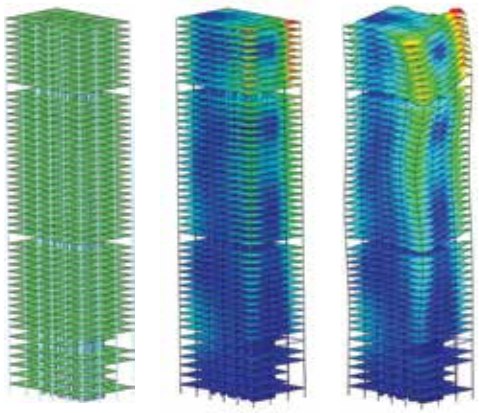
DIANA

SOLUTIONS FOR EARTHQUAKE ENGINEERING



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EARTHQUAKE ENGINEERING SOLUTIONS

With their enormous power, earthquakes can cause substantial disaster to densely populated areas. Often the earthquake is accompanied by water impact loadings resulting from tsunami, collapse of neighbouring structures and liquefaction of ground, or fire.

Today, new structures in earthquake sensitive areas are designed to sustain earthquakes without danger of damage or collapse.

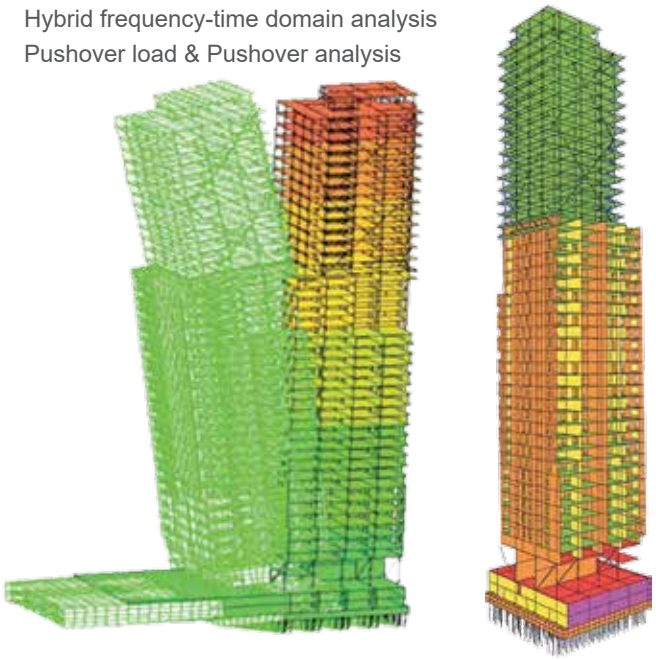
But if the condition of the structure has been unidentifiably changed, eg. by damage to the structure, deterioration of materials or altered loading, then the effect on earthquake resistance may be significantly altered.

For many non-standard structures, a proper earthquake design requires a dynamic finite element analysis. For simple assessment, a linear analysis in frequency domain may be sufficient. However, for other applications, the full nonlinear characteristics of possible failure mechanisms and interaction of the structure with ground and environment need to be considered in a nonlinear time stepping analysis.

DIANA offers solutions for both simple linear dynamic analysis, which can be applied for the design of structures, and also full nonlinear dynamic analysis taking into account the loading history of the structure.

Types of Earthquake Analysis

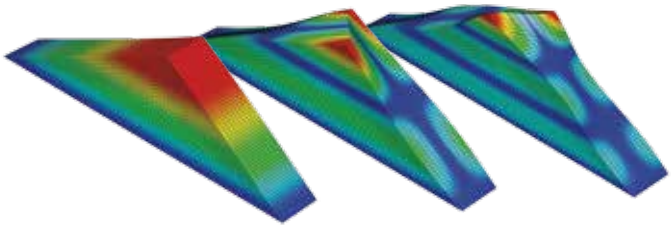
- Linear transient analysis with different time integration schemes
- Direct frequency response analysis
- Modal response analysis & Spectral response analysis
- Nonlinear transient analysis with different time integration schemes
- Hybrid frequency-time domain analysis
- Pushover load & Pushover analysis



Eigenvalue analysis of a multi-storey building

Fluid-structure Interaction

All dynamic analysis procedures can be used in combination with fluid-structure interaction effects. At a fluid-structure interface a full coupled acceleration-pressure matrix is calculated for normal displacements on the interface. This interaction matrix accounts for effect of fluid dynamics to the structure in the structural analysis. Frequency dependent effects, e.g. fluid compressibility and boundary damping, can be defined with a range of analysis types.



3D eigenvalue analysis of a dam section

Element Types

All structural element types can be used in all available dynamic analysis procedures

Mass & Damping

- Mass density per unit volume
- Reduced mass density for dead weight correction
- Distributed mass elements with damping properties for defining non-reflection boundaries
- Consistent and lumped concentrated translational masses and rotational inertia
- Viscous or Rayleigh damping
- Structural or hysteretic damping
- Continuous damping via discrete spring/dashpot elements

Specific Loads & Initial Conditions

- Base excitations, single and multi-directional
- Prescribed nodal accelerations and displacements
- Time-load diagrams, e.g. accelerograms
- Frequency-load diagrams, e.g. spectra
- Specified initial displacement and/or velocity fields
- Initial stresses

Crack analysis of a historic construction under a dynamic loading

Analysis Types

Specific analysis functions

- Possibility to add stress-stiffness to linear elastic stiffness matrix in frequency analysis
- For direct Frequency Response output of complex results and/or amplitude-phase results
- Lanczos Eigensolver with various decomposition techniques, shifting option, and automatic ordering
- Spectral Response with ABS, SRSS, and CQC output
- Euler backward, Newmark, Wilson-theta, Hilber-Hughes-Taylor, and Runge-Kutta time-integration

Nonlinear materials for earthquake analysis

- Total-strain cracking models
- Modified Maekawa-Fukuura concrete model (Multi-Axial Damage and Cracked Concrete models)
- Monti-Nuti, Menegotto-Pinto and Dodd-Restreppo-steel models
- Modified 2-surface steel model
- Hardin-Drnevich and Ramberg-Osgood simple soil models
- UBC, Bowl, Nishi and Towhata-Iai liquefaction models
- Engineering liquefaction analysis

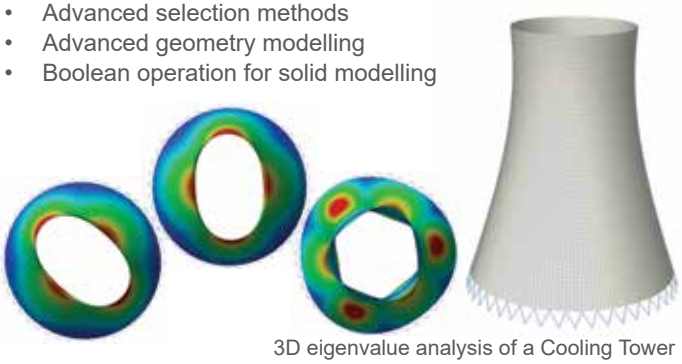
General Product Functionality

Element types

- Truss
- Timoshenko, Bernoulli, and Mindlin beam
- Plane stress and plane strain
- Complete/general plane strain
- Axisymmetric
- Plate bending, flat, curved and layered shells
- Solid, composed (line/surface), interface and contact
- Discrete spring/dashpot
- Base spring and bounding
- Point mass/damping
- Embedded reinforcements
- Flow
- Embedded pile
- Boundary surface
- Perfectly Matched Layers (PML)

Preprocessing

- CAD like geometry modelling functionality
- Parasolid built-in tools
- Import CAD/Revit file formats
- Python scripting
- Advanced selection methods
- Advanced geometry modelling
- Boolean operation for solid modelling



3D eigenvalue analysis of a Cooling Tower

- Auto clash detection
- Geometry check and repair tools
- Practical mouse snapping
- Auto-, map- and protrude-mesh methods
- Hybrid mesher
- Mesh manipulation and check functionality
- Loads and boundaries applicable both on geometry or mesh
- Function based definition of loads and boundary conditions
- MS-Excel compatible tables

Postprocessing

- Contour and vector plots
- Iso-surface, slice, clipping and partition plot
- Diagram and vector plot
- Results extraction to MS-Excel compatible table
- Screen-shots in different picture formats
- Result animation
- Automatic report generation

Solution procedures

- Automatic solver selection
- Out-of-core direct equation solvers
- Nonlinear equation solvers
- Automatic substructuring
- Eigenvalue analysis
- Newton-Raphson, Quasi-Newton, Linear and Constant stiffness iterative procedures
- Load and displacement control incremental procedures
- Arc length control incremental procedure
- Adaptive load and time increments (auto load step option)
- Automatic incremental loading
- Direct, iterative and eigen solvers with parallel processing
- Updated and total Lagrange geometrical nonlinear formulation

Services

Support & training

Successful finite element modelling requires sound understanding of the background theory with good engineering judgment. We at DIANA FEA BV together with our partners are dedicated to provide the highest level of service for DIANA:

- Personalised hotline and Email support by highly qualified staff
- Customised training solutions
- Regular training courses
- Extensive technical and theoretical manuals
- Online training sessions

Analysis consultancy

DIANA FEA BV offers to carry out analysis consultancy projects on behalf of their clients which includes the analysis with DIANA and the interpretation of results

Software services

DIANA FEA BV Consultants and software development team can provide customised solutions for your engineering problems:

- Specialised software with dedicated GUI
- New modelling capabilities development and implementation
- Integration with customer software

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