The State of the Art Analysis and Design of Structures: Application of RISA-3D

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Introduction

The author has been using RISA family of products for over 5 years now. RISA provides engineering profession with the state-of-the-art tools for analysis and design of structures and infrastructure. It is also used as a modeling tool for structural simulation of industrial and commercial buildings and civil structures. One major reason for the popularity of RISA lies in its effortless interface that meets a powerful analysis engine for static, dynamic, and RSA analyses for the design of different types of structures using common structural materials including steel, concrete, timber (wood), and cold-formed metals. It is generally regarded by many engineers, architects, and researchers as a modern, robust, accurate, and visually sensible tool to provide solutions for optimization and solving engineering design and scientific problems. In many teaching and learning environments, RISA family of products may also be used as an effective teaching tool to demonstrate the robustness and the ductility of the structures under the application of gravity and lateral loads both in the classrooms and corporate training sites. It can also be used to demonstrate the serviceability of the structures and undeformed and deformed shapes of different structural elements. RISA family of products includes RISA-3D, RISA-2D, RISAFloor, RISATower, RISAMasonry, RISAFoot, RISABase, RISASection, and RISA CIS/2 Translator. Each product has many unique advantages for design and analysis of structures.

This review is intended to be brief, introductory, and for educational and informational purposes only. Reviewing the entire RISA family of products can be the subject of many reviews and can not be presented here. This article presents only some of the main features and functionalities that make RISA-3D (Version 7) distinctive software for structural analysis and design. This article is based solely on the author's professional experience with using the software. Any findings and opinions, implicitly and or explicitly, reported here are those of the author and do not necessarily reflect those of the software's designer(s), manufacturer(s), their subsidiaries and partners, and their distributor(s).

General Features and Capabilities of RISA-3D (Version 7)

RISA-3D is user friendly and is regarded by many professionals as software of choice for structural analysis/design of industrial and commercial buildings and civil structures. It has been used for many projects throughout the world and here in the United States. A sample project for the expansion of the Miami International Airport in Miami, FL is shown in Fig. 1. RISA-3D is based on Finite Element Method (FEM) and is used for the analysis and design of general frame, truss, and plate and shell structures. Version 7 includes more efficient and faster features such as solid element generation with automatic meshing and accelerated sparse solver that are up to 100 times faster than before. It also conforms to AISC 13th Edition Steel Code (ASD & LRFD) and NDS 2005 Wood Code. It also has the capabilities of integration with RISAFoundation. RISA-3D has been optimized to work on Windows 2000/XP/Vista platforms and is provided with extensive customization options and user defaults, comprehensive printed reference manual and tutorials, an encyclopedic online help with index and cross-reference, and comprehensive technical support provided by Professional Engineers.
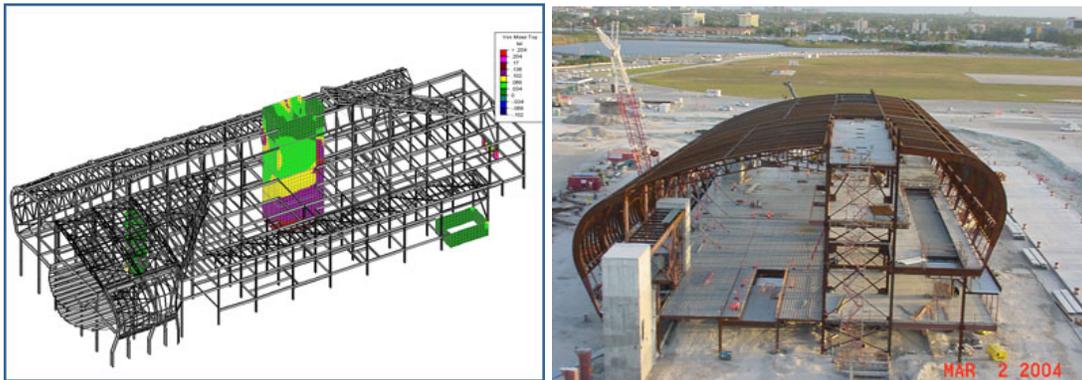

Figure 1: Sample Project using RISA-3D in Miami, Florida
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Modeling Features

Only some major features are presented here. The reader is advised to refer to the RISA Technologies website with the URL given at the end of this article.

RISA-3D provides a three-dimensional, comprehensive, CAD-like drawing/editing environment (Fig. 2). In such an environment one can draw, generate, modify, and load elements as well as snap, move, rotate, copy, mirror, scale, split, merge, mesh, delete, apply, etc. The drawing grids are versatile and robust, and it includes orthogonal, radial, and skewed drawings.   Universal snaps and object snaps allow drawing without grids. RISA-3D includes powerful graphic select/unselect tools including box, line, polygon, invert, criteria, spreadsheet based, and save/recall selections with locking. With the capability of opening multiple spreadsheets simultaneously, it has true spreadsheet editing capabilities with cut, paste, fill, math, sort, find, etc. The dynamic synchronization

between spreadsheets and graphics of RISA-3D and constant in-stream error checking and data validation combined with unlimited undo/redo capability and automatic timed backup greatly increase the speed and efficiency.   Other modeling features include automatic generation templates for grids, disks, cylinders, cones, arcs, trusses, tanks, hydrostatic loads, etc., support for all units systems and conversions at any time, automatic interaction with RISASection custom shape libraries, importing DXF, RISA-2D, STAAD, ProSteel3D and CIS/2 files, exporting DXF, SDNF, DesconWin, ProSteel3D and CIS/2 files, and a robust two-way link with Revit Structure 2008.
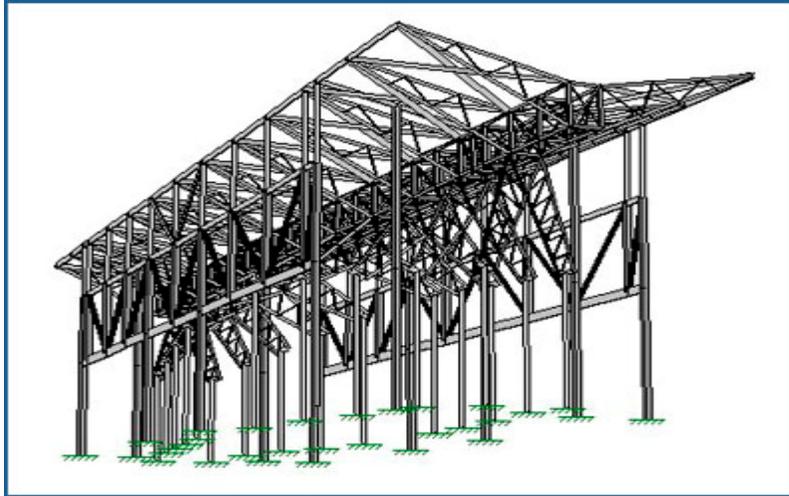

Figure 2: 3-D Modeling of Airborne and Special Operations Museum using RISA-3D

Analysis Features

RISA-3D (Version 7) includes accelerated true sparse solver for static analysis, and flexible modeling capabilities for P-Delta effects. The story drift calculation capabilities provide relative drift and ratio to height calculations, important concerns for dynamic analysis and code conformance. Its accelerated Sparse Lanzcos dynamics solver is rapid and robust.   It is capable of multiple simultaneous dynamic and response spectra analysis using Gupta, CQC or SRSS with automatic calculations of scaling factors, automatic inclusion of mass offset (5% or user defined) for dynamic analysis, and automatic generation of code-based wind and seismic forces. Member modeling in RISA-3D is a "true" physical member modeling in which members are aware of interior joints. At the user's discretion, users may inactivate members, plates, solids and diaphragms without deleting them. Members may include one way members, for tension only bracing, slipping, etc. Depending on the application, for modeling soil and other members stiffness into considerations, one way springs may also be considered in the model. Euler Buckling members can also be generated and compress up to their buckling load to study the affects, then they can be turned off. One remarkable feature of RISA-3D is automatic self-weight calculations for members, plates and solids.

Elements can be modeled as 3- or 4-node plate/shell elements with plane stress only option or as 8-node solid elements with automatic meshing (Fig. 3).   The high end mesh generation can create a polygon with any number of sides to create a mesh of well formed quadrilateral elements without using any triangular elements. Other major features are accurate analysis of tapered wide flanges, automatic rigid diaphragm modeling with detachable joints, area loads with one-way or two-way distributions with optional "blow through" distribution for loading open structures, plate thermal loads, simultaneous moving loads (AASHTO/custom for bridges, cranes, etc.), torsional warping calculations for stiffness, stress and design, member end releases, rigid end offsets, and top of member offsets, enforced joint displacements. RISA-3D can be used to perform stress calculations on any arbitrary shape.
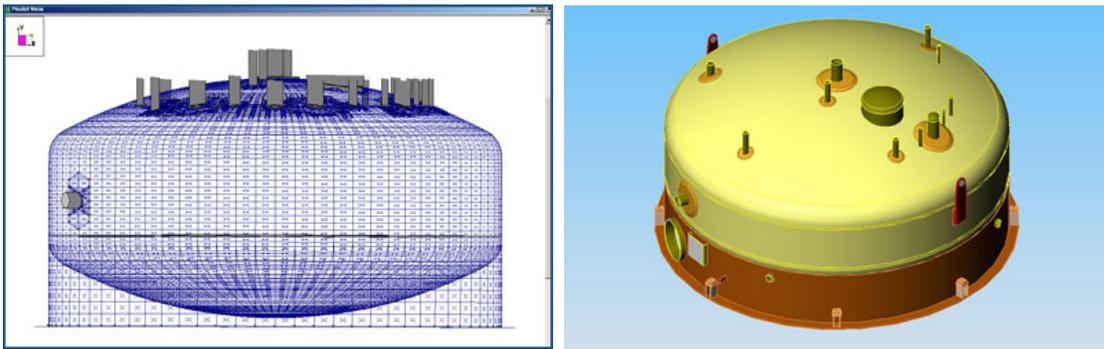

Figure 3: Element Generation Snapshot of RISA-3D for Specialized Process Vessel
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Design Features

RISA-3D can be used for static and dynamic (seismic) design, optimization, and simulation of structures made of common structural materials like concrete, hot rolled steel, cold formed steel, and wood. For seismic design, it can automatically generate spectra for UBC 1997, and IBC 2000/2003. It can be used for optimization of member sizes for all materials and all design codes, controlled by standard or user-defined lists of available sizes and criteria, and it can be used for automatic calculation of custom shape properties.

Reinforced Concrete: For reinforced concrete design of structures, RISA-3D has the capability of "program-selected" or "user-defined" layouts for flexure and shear reinforcing rebar with the option of maintaining consistent bar sizes through adjacent spans. Whether using parabolic or rectangular concrete stress block at a cross-section, the exact integration of concrete stress is possible. The design of concrete beam detailing is possible for rectangular, T-beam, or L-shaped. For the design of reinforced concrete columns, interactions diagrams can be viewed in RISA-3D. It is important to mention here that the design can be checked to ensure conformity to concrete design codes listed as: ACI 1999/2002, BS 8110-97, CSA A23.3-94, IS456: 2000, EC 2-1992, NZS3101-1995, AS 3600-2001, NTC-DF2004. RISA-3D has seamless integration with RISAFoot (Ver 2+) for advanced footing design.

Steel: For the design of steel structures, extensive user controlled generation of load combinations according to ASCE, UBC, IBC, BOCA, SBC, ACI, and International code are possible. The steel design codes include: AISC 13th ed., ASD 9th ed., LRFD 2nd & 3rd eds., HSS Specification, CAN/CSA-S16.1-1994 & 2004, BS 5950-1-2000, IS 800-1984, Euro 3-1993, NZS 3404-1:1997, and AS 4100-1998 including local shape databases. The steel Shapes: AISC, HSS, CAN, ARBED, British, Euro, Indian, Chilean, etc. In his professional work, the author has experience using AISC and HSS steel shapes in accordance with LRFD design approach. Design capabilities of RISA is also expanded to include light gage shapes of AISI, SSMA, Dale / Incor, Dietrich, and Marino\WARE and cold-formed steel design of AISI 1999/2001, and CSA S136-01 cold formed steel design. Intelligent unbraced length calculations for physical members and automatic approximation of K factors are some of the powerful capabilities of RISA-3D in designing steel structures. More capabilities include the AISC 13th ed. Direct Analysis Method, and tapered wide flange design with either ASD or LRFD codes.

Wood: RISA-3D conforms to NDS 91/97/2001/2005 wood design, and can be used for the design of Glued-laminated (Glulam) shapes, SCL, multi-ply, and full sawn. It also includes a complete NDS species/grade and Glulam database.

Results and Reports Generation

Based on the author's experience, RISA-3D has the capabilities to deliver the highest-quality, most-reliable structural simulation results available in the industry. It allows simulation of many different types of structures, from the most intricate of structures to the complicated assemblies. The results can be in graphic presentation of color-coded results and plotted designs with color contours of plate, solid stresses/forces with smoothing and animation. The spreadsheet results can be presented with sorting and filtering of: reactions, deflections, forces, stresses, optimized sizes, code designs, concrete reinforcing, material takeoffs, frequencies, mode shapes, etc. It can be presented in standard and user-defined reports with graphic member detail reports with force/stress/deflection diagrams and detailed design calculations and expanded diagrams. Solutions of the analysis and the design can be saved and restore quickly.

More Information

Much more information about the RISA family of products including many case studies and verification problems can be found at the company's website at http://www.risatech.com via the internet.

Acknowledgements