# INTEGRATED STRUCTURAL ANALYSIS AND DESIGN SOFTWARE

FOR WINDOWS 95<sup>®</sup> & WINDOWS NT<sup>®</sup>

THREE DIMENSIONAL STATIC AND DYNAMIC FINITE ELEMENT ANALYSIS AND DESIGN OF STRUCTURES

COMPUTERS & STRUCTURES INC.

STRUCTURAL AND EARTHQUAKE ENGINEERING SOFTWARE

# THREE DIMENSIONAL STATIC AND DYNAMIC FINITE ELEMENT ANALYSIS AND DESIGN OF STRUCTURES

# **USER FRIENDLY GRAPHICAL INTERFACE**

Fully integrated interface within Windows 95 and Windows NT Powerful new 2D and 3D model builder 3D model generation using plans, elevations and developed views Automated templates for typical structures Easy editing with move, merge, mirror and replicate Convenient dividing and meshing of elements Accurate dimensioning with guidelines and snapping Cut, copy and paste options Unlimited levels of undo and redo Quick draw options to create elements with one mouse click Powerful grouping, selection and display options On screen assignment of properties, loading and supports Multiple views in 3D perspective with zooming and panning Orthographic and user defined views Copy / Paste to and from spread sheets Import and export of .DXF file for model geometry Multiple rectangular and cylindrical coordinate systems Detailed context sensitive online help Analysis integrated with postprocessing and design Right button click for instantaneous current element or



SAP2000 represents the most sophisticated and user-friendly release of the SAP series of computer programs. This version of SAP is completely integrated within Microsoft Windows. It features a powerful graphical interface unmatched in terms of ease-of-use and productivity.

Creation and modification of the model, execution of the analysis, and checking and optimization of the design are all done through this single interface. Graphical displays of the results, including real-time animations of time-history displacements, are easily produced. SAP2000 offers a quantum leap forward in the way models are created and modified, and in the way analysis and design are managed.

The analytical capabilities are just as powerful, representing the latest developments in numerical techniques and solution algorithms. This release is available in three different analytical versions, all sharing the same graphical interface: SAP2000, SAP2000 PLUS, and SAP2000 Nonlinear. All of these programs feature sophisticated capabilities, such as fast equation solvers, force and displacement loading, non-prismatic frame elements, highly accurate shell elements, Eigen and Ritz dynamic analysis, multiple coordinate systems for skewed geometry, many different constraint options, the ability to merge independently defined meshes, a fully-coupled 6x6 spring stiffness, and the option to combine or envelope multiple dynamic analyses in the same run.

The SAP2000 PLUS program adds unlimited capacity, bridgeanalysis capabilities, a complete range of finite elements and time-history analysis options. Ground motion effects with multiple-base excitations can be included. The SAP2000 Nonlinear version extends the PLUS capabilities by adding static pushover analysis and dynamic nonlinear analysis capability. The pushover analysis uses frame plastic hinge elements. The dynamic nonlinear analysis uses a nonlinear link element to model gaps, hooks dampers isolators and plastic hinges. Buildings and bridges with passive energy absorption systems and base isolator systems can be analyzed.

All of the above programs feature powerful and completely integrated design modules for steel and concrete, both available from within the same interface used to create and analyze the model. The design of steel frame members features initial member sizing and iterative optimization. The design of concrete frame members includes the calculation of the amount of reinforcing steel required. Members can be grouped for design purposes, and a single mouse click on an element brings up the detailed design calculations. SAP2000 supports the latest US codes and Eurocodes.

The SAP name has been synonymous with state-of-the-art analytical solutions since the introduction of SAP, SOLIDSAP, and SAP IV over twenty-five years ago. To these sophisticated numerical techniques, SAP2000 adds a tremendously easy and complete graphical user interface linked with powerful design capabilities, providing the structural engineer an analysis and design program unequaled in efficiency and productivity.

"Tomorrow's Technology — Today!"



TEMPLATES





CONCRETE DESIGN

# THE MOST POWERFUL IS NOW ALSO THE MOST FRIENDLY

THE STANDARD ELEMENTS

## The 2D and 3D Beam and Truss Element

STANDARD

- Multiple non-prismatic segments over element length
  Point, uniform and trapezoidal loading in any direction
- Temperature and thermal gradient loading
- Prestress loading
- Automated end offset evaluation
- Moment and shear releases
- Built-in steel sections

#### The 3D Shell Element

- General quadrilateral or triangular element
- Orthotropic materials
- Six degrees of freedom per joint
- Shell, plate or membrane action
- Thick shell option
- Gravity, uniform, pressure, temperature and thermal gradient loading

### The Spring Element

- Joint to ground (support) spring
- Global and skewed springs
- Coupled 6x6 user-defined spring stiffness option (for foundation modeling)

## **Analytical Options**

- Static and/or dynamic response spectrum analysis
- P-delta analysis with either static or dynamic analysis
  Blocked active column equation solver
- Automated fast profile optimization
- Generalized joint constraint options including: rigid bodies, diaphragms, rods and welds
- Applied force and applied displacement loading
- Gravity, pressure and thermal loadingEigen analysis with an accelerated subspace iteration algorithm
- Ritz analysis for fast predominant mode evaluation
- Multiple response spectrum cases in single run
- Modal combination by the SRSS, the CQC or the GMC (Gupta) method
- Directional combinations by the ABS or the SRSS method
- Static and dynamic response combinations and envelopes

#### Analysis Output Display Options

- 3D perspective graphical displays of undeformed and
- deformed structural geometries
- Static deformed shapes and mode shapes
- Loading diagrams
- Bending moment and shear force diagrams
- Stress contours
- Animation of deformed shapes and mode shapes
- Animated stress contours
- Multiple windows displaying different parameters
   Instantaneous graphical and tabulated output details for
- specific joint or element with right button click
- Static and dynamic load combinations and envelopes

# Steel and Concrete Design

- Fully interactive and graphical steel and concrete frame member design
- AISC (ASD and LRFD), ACI, British and Eurocodes
- Design for static and dynamic loads Ductile and non-ductile design
- Member-grouping for design envelopes Detailed onscreen design information with right button click Steel member selection and optimization
- Biaxial moment-axial load column interaction diagrams



# SAP2000 PLUS ELEMENTS

SAP2000 Plus extends the capabilities of the standard version with unlimited capacity and additional analytical capabilities

#### **PLANE Element**

- 3 to 9 nodes plane stress or plane strain element
- Orthotropic material properties
- Gravity, thermal, surface pressure and pressure gradient loading

# **ASOLID Element**

- 3 to 9 nodes axisymmetric element
- Orthotropic material properties
- Gravity, thermal, surface pressure and pressure gradient loading

## SOLID Element

- Three dimensional 8 node brick element
- Anisotropic material properties
- Gravity, thermal, surface pressure and pressure gradient loading

#### Dynamic Time History Analysis

- Ground acceleration excitation
- Multiple base excitation
- Load forcing functions
- Transient or steady-state
- Multiple time history cases
- Sequential history cases
- Time history Windows AVI file
- Graphic displays of nodal and element time history records
- Functions vs time or function vs function displays
- Generation of response spectrum curves for any joint acceleration component
- Results can be combined with other loads for enveloping or step by step steel and concrete design

#### Bridge Analysis

- Moving load analysis
- Generation of influence lines and forces envelopes
- AASHTO vehicle loads
- User-defined truck, lane and train loads
- Determination of maximum and minimum displacements and reactions
- Capable of handing complex lane geometries
- Automatically calculates all possible permutations of traffic loads
- Provides correspondence between response components
- Results can be combined with other loads for enveloping or corresponding components for steel and concrete design



BRIDGE ANALYSIS





FORCE - DEFORMATION RELATIONSHIPS



ENERGY VS. TIME DISPLAYS

PUSHOVER ANALYSIS

# STATIC PUSHOVER BASE ISOLATORS VISCOUS DAMPERS STRUCTURAL POUNDING

SAP2000/NL-PUSH NONLINEAR ELEMENTS

NONLINEAR

SAP2000 Nonlinear extends the capabilities of the PLUS version to include nonlinear analysis options

#### The Frame Plastic Hinge Element for use with Static Pushover Analysis

- Axial, flexural, shear and torsional hinge
- Axial load-biaxial moment interaction
- Multilinear behavior including softening
- P-delta option

## Pushover Analysis Option

- Static pushover analysis starting from gravity loads
- Force or displacement control
- User-defined lateral load patterns
- Effective damping computations
- Capacity-spectrum computation
- Demand-spectrum comparisons

## The Nonlinear Link Element

- For use with the dynamic time history analysis option
- Link may be placed between any two joints or from joint to ground
- Viscous damper with nonlinear exponent on velocity term
- Gap (compression only) and Hook (tension only)
- Uniaxial plasticity (all 6 degrees of freedom)
- Base isolator with biaxial plasticity behavior
- Base isolator with friction and/or pendulum behavior
- AVI file option for creating real time displays of nonlinear deformation behavior
- Force versus deformation plots of nonlinear systems for energy dissipation studies

## The Wilson FNA Method

The SAP2000 nonlinear time history analysis uses the new numerical integration technique known as the Wilson FNA (Fast Nonlinear Analysis) Method. The procedure uses an iterative vector superposition algorithm that is extremely efficient for analyzing structures with predefined localized non linearities. The method has demonstrated significant reductions in processing times when compared with other nonlinear analysis methods.

PLAYING AVI FILE

# SAP2000®

SAP2000 STANDARD is fully integrated with Windows 95 and Windows NT, featuring a powerful graphical interface unmatched in ease-of-use, sophistication and productivity, and it includes: 2D and 3D Beam and Truss Element 3D Shell Element Spring Element P-Delta Analysis Option Steel and Concrete Design Static and Dynamic Response Spectrum Analysis 1500 Joint Capacity

SAP2000 PLUS extends the capabilities of the standard version with unlimited capacity and additional analytical capabilities including: PLANE Element ASOLID Element SOLID Element Dynamic Time History Analysis Bridge Analysis

SAP2000 NONLINEAR extends the capabilities of the PLUS version to

include nonlinear analysis options: Frame Plastic Hinge Element Nonlinear Link Element Wilson FNA Method Pushover Analysis

ALSO INCLUDED ...

Three Dimensional Dynamic Analysis of Structures" a CSI publication authored by Professor E.L. Wilson, Professor Emeritus, University of California, Berkeley The book places an emphasis on earthquake engineering and details some of the numerical methods upon which SAP2000 is based. Includes details of the Wilson FNA method.

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