the application interface
 - a. Toolbars for navigation, model viewing, and editing data
 - b. Spreadsheets
 - i. Nodes, members, boundary conditions, materials, wall panels/plates, loads
 - c. Graphic tools
 - i. These do everything that the spreadsheets do, but directly in the model rather than tabular format
 - d. Wall panel editor
 - i. Editing tool specifically for wall panels



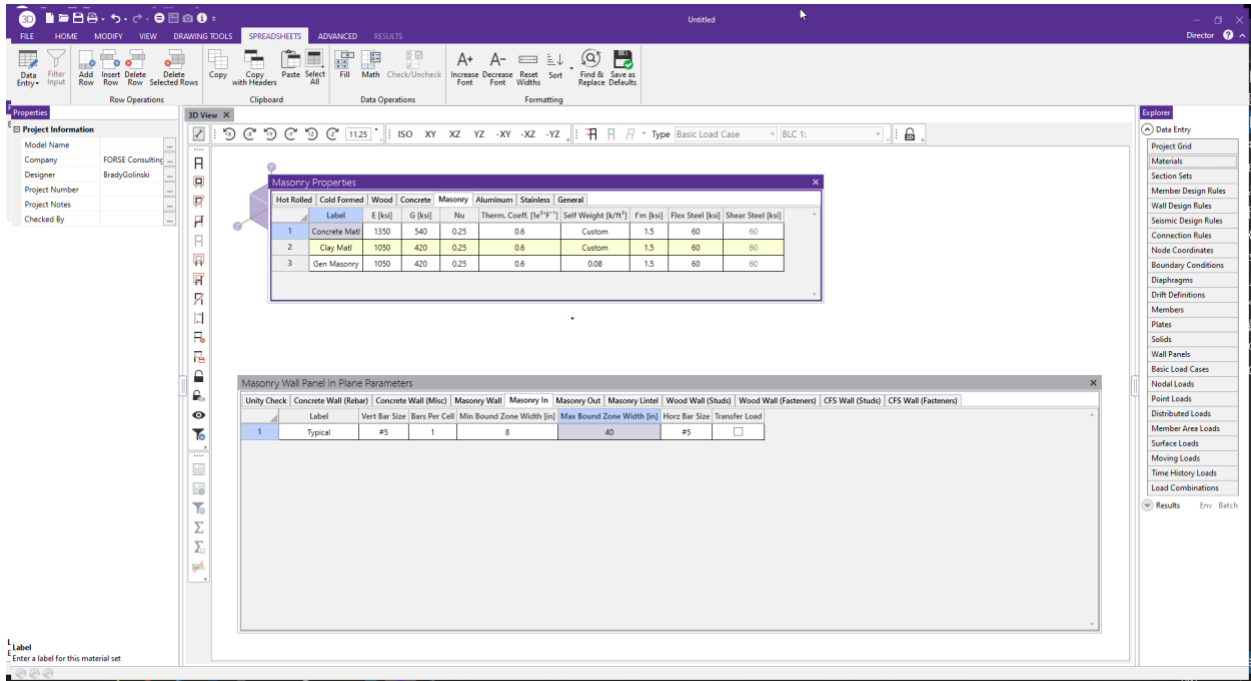
Screen shot 1—application interface

Modeling Tip: right click on the view screen to access these tools

3. Begin by defining CMU properties
 - e. Use Materials spreadsheet>Masonry tab to define structural properties
 - i. Modulus of elasticity
 - ii. Masonry strength (f'_m)
 - iii. Reinforcing yield strength
 - iv. Masonry self weight
 - f. Use Wall Design Rules spreadsheet>Masonry Wall tab to define block size and grout spacing
 - i. Nominal block width
 - ii. Grouting—fully, partially (at reinforced cells), ungrouted
 - iii. Reinforced versus unreinforced
 - g. Wall Design Rules spreadsheet>Masonry In tab for in-plane design parameters—boundary steel at wall ends
 - i. Vertical bar size
 - ii. Bars per cell
 - iii. Minimum and maximum boundary zone width
 - iv. Horizontal bar size
 - v. Transfer load—will transfer in-plane loads from regions above and below openings to adjacent regions (design of regions above and below walls will be omitted)
 - h. Wall Design Rules spreadsheet>Masonry Out tab for out-of-plane design parameters
 - i. Vertical bar size
 - ii. Minimum and maximum vertical bar spacing
 - iii. Bar placement (center of cell, each face, or staggered)
 - iv. Mortar type
 - v. Cement type
 - vi. Transfer load—will transfer out-of-plane loads from regions above and below openings to adjacent regions (design of regions above and below walls will be omitted)

- i. Wall Design Rules spreadsheet>Masonry Lintel tab to define lintel design parameters
 - i. Lintel depth
 - ii. Lintel bearing length
 - iii. Bar size
 - iv. Minimum and maximum number of bars
 - v. Number of reinforcing layers
 - vi. Layer spacing, if more than one
 - vii. Distance from bottom layer to bottom of lintel
 - viii. Stirrup size
 - ix. Analysis method (simply supported or FEA)

1. Note: FORSE recommends “FEA method” as the program reports the actual forces from the analysis. This requires design of the lintel in a separate program. The “simply supported method” does not utilize the actual forces from the lintel – RISA manipulates the forces in the lintel to zero out the moment at the end of the span. This is incorrect.



Screen shot 2—Masonry Properties and Masonry Wall Panel spreadsheets

Modeling Tip: Multiple design rules can be input on all of the tabs listed above to account for different designs within the same project

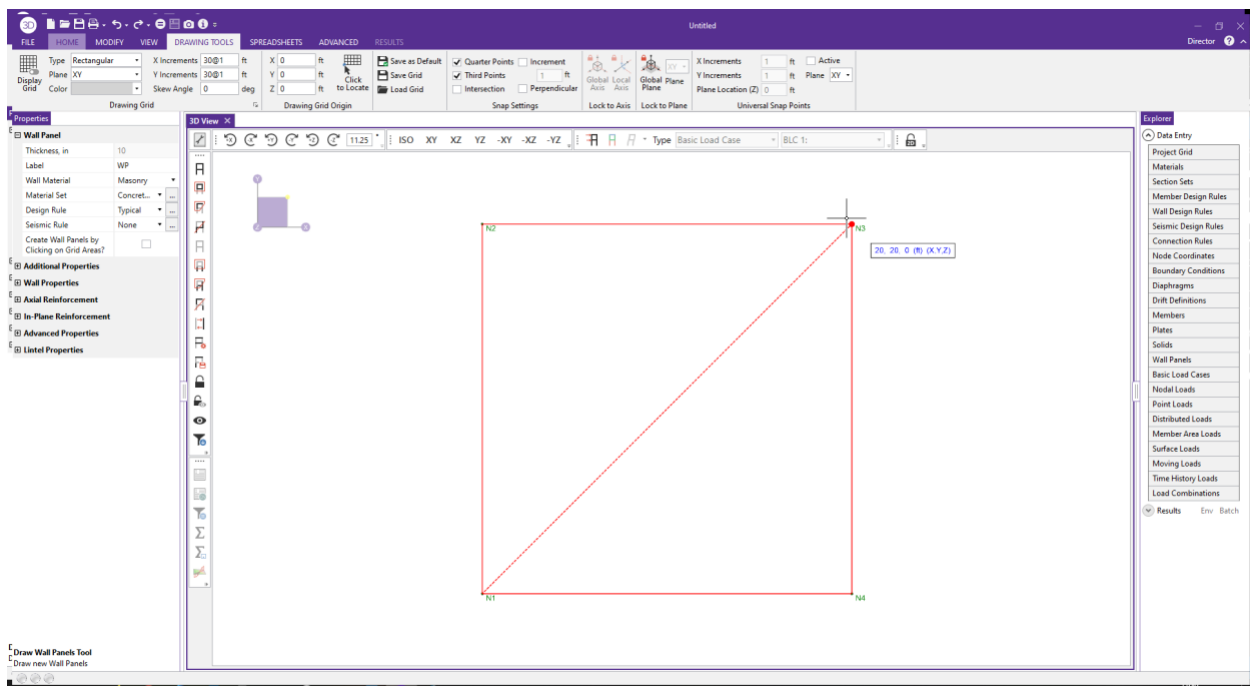
- j. Seismic Design Rules spreadsheet>Masonry Walls

- i. Wall types: Ordinary, Intermediate, or Special
- ii. Special Boundary Elements: Whether they will be included per TMS 402-16 section 9.3.6.6.1 through 9.3.6.6.5
- iii. 1.5x shear multiplier for ASD design in high seismic zones per TMS 402-16 section 7.3.2.6.1.2

4. Define masonry geometry

a. Start with one masonry wall elevation

- i. Add nodes at wall corners in Joint Coordinates spreadsheet
- ii. Draw wall using Draw New Wall Panels tool in Graphic Editing Toolbar.
- iii. It is possible to draw a new wall without adding joints first if using the Drawing Grid



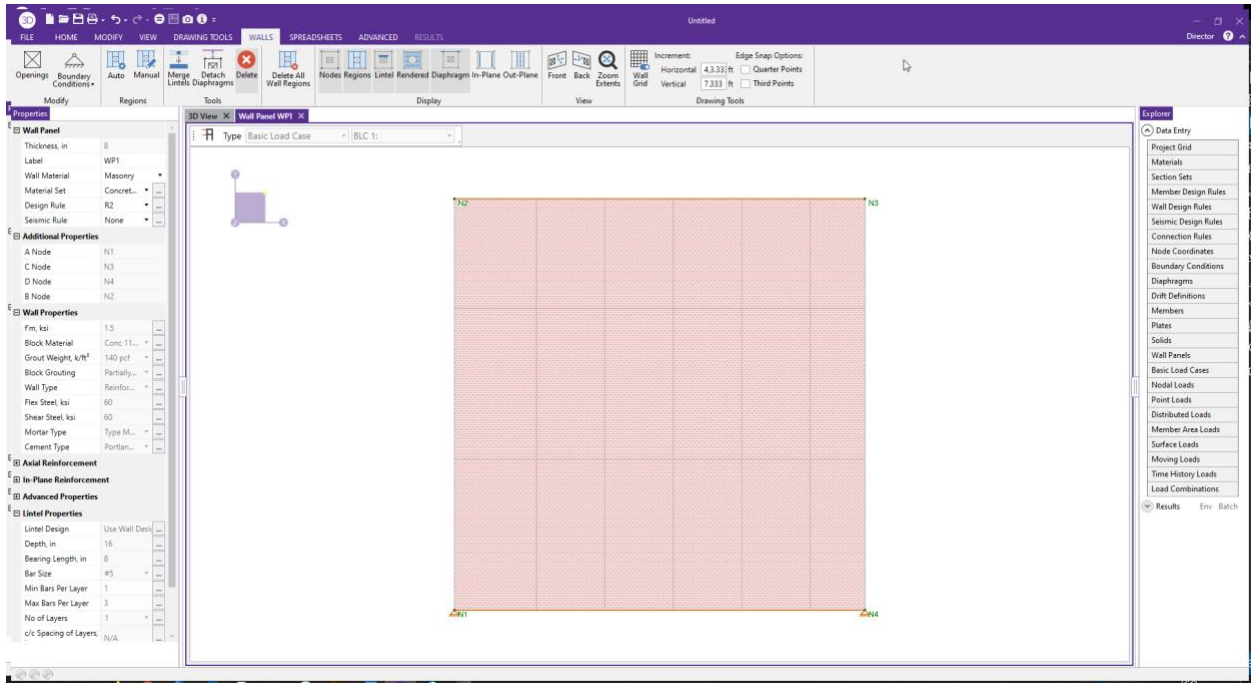
Screen shot 3—select nodes in this order when drawing wall panels

Modeling Tip: Nodes/grid corners must form a rectangular shape for the wall to be drawn. At a minimum, the nodes at diagonal corners must be drawn first. If nodes do not exist at the other corners to form a rectangular shape, the program will add them when the wall panel is drawn.

- b. Stack walls at multistory conditions
- c. Define a new wall panel where out of plane load changes
 - i. Can also change material and/or design rules

Modeling Tip: If adjacent wall panels (horizontally or vertically) share joints at corners, they will behave as a continuous wall

- d. Control joints
 - i. Program does not have a way to model control joints directly, but they can be approximated by creating a gap and a gap element
 - 1. Place wall panel edges a distance apart that corresponds to the control joint width
 - 2. Add a fully rigid, compression-only gap member between wall panels
 - 3. Add a negative thermal load to the gap member to achieve longitudinal shrinkage equal to the gap width
 - 4. This ensures the panels will act independently until they deflect close enough to touch each other
- e. Wall panel editor
 - i. Double click on any wall panel to enter the wall panel editor
 - ii. Add boundary conditions (this is the only way to add support along an entire panel edge)
 - iii. Define openings in the wall panel
 - 1. Must set up a grid for this in the wall panel editor; nodes are not active in the wall panel editor
 - 2. Grid can be set up in the wall panel editor for each individual wall panel
 - 3. Grid lines do not need to be spaced at regular intervals; it is possible to place grid lines only at the edges of each opening
 - iv. Define lintels above openings
 - 1. Lintels are automatically created with each opening
 - 2. Only one design rule per wall panel
 - 3. To have different lintel designs in the same panel, use custom design (double-click on openings to open lintel properties window)
 - v. Define wall regions
 - 1. Can be defined automatically by RISA or manually
 - 2. Program will automatically assign separate regions above and below a diaphragm
 - 3. Wall regions can be designed per the design rule of the wall panel or with custom parameters (double-click on regions to set custom parameters)



Screen shot 4—Wall Panel editor window

5. Define loads

- a. Set up different cases in the Basic Load Cases spreadsheet
- b. Set Category for each load case
 - i. Multiple load cases can be assigned to each category
 - ii. This is not necessary for manual load combinations but is required for generated load combinations

BLC De.	Category	X Gravity	Y Gravity	Z Gravity	Nodal	Point	Distribu...	Area(M...	Surface...
1	dead	DL							
2	live	LL							
3	None								
4	None								
5	None								
6	None								
7	None								
8	None								
9	None								
10	None								
11	None								
12	None								
13	None								
14	None								

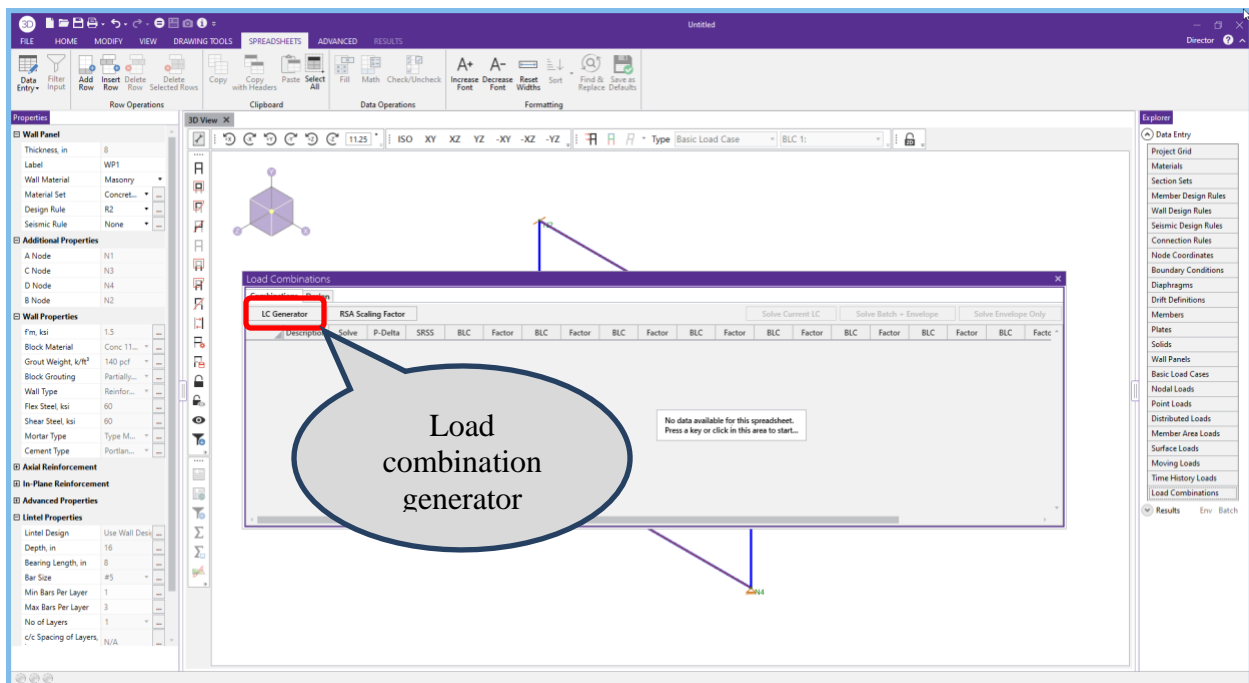
Screen shot 5—Basic Load Cases spreadsheet

- c. In-plane loads
 - i. Apply shear loads

1. As a joint load at a node—apply in Joint Loads spreadsheet or with Joint Loads graphic tool
 2. As a distributed load at a wall panel edge—apply using the Distributed Loads graphic tool
- ii. Apply vertical uniform loads from diaphragms with Distributed Loads graphic tool—not possible to do in Distributed Loads spreadsheet
 - iii. Gravity load can be applied in the Basic Load Cases spreadsheet
- d. Out-of-plane loads
- i. Apply lateral loads to the entire wall panel with the Surface Loads spreadsheet or graphic tool
 - ii. Surface load can be applied to a portion of the panel height, but must be applied to full panel width (surface load can vary linearly in the vertical direction)
 - iii. To change lateral pressure, for example near a building corner, start a new wall panel

Modeling Tip: All load spreadsheets are accessed through the Basic Load Cases spreadsheet

- e. Set up load combinations with load factors in the Load Combinations spreadsheet
 - i. This can be done manually or automatically with the LC Generator button

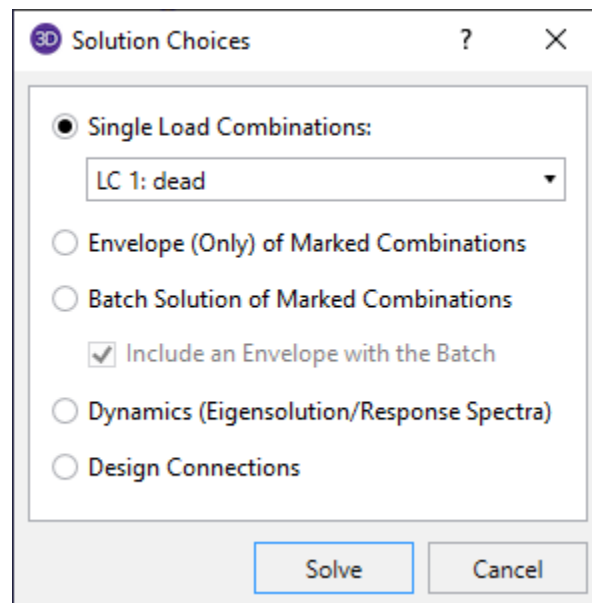


Screen shot 6—Load combinations

6. Model design and analysis

- f. Model Settings menu
 - i. Use Codes tab to set governing code (see page 2 of this document for available codes)
 - ii. Use Solution tab to set the mesh size for finite element analysis
- g. Analyze the model by clicking Solve on the menu bar or the Equal sign button
 - i. Choose which load combination to analyze
 - ii. Analyze Envelope forces of selected load combinations
 - iii. Analyze multiple load combinations simultaneously with Batch Solution
- h. Check Wall Panel Design spreadsheet
 - i. Results are shown on Masonry In, Masonry Out, and Masonry Lintel tabs
- i. Check Detail button on left side of screen (not available for an Envelope solution)
 - i. Shows details for the wall panel by region, in-plane and out-of-plane sections
 - ii. Shows input and output
 - iii. Code checks, axial, shear and moment diagrams
 - iv. Wall cross sections showing vertical reinforcing for in-plane and out-of-plane loads

7. Save model and end



Screen shot 7—analysis options

Section 2: More Information about Masonry in RISA-3D v21

1. Masonry parapets
 - a. RISA does not have a dedicated method to model parapets
 - b. Parapets can be a separate wall panel continuous with the top of the panel below, or just a continuation of the panel below
 - c. If a diaphragm is modeled at the roof level, RISA will automatically make separate wall regions above and below the diaphragm if the parapet is part of the same panel as the wall below
 - d. Add parapet wall pressure as a Surface Load—it's not necessary to have a separate wall panel for this
2. Non-load bearing walls
 - a. Non-load bearing walls can be modeled by making sure that floor/roof framing does not connect to the top of the wall
3. Load bearing walls
 - a. Members supported on walls will transfer loads directly to the walls
 - b. Rigid end offsets can be used to account for eccentricity of the member connection from the wall centerline
4. Masonry wall stiffness
 - a. Wall stiffness can be updated automatically—Model Settings menu > Solution tab—select “Optimize Masonry, Wood and CFS Walls”
 - b. Equivalent moment of inertia is calculated from the maximum moment in the region and used to update the stiffness of the wall during design

Section 3: Workflow for Importing a Revit Structure Model

1. RISA-3D v21 can import models from Revit Structure
 - a. Requires separate program—RISA-Revit Link; download from RISA
 - b. Number of round-trip transfers between RISA-3D and Revit is unlimited
 - c. Link maintains geometry and design parameters
 - d. Link creates a separate Exchange file when model is exported from either program
 - e. In the other program, open the Exchange file to import the model
 - f. Model and exchange file are backed up during each transfer
2. Most common method is to begin the model in Revit and transfer to RISA-3D
 - a. The architect usually produces a Revit model first, which can be used as a template to start the structural model
 - b. Revit is a physical model; RISA is an analytical model
 - c. It is easier to first model complex arrangements or connections in Revit (which needs to accurately portray these items) then transfer to a simpler arrangement in RISA
 - d. For example, in Revit, a fixed connection needs to accurately model how a beam connects to a column for construction documents—in RISA, modeling a fixed connection provides enough information for accurate analysis
3. Items and information that are transferred
 - a. Materials for walls in Revit become General materials, not Masonry, in RISA-3D
 - b. Boundary conditions applied to elements in Revit are applied to the appropriate joints when transferred to a RISA-3D model—translations, rotations, and spring stiffnesses are also transferred
 - c. Walls modeled as Structural in Revit are transferred to RISA-3D as Wall Panels
 - d. Wall Panels and vertical Plate elements in RISA-3D will be imported into Revit as structural walls
 - e. Wall opening sizes and locations are also transferred between models