GTS NX

Geo-Technical analysis System New eXperience

WHY GTS NX

New Experience of
Geo-Technical Analysis System

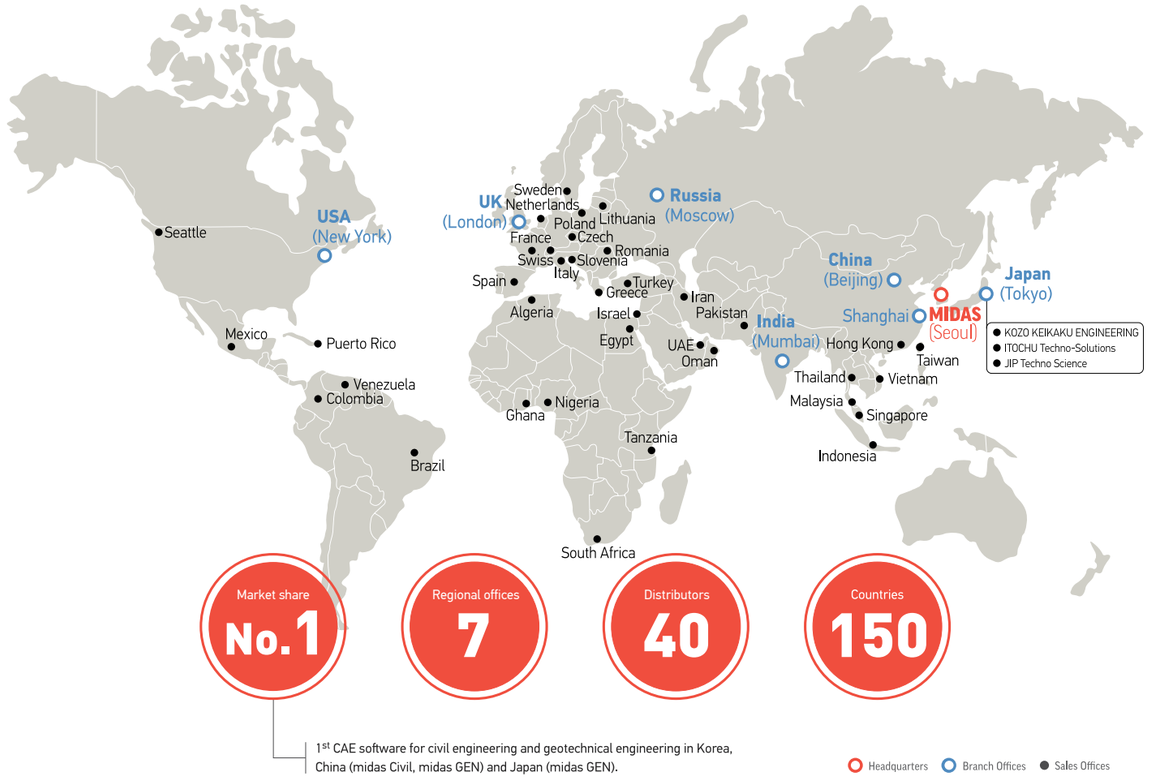
MIDAS

Integrated Solver Optimized for the next generation 64-bit platform

Finite Element Solutions for Geotechnical Engineering

http://www.midasGTSNX.com

GLOBAL LEADER IN PROVIDING ENGINEERING SOLUTIONS & SERVICES

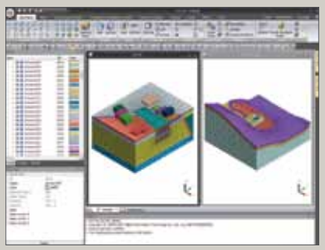


MIDAS Geotechnical Software

Next generation solutions using the latest technologies and optimized solvers.

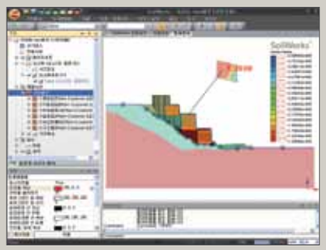
GTS NX

Integrated solution for 2D / 3D geotechnical analysis



SoilWorks

Geotechnical Solutions for Practical Design



A NEW EXPERIENCE WITH GTS NX

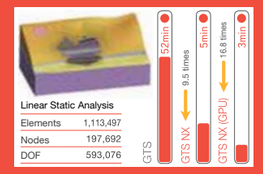
New eXperience of Geo-Technical analysis System

GTS NX
Geo-Technical analysis System New eXperience

01

Next generation 64-bit geotechnical FE software

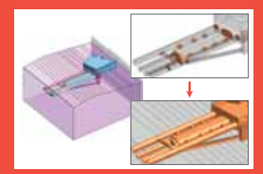
- Analysis time up to 16x faster than the previous versions
- Large scale modeling without limitations
- Complex 3D modeling capacity / speed enhancement
- Mesh generation quality / speed enhancement
- Civil, Gen model interface



02

3D modeling automation tools

- Interface auto-creation
- Imprint auto-generation
- Blasting / train load wizard
- 3D strata auto-generation



03

Practical boundary conditions

- Seepage force automatically considered based on water level difference
- 3D water level auto-generation
- Seepage analysis considering rainfall
- Static load – dynamic load automatic conversion
- Dynamic analysis considering water level and self-weight

04

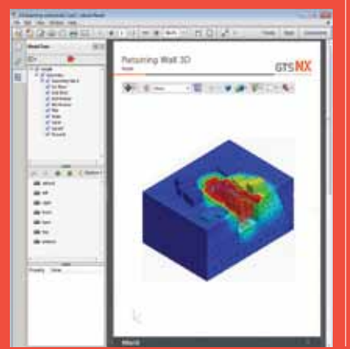
Additional Advanced Analysis

- Nonlinear time history analysis
- Stress – seepage fully coupled analysis
- Nonlinear time history – SRM coupled analysis
- Seepage-Stress and Seepage-Slope fully coupled analysis

05

Result Analysis / Output Enhancement

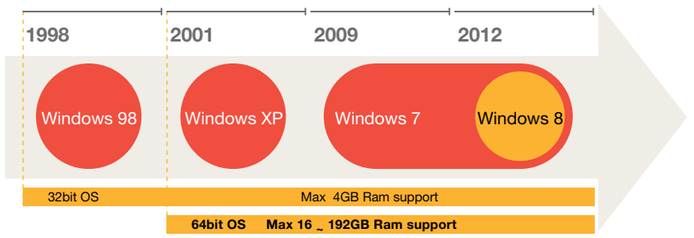
- 3D PDF Report for model and analysis results
- Text output for selected elements and result items
- For vibration and blasting analysis, noise can be measured using the analysis result



Framework

Next generation 64-bit platform

1 Full support for 64-bit OS environment



GTS NX 64bit

Enhanced geometry modeling capacity / speed

Superior Analysis Speed

Enhanced analysis capability for large scale models

2 Geometry modeling capacity / speed enhancement

- New 64-bit framework
- Optimized graphics engine for large scale models
  - Less memory usage, faster results & file processing speed with no volume limitation
  - Enhanced 3D geometry modeling capacity / speed
  - No failure / iterative calculation for complex models

∗ FPS (Frames Per Second): number of images per second ex) digital TV → 30 FPS, Movies → 24 FPS

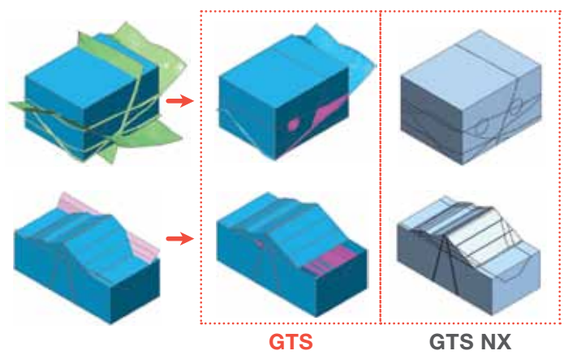
Memory and calculation speed

Version	Memory	FPS
GTS	803MB	14
GTS NX	409MB	25

Geometry modeling capacity / speed comparison

Version	modeling result
GTS	Failed (39 sec) 5 solids generated
GTS NX	Completed (22 sec)

Version	modeling result
GTS	Failed (20 sec) incomplete solids generated
GTS NX	Completed (5 sec)



GTS NX | 1. Presentation of the next generation platform

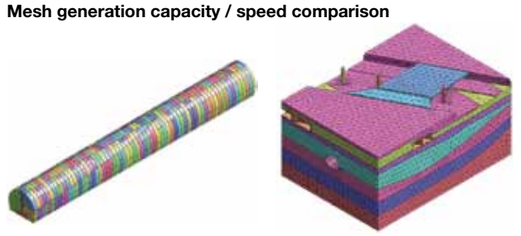
Framework

Next generation 64-bit platform

3 Faster analysis speed

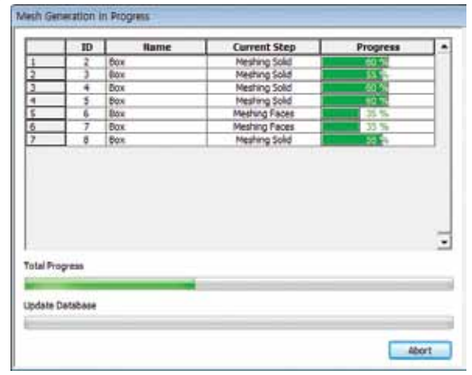
- Enhanced mesh generation speed
  - Multi-CPU supported for mesh generation
  - Significant enhancement in mesh generation speed of large scale models
  - High quality mesh generation for complex geometry models
  - Meshing progress check and erroneous mesh auto-detection

Mesh generation capacity / speed comparison



Version	64 solids	307 solids
GTS	58 sec (2 solids failed)	326 sec (100% success)
GTS NX	9 sec (Completed 100%)	22 sec (Completed 100%)

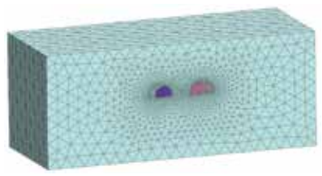
Multi-Thread mesh generation supported



4 Enhanced analysis capability for large scale models

- Faster analysis speed through 64-bit integrated solver
  - Better analysis result display through optimized interface
  - Enhanced iterative analysis for changes in boundary conditions

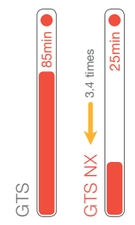
Analysis and result output

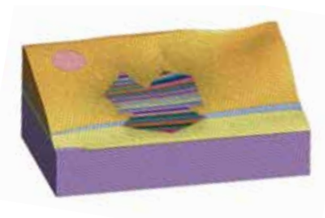


Elements	394,986
Nodes	71,816
DOF	215,448

Number of construction stages: 25

Version	Analysis time
GTS	60 min (+25 min)
GTS NX	25 min (+54 sec)

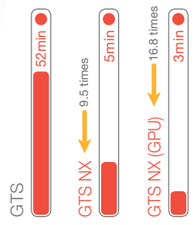




Elements	1,113,497
Nodes	197,692
DOF	593,076

Linear static analysis

Version	Analysis time
GTS	29 min (+23 min)
GTS NX	5 min (+40 sec)
GTS NX (GPU)	2 min (+40 sec)



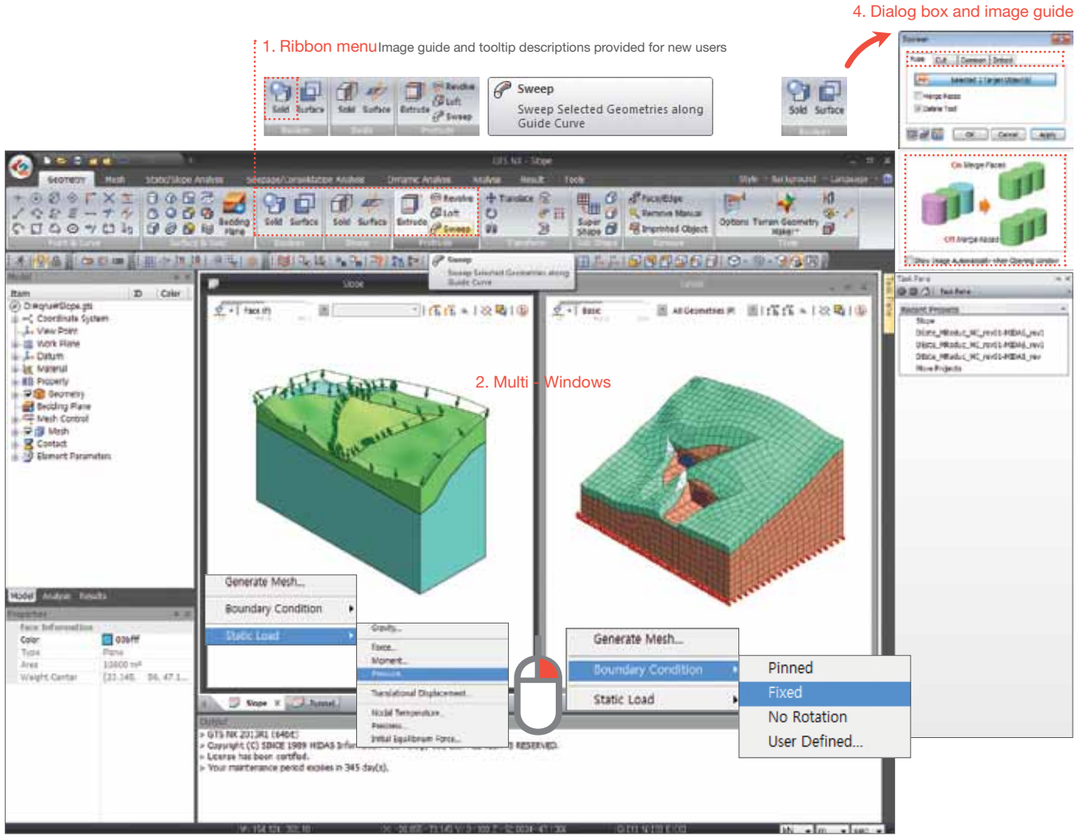
∗ (+: time to read model information after starting analysis)

Framework

User Oriented Software Interface

5 Intuitive menu structure

1. Ribbon menu
   - Analogous functions are grouped together
   - Menu organized to streamline modeling workflow
   - Descriptions of functions through Tooltip
2. Different model files can be displayed simultaneously through the **Multi-Window** feature.
3. Minimized mouse movement and usage
   - Loading / boundary condition auto-generation through right click
4. Guide for novice users
   - In-depth descriptions of features and options



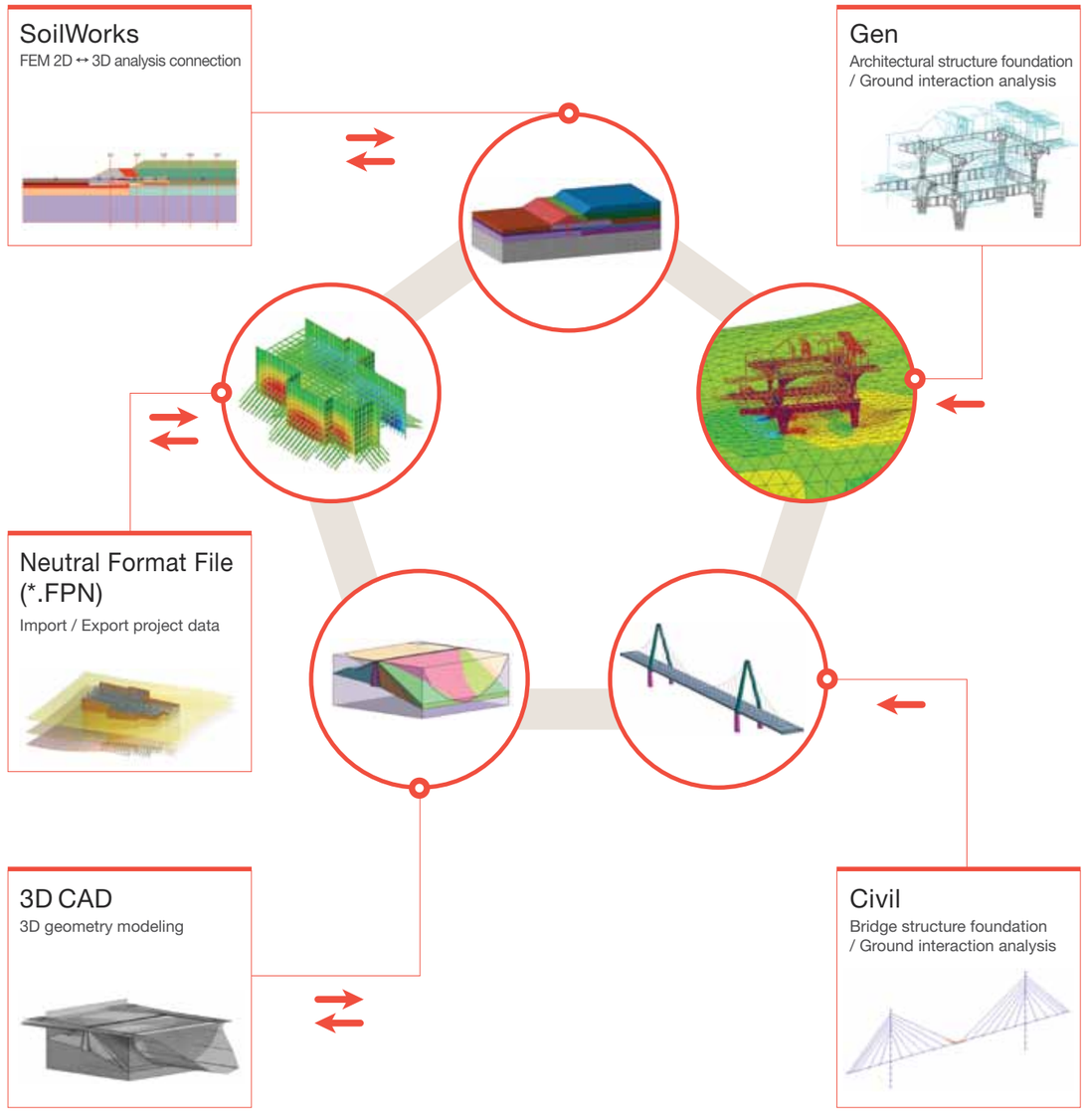
3. Right click – loading and boundary conditions auto-generation

Framework

Data exchange with other software

6 Full compatibility with other software

- MIDAS project data directly imported from Gen, Civil & SoilWorks
- CAD file import / export capacity
  DXF, DWG, Parasolid & 2D / 3D CAD geometric models supported
- Civil / Gen cross-sections transformed into GTS NX solids
  Architecture / civil engineering structure detailed modeling interface



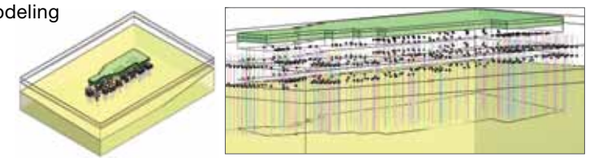
Modeling Wizard

Geometric Model Auto-Generation

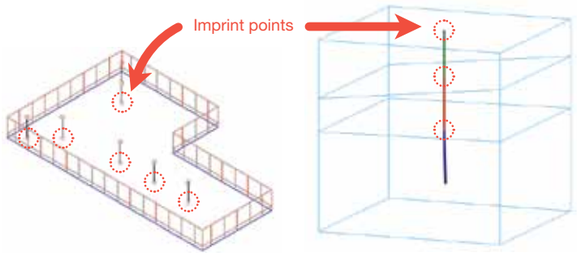
1 Geometry modeling / modification automation

A simple process of detecting and auto-correcting modeling errors for users of all experience levels

- Imprint auto-generation
  - Line auto-division and line – solid auto-connection
  - Simplified modeling process for structural members penetrating into ground strata
- Model simplification
  - Small faces and lines detected / deleted and merged



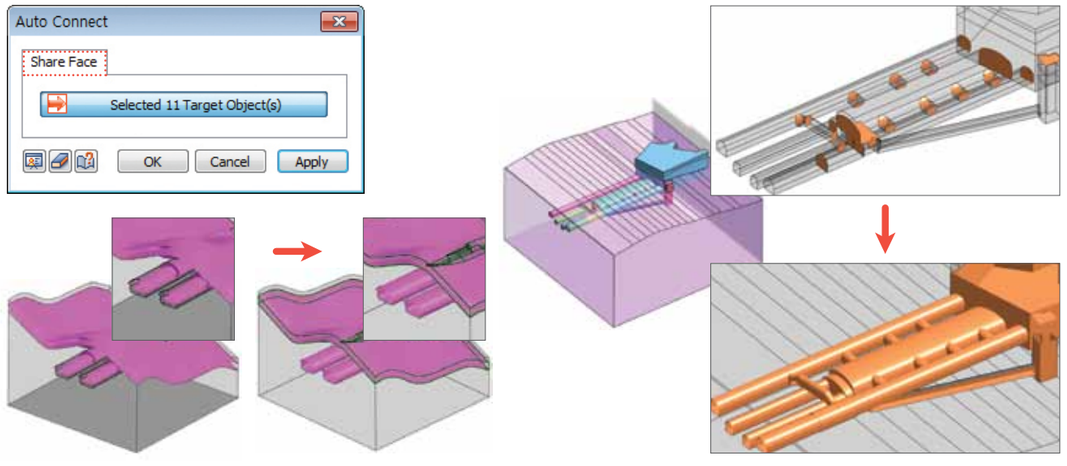
Geometric model simplification



Auto-Imprint

- 3D solid interface auto-generation
  - Shared faces between adjacent solids automatically generated / duplicated shapes auto-deleted
  - Significantly reduced 3D modeling time through such features as modeling mistake prevention / division / moving / deletion

Shared face auto-generation



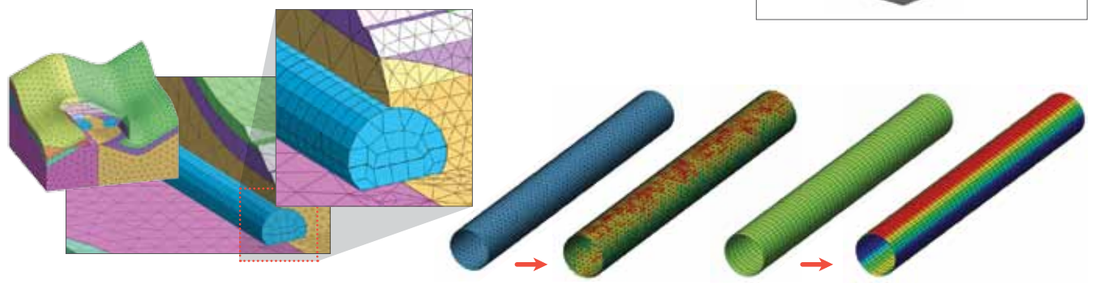
Modeling Wizard

Optimization to Minimize Number of Elements

2 Enhanced mesh generation and quality

- High quality hybrid mesh auto-generation
  - Hexahedral elements can be used in complex geometries for more accurate results.
  - Unified results on structural members can be checked without changing element coordinate system.
- Bonded Contact auto-generation
  - Adjacent elements having no shared nodes can be detected and connected automatically.
  - FEM analysis error prevention
  - Modeling accomplished with a minimum number of elements resulting in even higher accuracy in results

Hybrid Element Composition

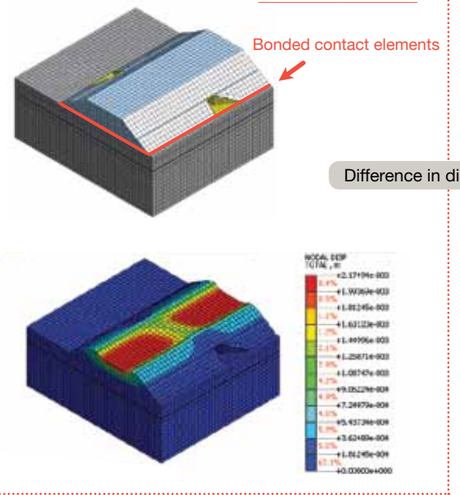


Hybrid element + bonded contact auto-generation **Triangle face elements** **Hybrid elements**

Hybrid element + contact result comparison

Hybrid mesh + bonded contact Model

Elements	34,853
Nodes	32,684



GTS NX

Shared nodes Model

Elements	177,142
Nodes	32,476

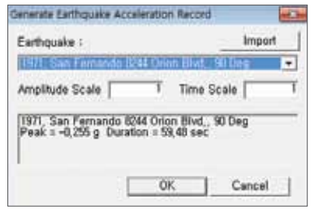
GTS

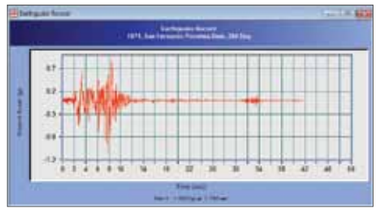
Modeling Wizard

Complex Load Case Auto-Generation

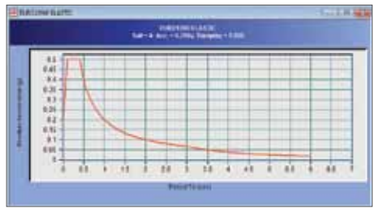
3 Seismic data auto-generation

- Historical seismic database
- Response spectrum generation based on ground level





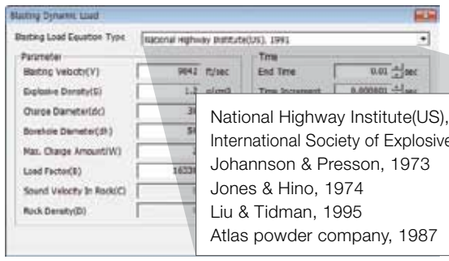
Earthquake record



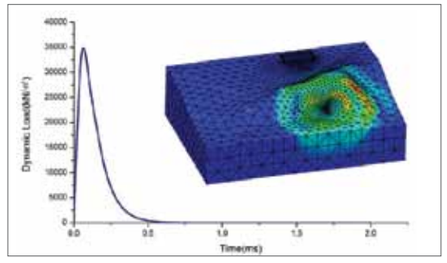
Design response spectra

4 Blast dynamic load auto-generation

- Impluse blast load data auto-generation
  - Tools are provided to automatically calculate blast loading.

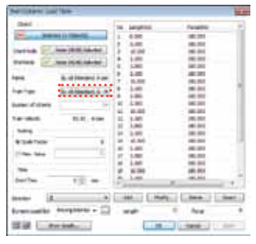


National Highway Institute(US), 1991
International Society of Explosive Engineers, 2000
Johannson & Presson, 1973
Jones & Hino, 1974
Liu & Tidman, 1995
Atlas powder company, 1987

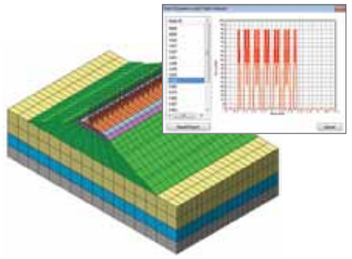


5 Train dynamic load table

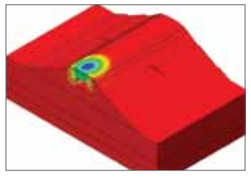
- Train moving load auto-generation
  - User defined train load creation
- Dynamic load automatically applied to railroad



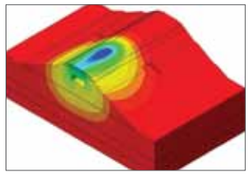
Train dynamic load



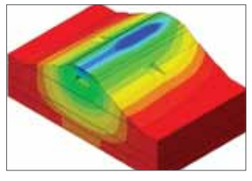
Train dynamic load calculation & auto application



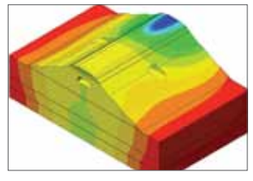
T = 0.2 sec



T = 0.7 sec



T = 1.7 sec



T = 2.0 sec

GTS NX | 2. Modeling features and Wizards

Modeling Wizard

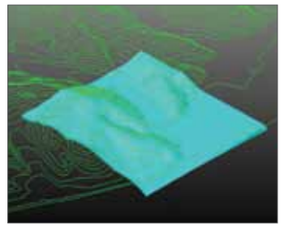
Efficient Modeling with Automation Tools

6 Ground auto-generation wizard

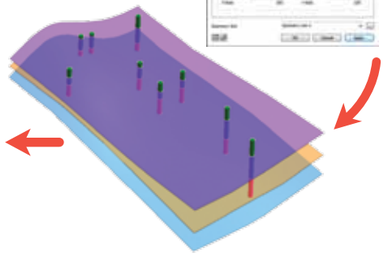
- 3D ground surface generation from digital map
- 3D ground strata generation using boring hole wizard

Digital map – ground surface generation wizard

Boring data – Bedding Plane wizard

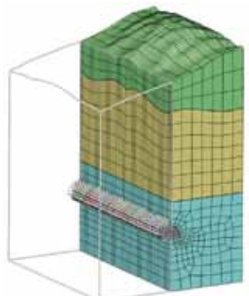


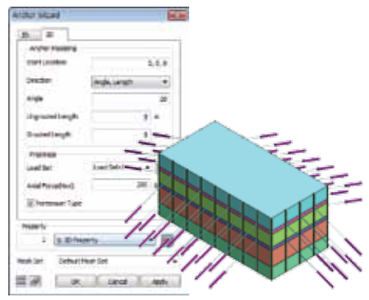
Boring hole data



- Standardized ground / structures modeling automation wizard
  - 3D tunnel modeling wizard
  - 2D / 3D anchor modeling wizard

Tunnel wizard





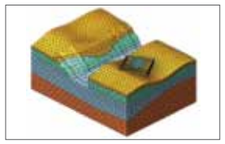
Anchor wizard

Analysis Method

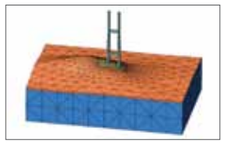
Extended Application Areas

1 **Expanded application areas attributed to expanded analysis methods**

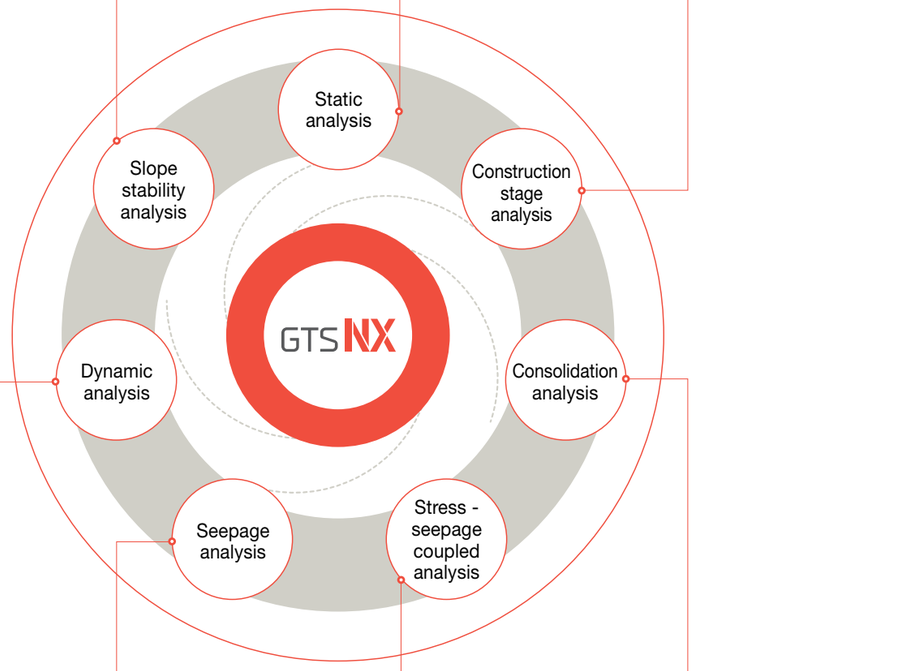
Strength Reduction Method (SRM)
Stress Analysis Method (SAM)
Nonlinear time history - SRM coupled analysis



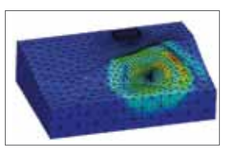
Linear static
Nonlinear static



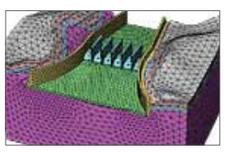
Stress analysis (drained, undrained)
Seepage construction stage
Stress - seepage - slope coupled
Consolidation construction stage
Stress – seepage fully coupled



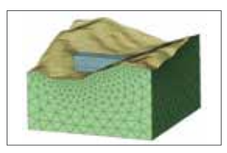
Eigenvalue / 1D free field
Response spectrum
Time history (linear / **nonlinear**)
2D equivalent linear analysis



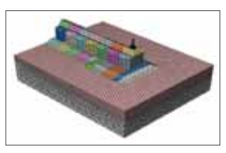
Steady state flow
Transient seepage analysis



Fully coupled analysis
Construction stage



Consolidation
Construction stage



GTS NX | 3. Analysis Methods and Options

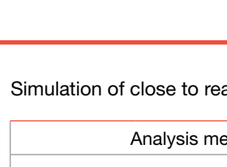
Analysis Method

Extended Application Areas

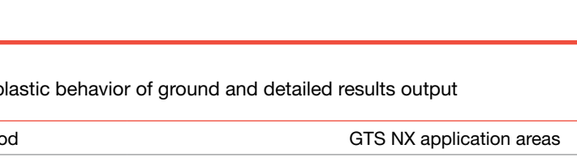
Simulation of close to real plastic behavior of ground and detailed results output

Analysis method		GTS NX application areas
Linear / nonlinear + construction stage analysis		Drained / **undrained (more options added)** Unsaturated properties of soils can be considered. **Seepage force is considered automatically based on difference in water levels.**
Seepage	Transient flow analysis	Ground surface saturation and rise in water level due to rainfall
Fully coupled analysis / Consolidation analysis		Convergence enhancement of Euler Method – **superior stability in stress convergence** without influence from load steps **Fully coupled seepage analysis considering unsaturated properties** **Consideration of water level fluctuations following pore water pressure** MCC material model considered for embankment
Slope stability analysis	Strength reduction method (SRM)	Stable arc-length convergence method **Addition of applicable material models (MC, MMC, DP)**
Dynamic analysis	Linear / nonlinear time history analysis	**Water level and self weight consideration** **Addition of nonlinear time history analysis method** Enhanced structural seismic safety investigation
Coupled analysis	Nonlinear time history + SRM	Slope stability check in high seismic risk areas

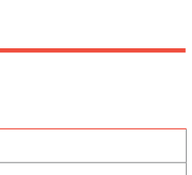
GTS



Linear dynamic analysis results

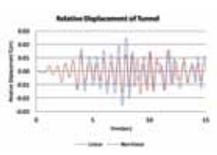


Non-consideration of seepage force

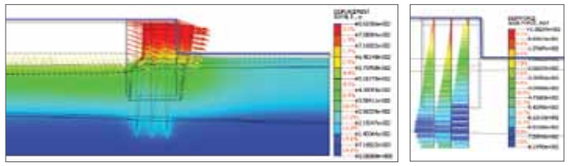


3D slope failure surface

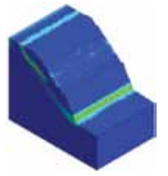
GTS NX



Nonlinear dynamic analysis result comparison



Consideration of seepage force + automatic water pressure



3D failure surface (+ resolution of safety factor)

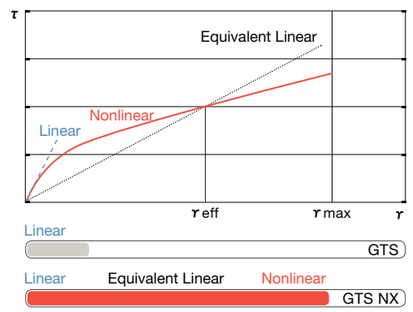
Analysis Method

Enhancement of Dynamic Analysis Capabilities

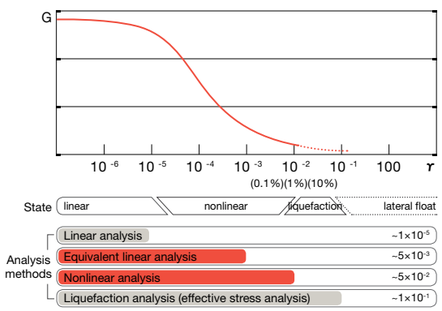
2 1D / 2D / 3D model ~ nonlinear dynamic analysis

Dynamic analysis method in GTS NX

Linear dynamic analysis	Efficient analysis method for most cases when ground deformation is very small
Equivalent linear analysis	By applying the frequency analysis method using the secant modulus of elasticity corresponding to the effective shear strain, the analysis speed can be optimized. When the ground is stiff or the magnitude of earthquake acceleration is small, reasonable results can be expected due to insignificant effects of nonlinear behavior of the ground.
Nonlinear dynamic analysis	Pore water pressure can be generated and considered in time history analysis method to simulate nonlinear characteristics of ground. When ground deformation is especially large or if resonance occurs, nonlinear analysis needs to be carried out.

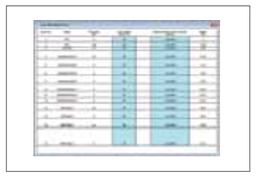


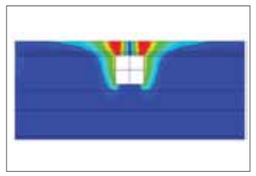
Linear – Equivalent linear – Nonlinear analysis Stress – strain relationship

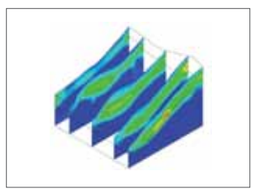


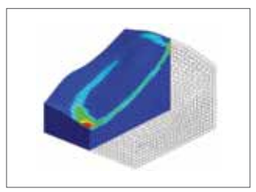
Strain ranges for different dynamic analysis methods

- 2D equivalent linear analysis
  - Continued reflection of shear strain following vibration load scale
  - **Detailed evaluation of underground structure's seismicity**
- 3D nonlinear dynamic analysis
  - Ground – structure interaction directly considered in seismic performance
  - Detailed evaluation of the performance of nuclear facility / Plant / civil structures
- Nonlinear time history + strength reduction method (SRM) coupled analysis
  - Slope stability subject to an earthquake
  - Large scale landslide risk assessment
  - Landslides / Slope disaster prevention / safety assessment









To be implemented in 2014

Liquefaction material model
- Seismic evaluation of soft soil
- Coupled nonlinear dynamic analysis
- Earthquake, liquefaction evaluation of coastal structures and power plants

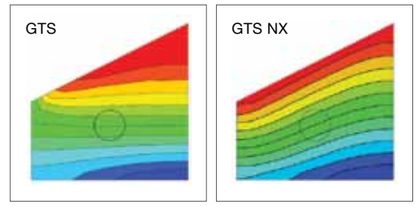
Geometrical nonlinearity
- Real deformation behavior application – safety investigations of large deformations
- Large scale slopes, on-shore embankment on soft soil

Analysis Options

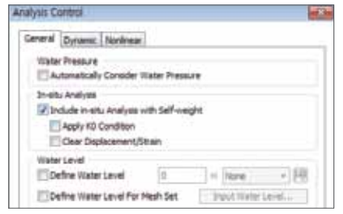
Enhancement of Analysis Options

1 Analysis option automation

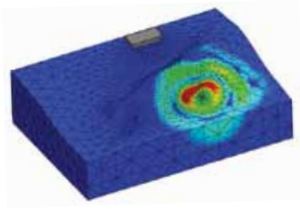
- Addition of Ko linear analysis
  - Calculation of ground initial stress corresponding to a specific Ko value
  - Construction stage analysis coupled with ground initial stress
  - Ability to consider initial conditions and stress in dynamic analysis
- Water pressure auto-consideration option
  - **Automatic application of water pressure** using the value of free boundary face (line) water level height or pore water pressure calculated from seepage analysis results
  - Possible to analyze stress results based on water level position or seepage analysis results



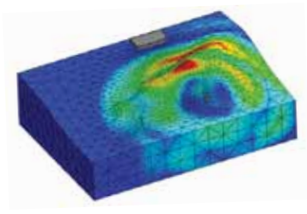
Initial horizontal stress in ground as per Ko value



Linear analysis considering Ko / self weight



Blast dynamic analysis results

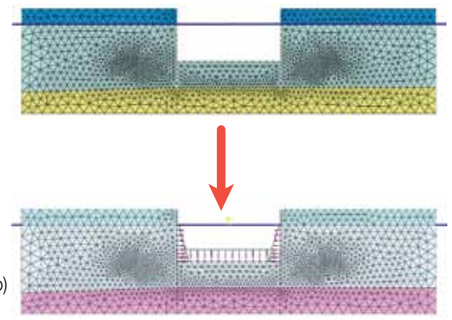


Blast dynamic analysis results considering self weight

A wider range of analysis types which consider water level conditions

Ability to consider water level in all range of Linear / Nonlinear, Static / Dynamic analyses
Seepage strength automatically applied based on water level difference.
Safety assesment for off shore structures under dynamic load (blasting, wave, earthquake)

- Addition of partial saturation consideration option
  - Calculation of effective stress based on the ground saturation level
  - Automatic consideration of ground unit weight and pore water pressure based on ground saturation level
  - Consideration of change in permeability coefficient change based on the partial saturation and void ratio
  - Addition of maximum pore water pressure restriction option
  - Consideration of change in water level due to consolidation subsidence
- Expanded scope of undrained analysis option
  - Undrained parameter (undrained stiffness, strength, Poisson's ratio) consideration
  - Ground / structure short term / long term stability investigation



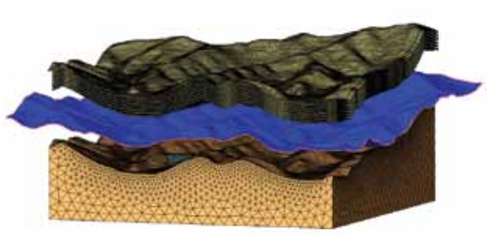
Automatic application of water pressure on excavated face below the water level

Analysis Options

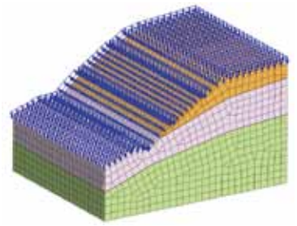
Enhanced Analysis Settings to Simulate In-Situ Conditions

2 Specific boundary conditions for various analysis types

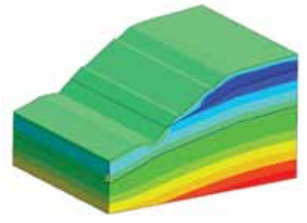
- Addition of 3D water level generation
  - A selected face in 3D space assigned as a water level
  - Automatic water pressure calculated as per water level height
- Addition of seepage analysis options
  - Surface flux: **addition of rainfall option**
  - Addition of boundary reinvestigation option: **automatic water level detection** & overflow shape simulation capacity



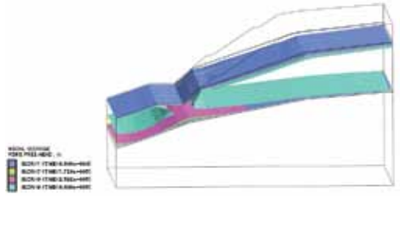
3D water level automatic generation



Rainfall intensity input



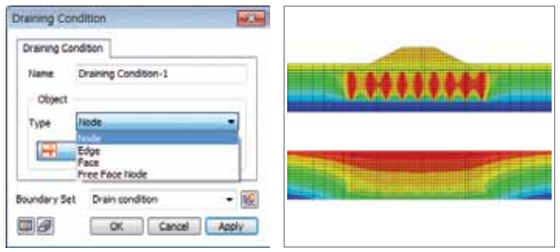
Generation of initial ground surface saturation zones



Change in water level surface with the time of rainfall

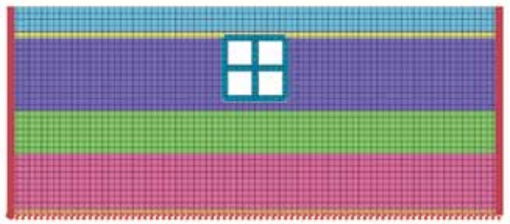
Rainfall option in seepage analysis

- Enhancement for consolidation analysis option
  - Consolidation draining conditions & addition of unconsolidated elements
  - Consolidation analysis boundary conditions easily defined by selecting nodes / elements
- Auto-Definition of dynamic analysis boundary conditions
  - Elastic / viscous boundary auto-generation – spring stiffness auto-calculated
  - **Auto-generation of transmitting boundaries** on both sides of the model



Suction drain method

- Static load – dynamic load auto-conversion
  - Generated static load converted to mass components by directions
  - Concentrated load, beam load & pressure load (including water pressure) can be used in dynamic analysis



Dynamic analysis (SSI) boundary condition auto-generation

Static load – dynamic load conversion

Analysis Options

Simulation of Customized Construction Stages

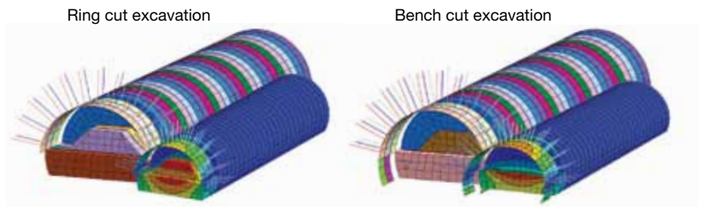
3 Define multiple construction stages

- Construction stage analysis settings (> = 2 stages)
  - Parametric multiple analyses in a single file for material / property / excavation method / construction method
  - No need to create multiple models for different conditions
  - Optimal construction method and construction sequence extracted

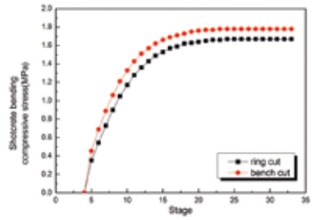
Multiple construction stage analysis

Ring cut excavation

Bench cut excavation

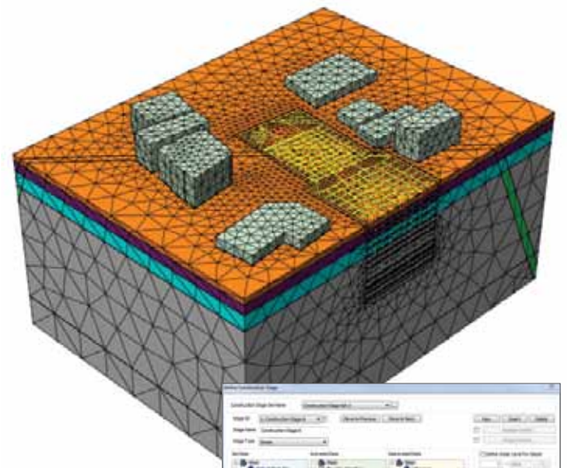


Comparison of results between different excavation methods in the same model file



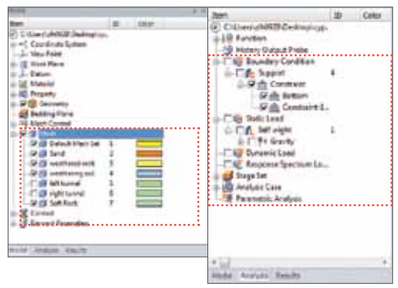
Comparison of bending compressive stresses in shotcrete between different excavation methods

- Construction stage auto-generation
  - Construction stages created by showing / hiding model parts on the screen

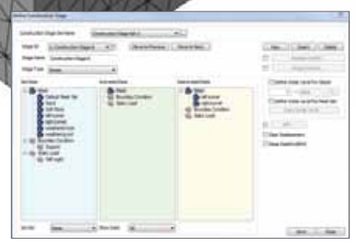


Show / hide mesh sets

Show / hide loading and boundary conditions



Show / hide status → activate / deactivate model data



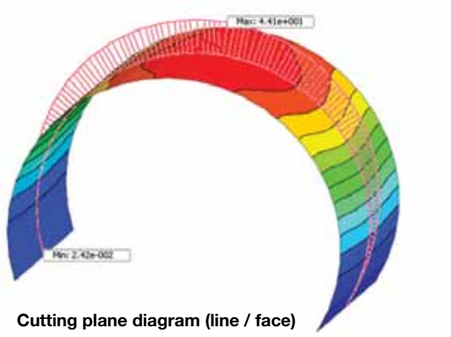
Construction stages defined based on the information shown on the display

Post & Output

Analysis Results with Easy Filtering and Extraction

1 New features for extracting analysis results

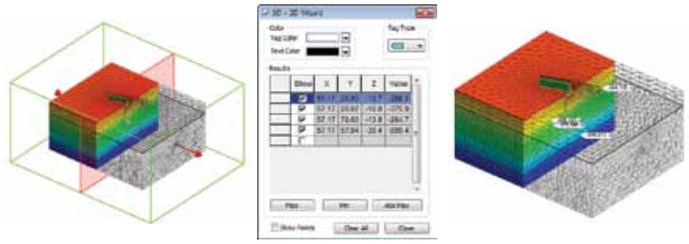
- On - curve diagram (Cutting diagram)
  - Diagram output for any result on cutting-line / cutting-plane
  - Diagram output for structural members / member forces (axial, shear & moment)
  - Diagram output for deformation / stress corresponding to 3D cutting-planes
- Image / graph automatic output and save for analysis results
  - Image save for any analysis result – fixed view supported
  - Table / graph output for any analysis result
  - Export to excel



Cutting plane diagram (line / face)

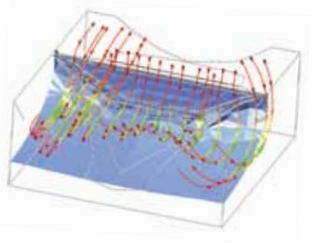
Result image / graph save

- 3D → 2D Wizard
  - 2D cross sectional results automatically generated & reported from 3D analysis results
  - Ability to check results on critical cross-sections from 3D analysis



3D → 2D result wizard

- Real-time animation result output
  - Time interval, construction stage analysis results can be saved in video format



3D flow animation output

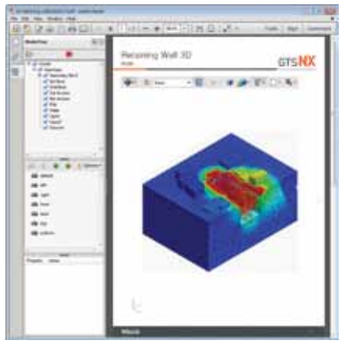
GTS NX | 5. Post process and results output

Post & Output

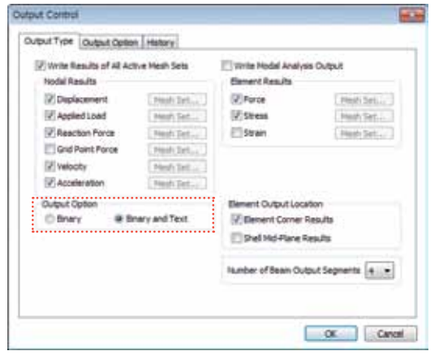
Analysis Report Generation

2 New Features for Analysis Report

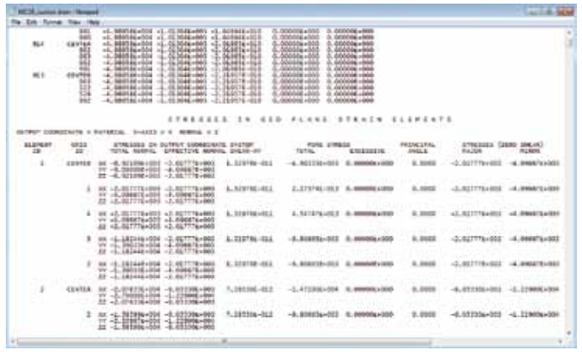
- 3D PDF report for model and analysis results
  - 3D model / analysis results viewed and operated in a PDF file
  - 3D model and analysis results checked in a PDF file
- Text Output for analysis results
  - Analysis result text output
- Addition of result output control
  - Result output type can be specified based on analysis cases and construction stages
  - Ability to export selected results on selected elements (nodes)
  - Time saved for result checking and data storage space for result files



3D PDF results output



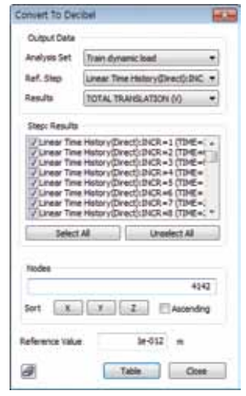
Output Control



Text Output

- Dynamic analysis results converted to decibel
  - Displacement / velocity / acceleration results automatically converted to decibel
  - Noise level gaged using the results of vibration and blast analysis

$$N(dB) = 20\log_{10}\left(\frac{X}{X_{ref}}\right)$$



Displacement / Velocity / acceleration – decibel conversion Decibel Reference Levels (ISO R 1683)

	Quantity	Definition	Ref. level
Amplitude Ratio	Vibratory Acc. Level	$L_a = 20 \log10 (a/a_0)$ dB	$a_0 = 10^{-6}$ m/s^2
	Vibratory Vel. Level	$L_v = 20 \log10 (v/v_0)$ dB	$v_0 = 10^{-9}$ m/s
	Vibratory Dis. Level	$L_d = 20 \log10 (d/d_0)$ dB	$d_0 = 10^{-12}$ m