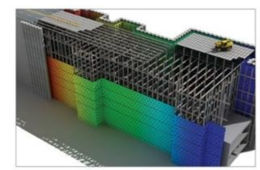
Release Notes

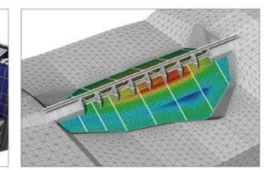
Release Date: June, 2017

Product Ver.: GTSNX 2017(v1.1)

GTS NX

Geo-Technical analysis System New eXperience





Integrated Solver Optimized for the next generation 64-bit platform

Finite Element Solutions for Geotechnical Engineering

MIDAS

Enhancements

1. Analysis

2. Pre/Post Processing

1. Analysis

1.1 Auto Calculation of K_0 and K_0^{nc}

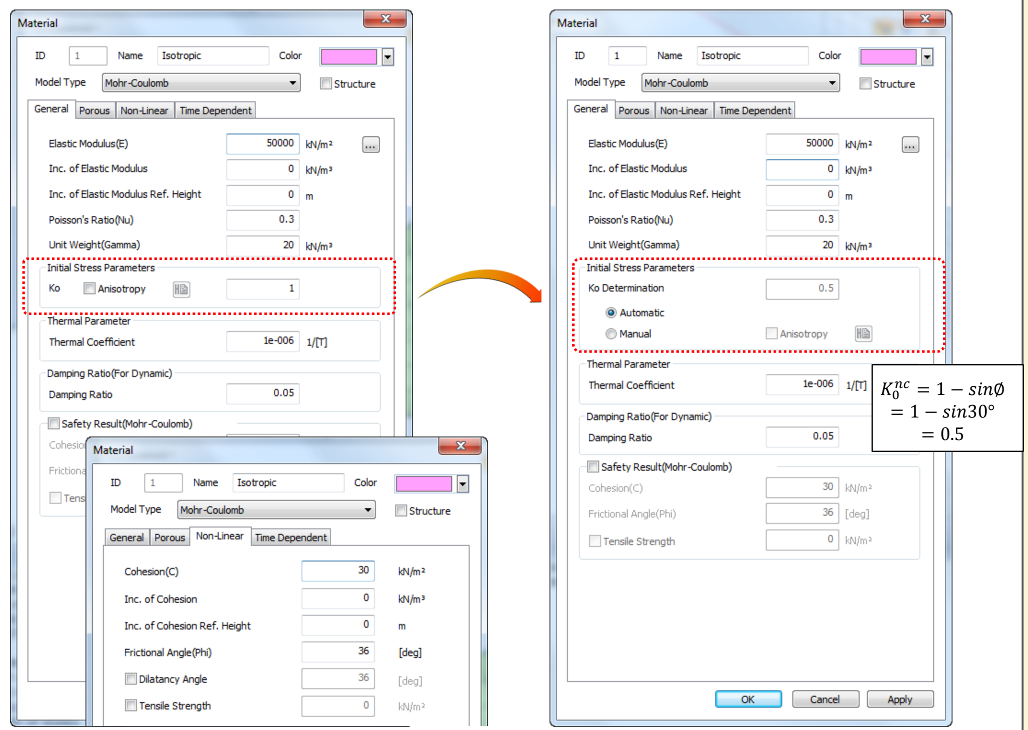
- Earth pressure coefficient K_0 can be calculated automatically based on the other input parameters such as the friction angle, overconsolidation ratio (OCR) and Poisson's ratio (v). (Manual input is also available)

※ In order to apply the K_0 for the calculation of initial stress of the ground, the user must check the K_0 condition option in analysis control dialog)

- **Material> Coordinate system / Function> Physical properties> General> Initial stress**

Material Constitutive Model	Automatic calculation of K_0 value
Mohr-Coulomb	$K_0^{nc} = 1 - sin\emptyset$ ※ Automatic calculation of K_0^{nc} by using frictional angle φ
Ducker-Prager	
Hyperbolic (Duncan-Chang)	
Modified Mohr-Coulomb	$K_0^{nc} = 1 - sin\emptyset$ ※ Automatic calculation of K_0^{nc} by using frictional angle φ $K_{0,x} = \frac{\sigma'^0_{xx}}{\sigma'^0_{yy}} = K_0^{nc} OCR \frac{\nu_{ur}}{1-\nu_{ur}}(OCR-1)$ ※ Calculates K_0 using K_0^{nc} and input OCR
Soft Soil	
Soft Soil Creep	
Hardening Soil (small strain stiffness)	
Generalized SCLAY 1S (MODS)	$K_{0,x} = \frac{\sigma'^0_{xx}}{\sigma'^0_{yy}} = K_0^{nc} OCR \frac{\nu_{ur}}{1-\nu_{ur}}(OCR-1)$ ※ *Manual estimation of* K_0^{nc} ※ Calculates K_0 using K_0^{nc}, OCR and v

[K_0 - automatic calculation]



[Auto calculation of K_0]

1. Analysis

1.2 UBC SAND: Liquefiable Area _ Modified UBC SAND Material

- An effective stress model for predicting liquefaction behavior of sand under seismic loading.
- GTSNX Liquefaction Model is extended to a full 3D implementation of the modified UBCSAND model using **implicit method.**

▪ ***Nonlinear Elastic:***

- Exponential function per effective pressure

$$G^e = K_G^e p_{ref}\left(\frac{p'+p_t}{p_{ref}}\right)^{ne}$$

▪ ***Plasticity / Shear***

- Yield function : Mohr – Coulomb
- Flow rule : Menetrey-Willam (non-associated)
- Hardening behavior : Hyperbolic hardening

$$\Delta\sin\phi_m = \frac{G^p}{p'}\Delta\kappa_s = K_G^p\left(\frac{p'}{p_{ref}}\right)^{np-1}\left\{1-\left(\frac{\sin\phi_m}{\sin\phi_p}\right)R_f\right\}^2\Delta\kappa_s$$

$$\Delta\kappa_s = \left|\Delta\varepsilon_1^p - \Delta\varepsilon_3^p\right|$$

▪ ***Plasticity / Compression (cap)***

- Yield function : Modified Mohr-Coulomb Cap

$$f_2 = \left(p+\Delta p\right)^2 + \alpha\left(\frac{q}{R_2(\theta)}\right)^2 - p_c^2 = 0$$

- Flow rule : Same with yield function (Associated flow)
- Hardening behavior : Hardening of allowable compression per volumetric strain

$$\Delta p_c = K_B^p p_{ref}\left(\frac{p'}{p_{ref}}\right)^{mp}\Delta\varepsilon_v^p$$

▪ ***Plasticity / Pressure cut-off***

- Yield function & Flow rule

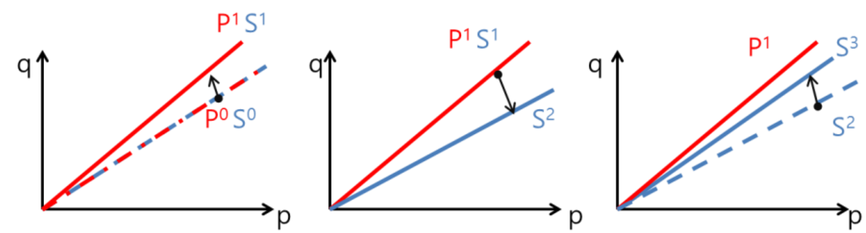
$$f_{pr} = p_{cut} - p'$$

- No Hardening behavior

▪ ***Cyclic loading behavior***

- Consider Shear, Plasticity function for primary and secondary yield surface respectively ➔ Check difference of hardening behavior
- Primary yield surface: In case that the current stress ratio (or mobilized friction angle) reach to the critical (MAX) state of the material
- Secondary yield surface: In case that the current stress ratio is smaller than the critical (MAX) state of the material according to the unloading/reloading conditions
- Secondary hardening (Soil Densification)

$$\Delta\sin\phi_m = K_{G,2}^p\left(\frac{p'}{p_{ref}}\right)^{np-1}\left\{1-\left(\frac{\sin\phi_m}{\sin\phi_p}\right)R_f\right\}^2\Delta\kappa_s,\quad K_{G,2}^p = K_G^p\left(4+\frac{n-1}{2}\right)F_{dens}$$



[Primary hardening] [Elastic unloading] [Secondary hardening]

2. Post Processing

1.3 UBC SAND: Liquefiable Area _ Input Parameter

- Additional parameters to simulate liquefaction
- Estimation of each parameter using Standard Penetration Test (SPT) - **$((N_1)_{60}$: Equivalent SPT blow count for clean sand.**

Parameter	Description	Reference
Pref	Reference Pressure	In-situ horizontal stress at mid-level of soil layer
Elastic (Power Law)		
K_G^e	Elastic shear modulus number	Dimensionless
ne	Elastic shear modulus exponent	Dimensionless
Plastic / Shear		
ϕ_p	Peak Friction Angle	Failure parameter as in MC model
ϕ_{cv}	Constant Volume Friction Angle	-
C	Cohesion	Failure parameter as in MC model
K_G^p	Plastic shear modulus number	Dimensionless
np	Plastic shear modulus exponent	Dimensionless
R_f	Failure ratio (qf / qa)	0.7~0.98 (< 1), decreases with increasing relative density
F_{post}	Post Liquefaction Calibration Factor	Residual shear modulus
F_{dens}	Soil Densification Calibration Factor	Cyclic Behavior
Advanced parameters		
Pcut	Plastic/Pressure Cutoff (Tensile Strength)	-
K_B^p	Cap Bulk Modulus Number	-
mp	Plastic Cap Modulus Exponent	-
OCR	Over Consolidation Ratio	Normal stress / Pre-overburden pressure

$$K_G^e = 21.7 \times 20.0 \times \left(N_1\right)_{60}^{0.333}$$

$$30^0 < \phi_{cv} < 34^0$$

$$\nu = 0.0163$$

$$K_G^p = K_G^e \left(N_1\right)_{60}^{2} \times 0.003 + 100.0$$

$$ne = 0.5$$

$$np = 0.4$$

$$\phi_p = \begin{cases} \phi_{cv} + \left(N_1\right)_{60} / 10.0 & \left(\left(N_1\right)_{60} < 15.0\right) \\ \phi_{cv} + \left(N_1\right)_{60} / 10.0 + \max\left(0.0, \dfrac{\left(N_1\right)_{60} - 15}{5}\right) & \left(\left(N_1\right)_{60} \geq 15.0\right) \end{cases}$$

$$R_f = 1.1 \times \left(N_1\right)_{60}^{-0.15}$$

[Parameters and Equations for Calibration]

2. Pre/Post Processing

2.1 UBC SAND Results : Liquefiable Area

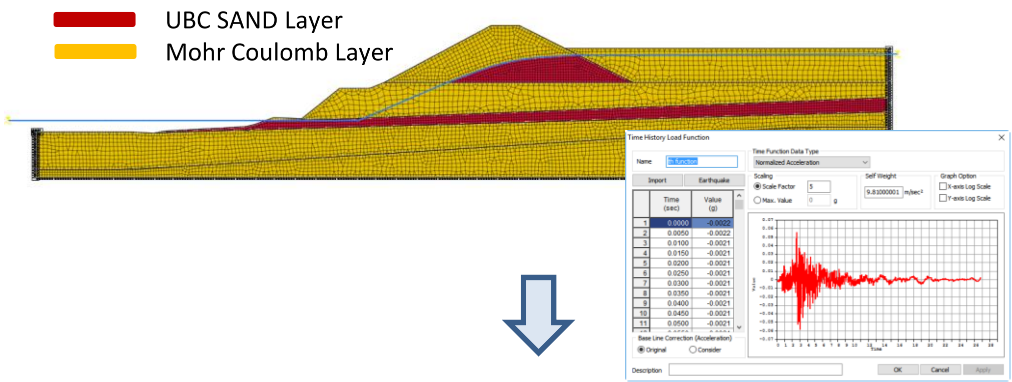
- Specific results which can check the liquefiable area directly
- Two types of results are available to measure the possibility of liquefaction.

Pore Pressure Ratio (PPR)

- The ratio of excessive pore pressure change and the initial effective pressure

$$PPR = -\frac{\Delta p_w}{p'_{init}} = \frac{p'_{init} - p'_{current}}{p'_{init}}$$

Δp_w	Excessive Pore Pressure Change
p'_{init}	Initial Effective Pressure
$p'_{current}$	Current Effective Pressure

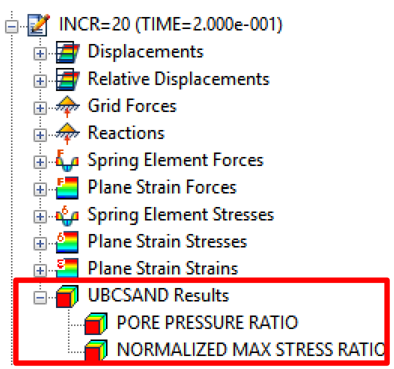


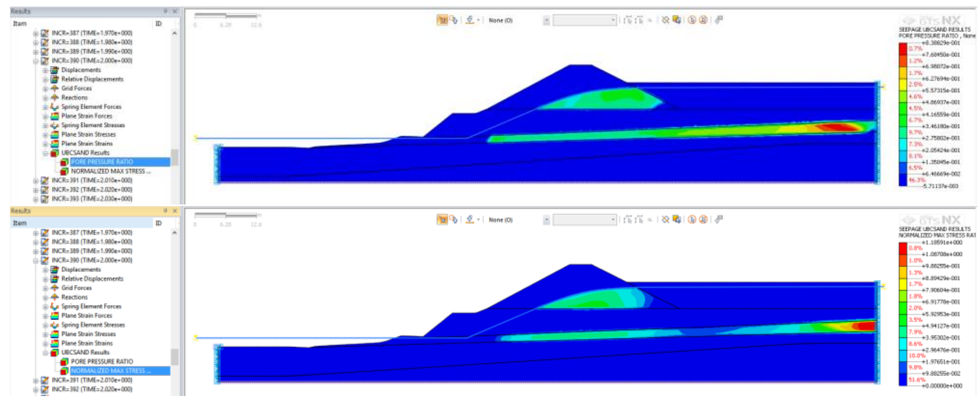
Normalized Max Stress Ratio

- The ratio of mobilized friction angle and the peak friction angle
- When the Max stress ratio is reached, the mobilized friction angle is close to the peak friction angle, liquefaction is triggered (1 = Liquefaction)

$$\max\left(\frac{\sin\phi_m}{\sin\phi_p}\right)$$

ϕ_m	Mobilized Friction Angle
ϕ_p	Peak Friction Angle



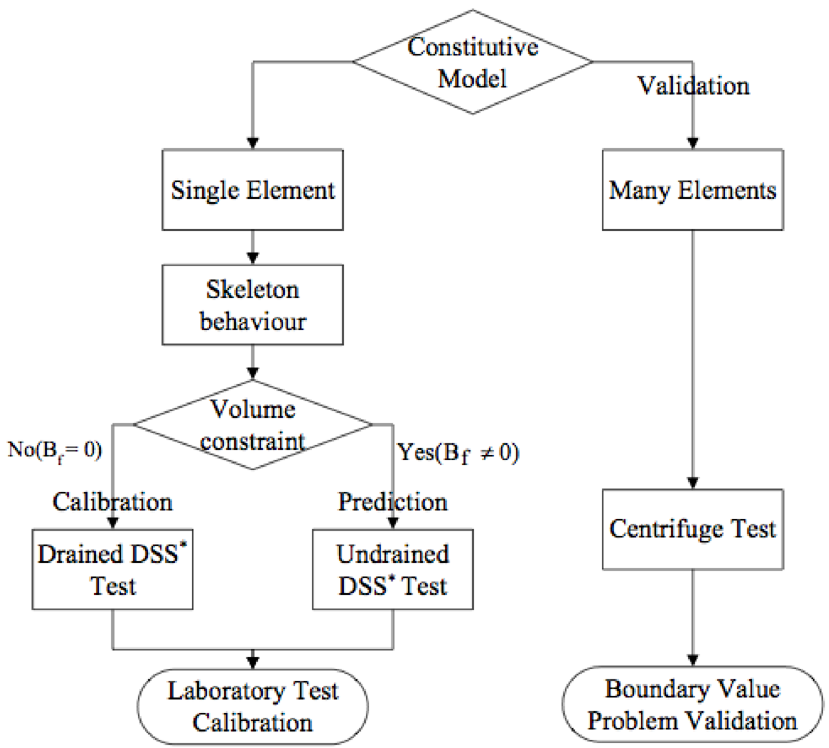


[Nonlinear Time History Analysis under the earth quake]

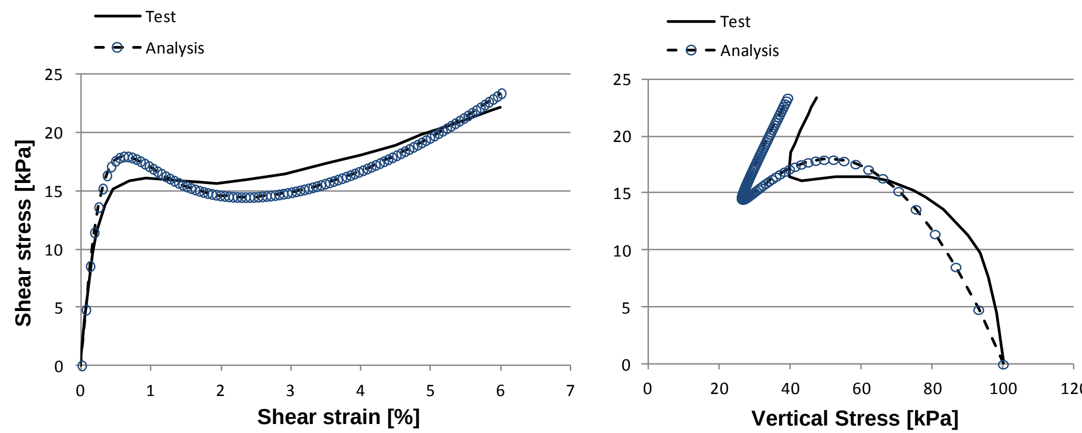
2. Pre/Post Processing

2.1 UBC SAND Results : Liquefiable Area _ Model Calibration

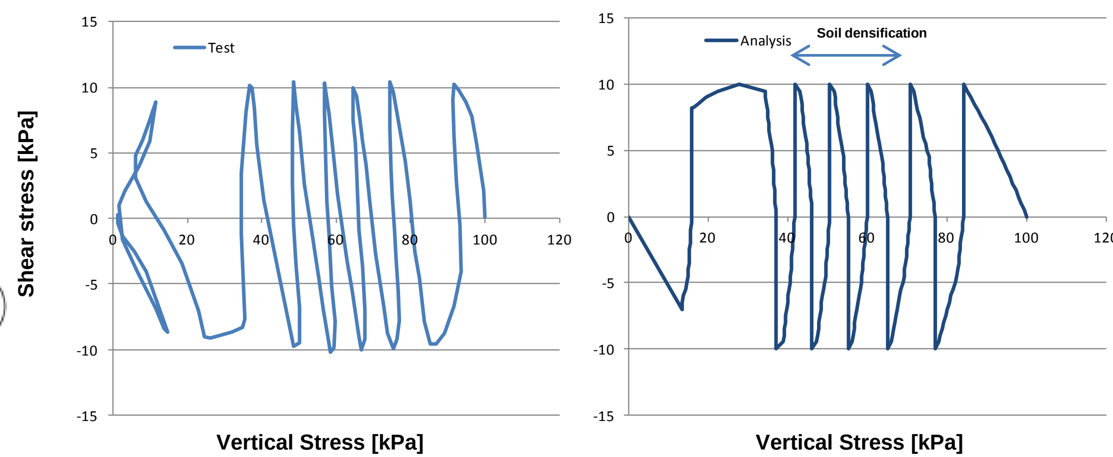
- Monotonic and cyclic drained Direct Simple Shear (DSS) test (skeleton response).
- Constant volume DSS test (undrained test)



* DSS stands for Direct Simple Shear.



[Undrained DSS (Monotonic)]



[Undrained DSS (Cyclic)]

2. Pre/Post Processing

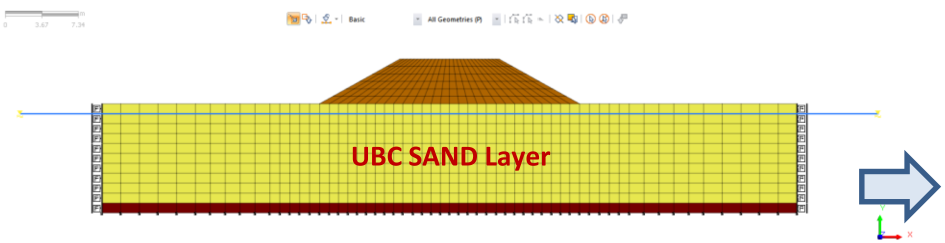
2.1 UBC SAND Results : Liquefiable Area _ Case Study

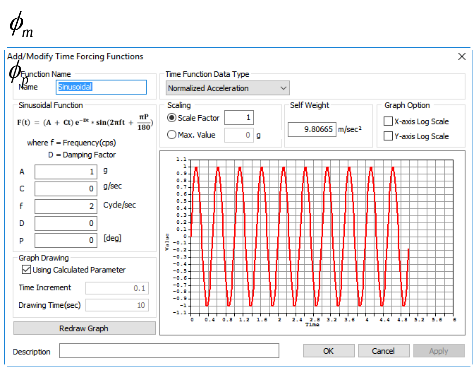
- ***Normalized Max Stress Ratio***

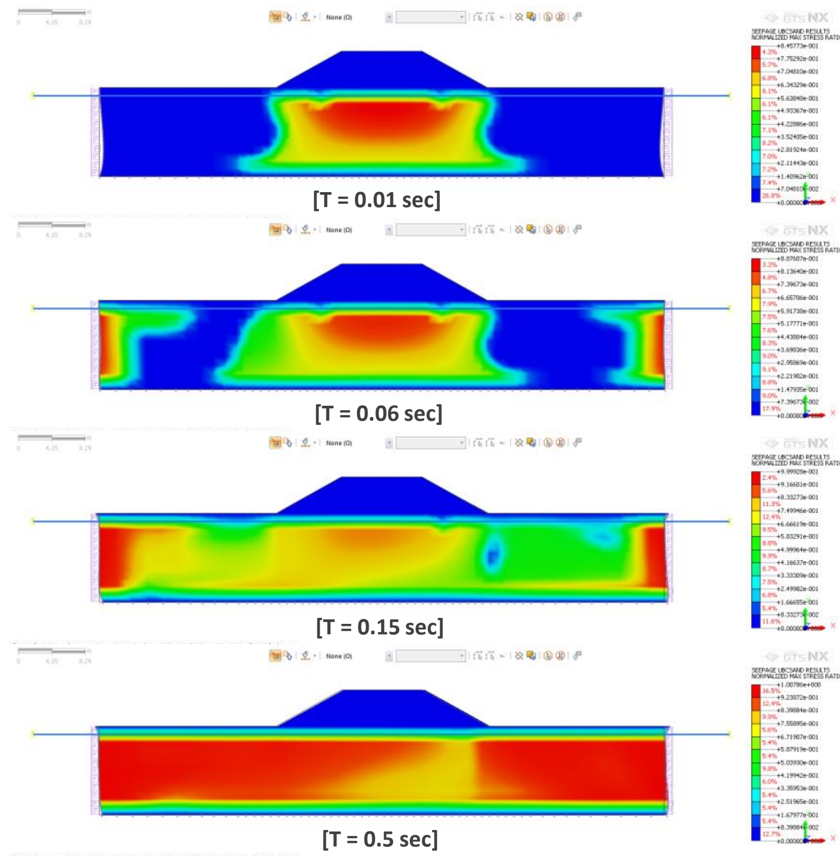
- When the Max possible stress ratio is reached, liquefaction is triggered and K_G^p is reduced as

$$K_G{}^P = K_G{}^P{}_0 * fac_{pos}$$

- , where fac_{pos} is a user defined post liquefaction calibration factor







[Nonlinear Time History Analysis under the cyclic loading]

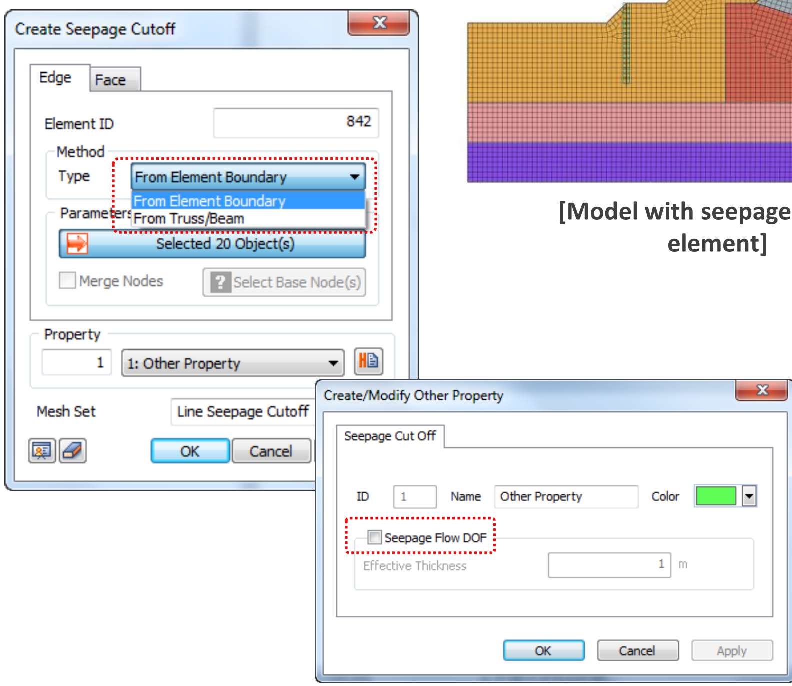
2. Pre/Post Processing

2.2 Seepage Cut Off (SCO) element

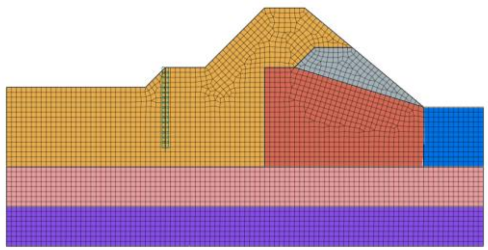
- Seepage Cut Off element is to provide “Structural Waterproofing Members”. The users can define it with 1D and 2D Elements for 2D and 3D models respectively.
- In 2D models, the users can define SCO element from Element boundary and Truss/Beam elements. In case of 3D model, the element boundary and Shell element are available to define SCO element.
- Seepage Flow DOF is to decide whether the users allow seepage flow passing through SCO elements or not.

(* Effective thickness: When considering seepage flow of SCO elements, the users should define the effective thickness as the thickness of the structural member.)

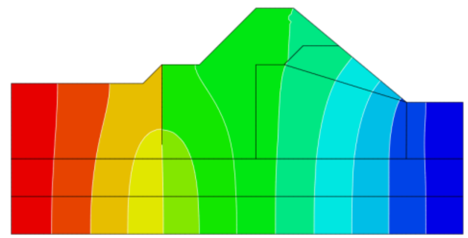
- **Mesh > Element > Seepage Cut Off**



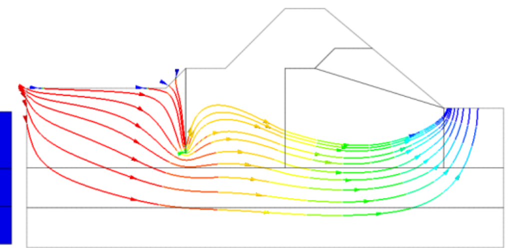
[Seepage Cut Off element and Seepage Flow]



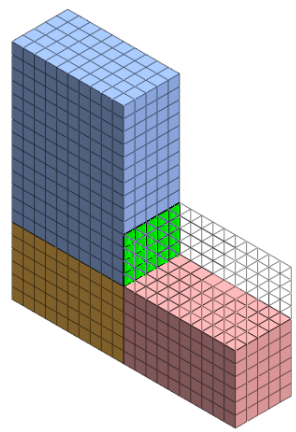
[Model with seepage Cut-Off element]



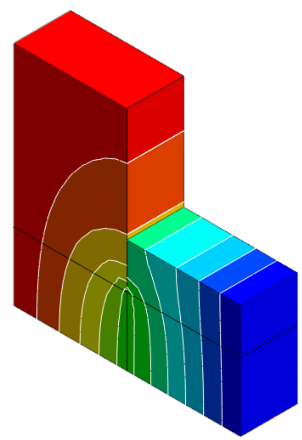
[2D Total Head result]



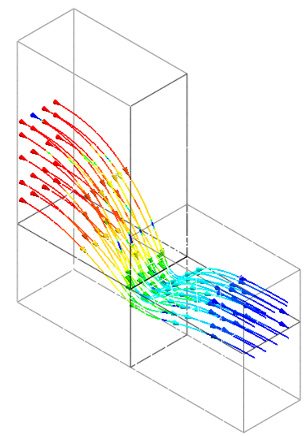
[2D Seepage flow lines]



[3D model with Seepage Cut Off defined on faces]



[3D Total Head result]



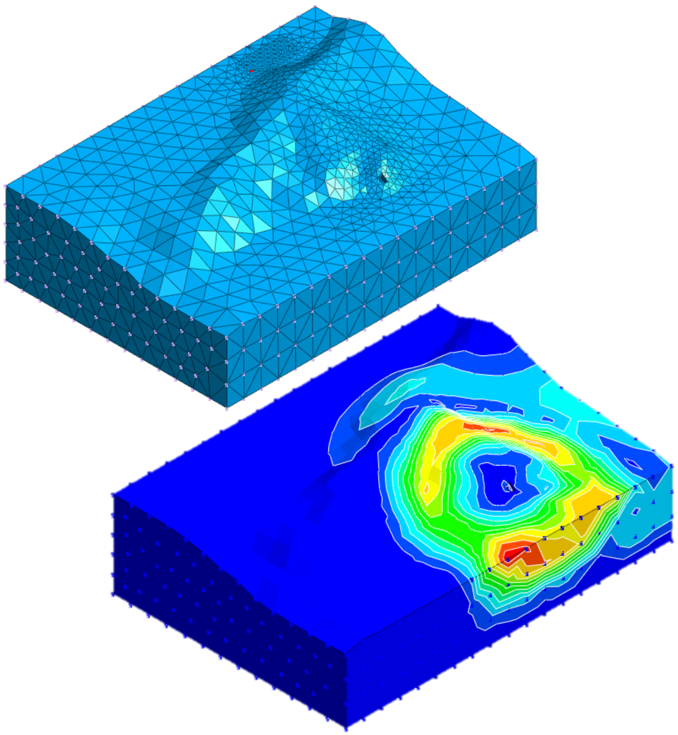
[3DSeepage flow lines]

2. Pre/Post Processing

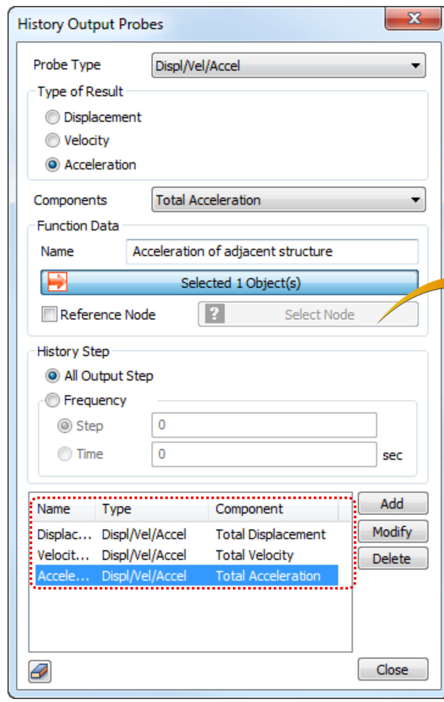
2.3 Improvement in History Output Control

- For the time history analysis, the users can check history output for the specific results at the specific locations.
- Once the users define the history output probes, it will be activated in output control data automatically.

- **Analysis > History > History Output Probes**

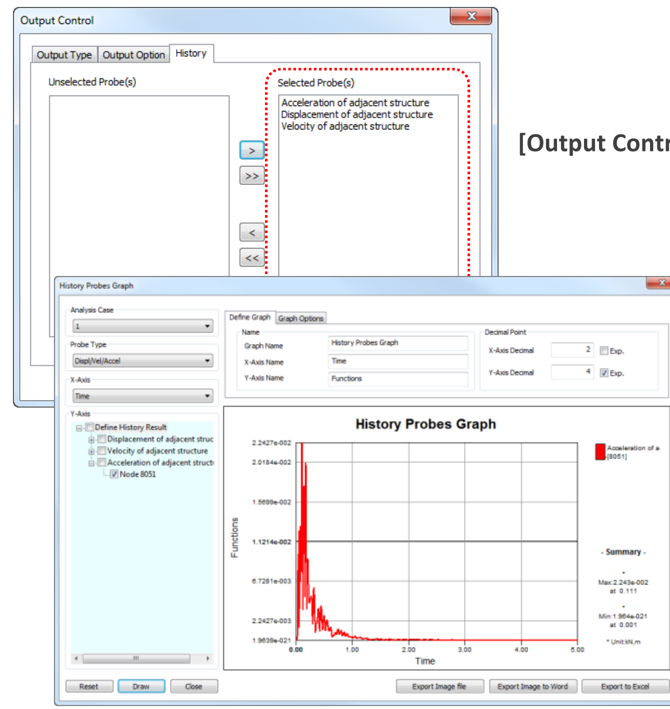


[3D Model]



[History Output Probes]

- **Analysis > Analysis Case > Output Control > History tab**



[Output Control]

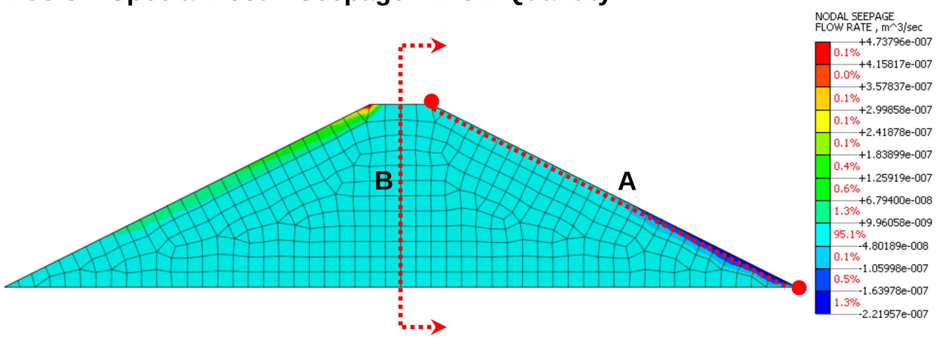
[History Result graph]

2. Pre/Post Processing

2.4 Flow Quantity – Arbitrary cutting type

- The users can check the flow quantity passing through any specific locations.
- In previous versions, the flow quantity was only measurable at the nodes where the users define the boundary conditions.

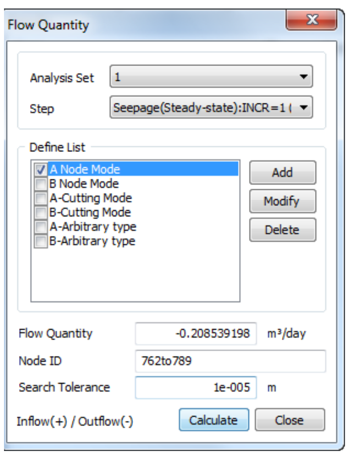
- **Tools > Special Post > Seepage > Flow Quantity**



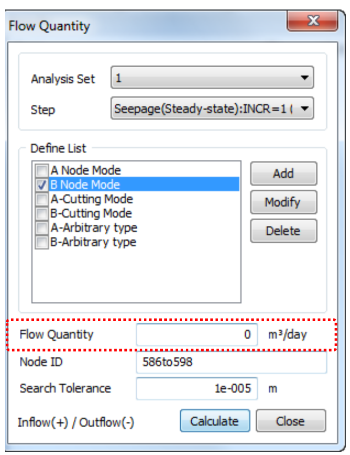
• Node / Cutting type - Calculate the flow quantity by calculating the sum of the flow rate calculated at the selected node.

• Arbitrary division type - calculates the flow rate of elements passing through arbitrary lines or faces

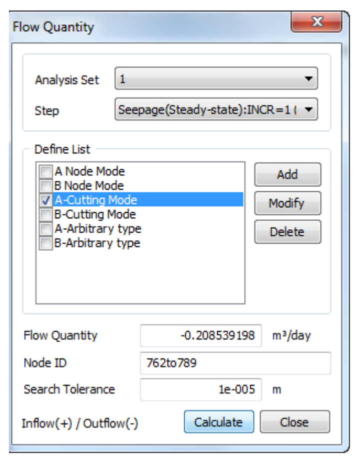
(※ In case of Arbitrary division type, the users should select the location within the e lements, not the outermost line of the elements.)



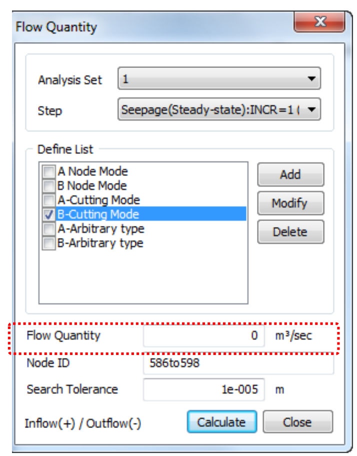
[Section A –Node Mode]



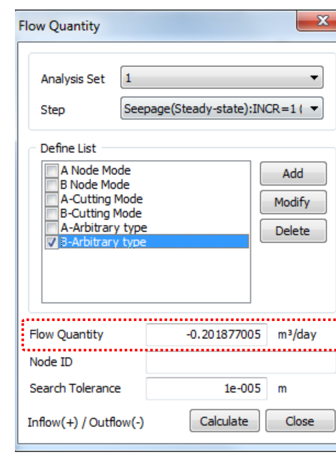
[Section B –Node Mode]



[Section A –Cutting Mode]



[Section B – Cutting Mode]



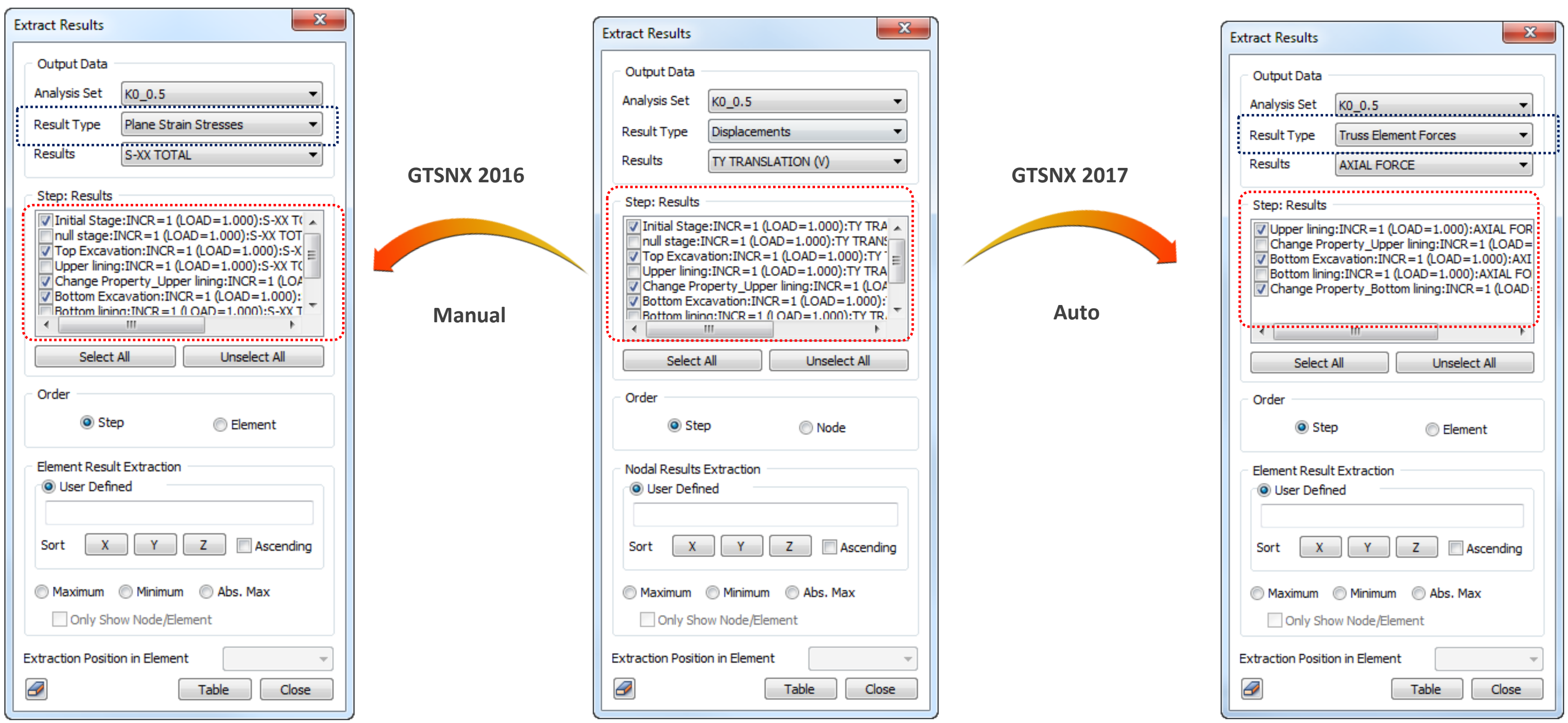
[Section B –Arbitrary division]

2. Pre/Post Processing

2.5 Improvement in Extract Results function

- When the users change the result type, all the selected steps had been initialized, so had to select the specific steps again in the previous version.
- GTSNX 2017 will keep the selected steps even if the users change the result type.

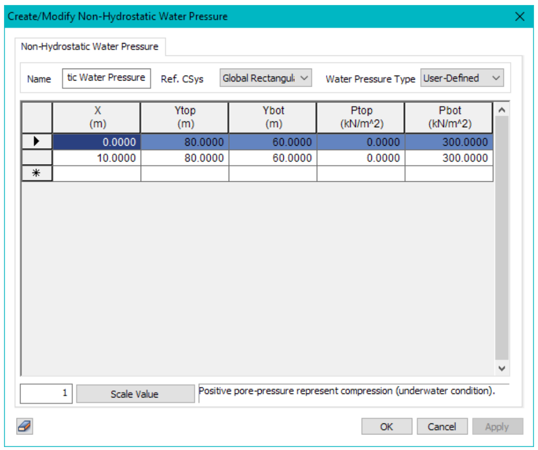
- **Result > Advanced > Extract**



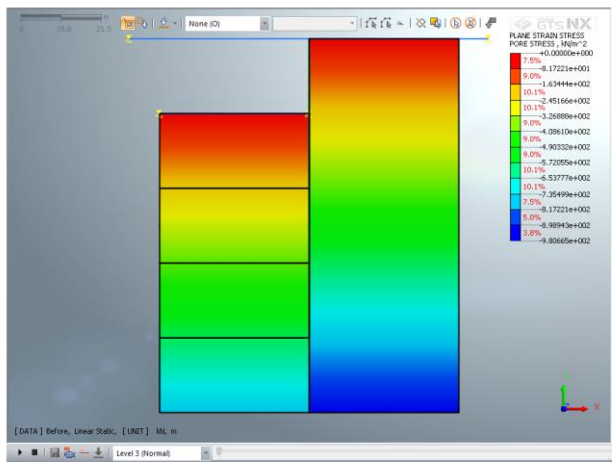
2. Pre/Post Processing

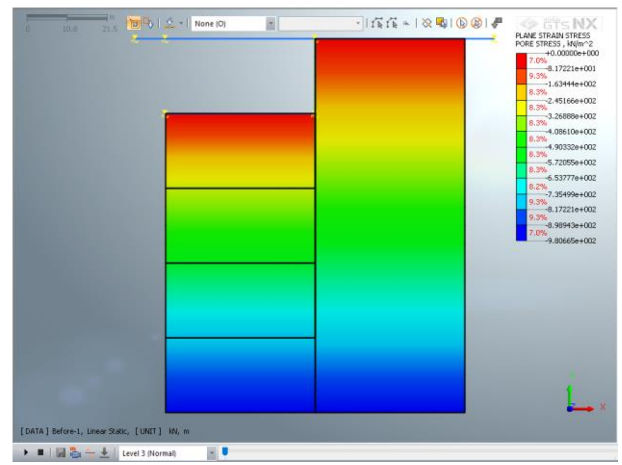
2.6 Non-hydrostatic Water Pressure (Add/Modify Analysis Case > Analysis Control > Define Water Level for Mesh Set > Input Water Level…)

- Additional option to allow definition of non-hydrostatic water pressure for specified mesh sets in the analysis control.
- Head: To set a water level specific to an assigned mesh set with an option to assign a condition function defined in General Function.
- Dry: To remove water pressure in the mesh set.
- Hydrostatic: To define a pressure value to be applied to the top of an assigned mesh set with a condition function defined in Non-Hydrostatic Water Pressure.
- User Defined: To allow a user defined pressure at top and bottom of an assigned mesh set with a condition function defined in Non-Hydrostatic Water Pressure.



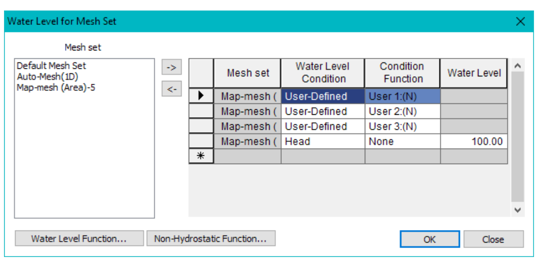
[Define multiple pressure functions]





[Discontinuity in pore water pressure during excavation]

[Continuity in pore water pressure using User Defined pressure]

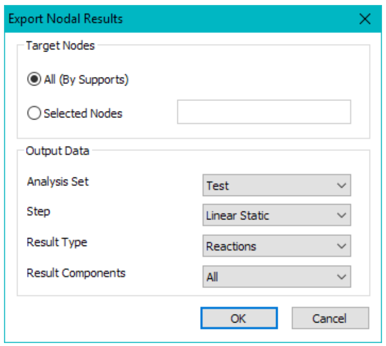


[Assign different functions to each mesh set]

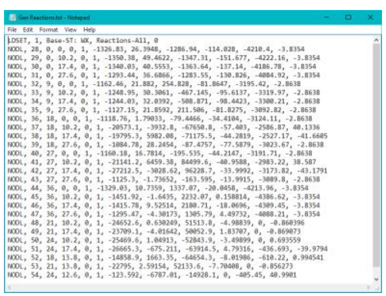
2. Pre/Post Processing

2.7 Import/Export Nodal Results (Menu > Export > Export Nodal Results(*.txt) & Menu > Import > Import Nodal Results(*.txt))

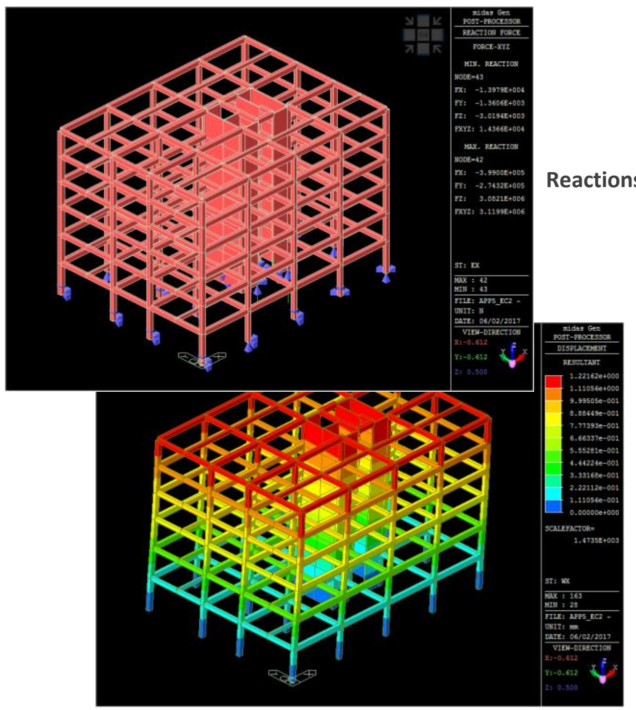
- Feature to allow import and export of nodal results for nodes with constraint defined.
- For export, users can opt to export results at all constraint locations or at selected constraint locations.
- Additionally, users can select the analysis set, step (construction stage), result type (reaction or displacement), and result component for output.
- The development allows users to import nodal results from midas Gen or Civil.
- Reactions will be imported as Nodal Forces (FX, FY, FZ) and Moments (MX, MY, MZ).
- Displacements will be imported as Prescribed Displacement (Tx, Ty, Tz) excluding rotation.



[Export Nodal Results options]



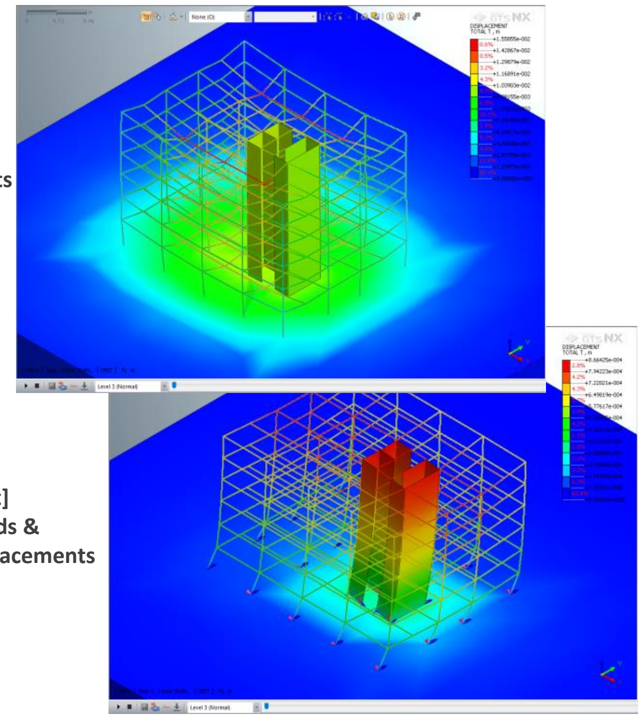
[Export results in .txt format]



[Analysis Results from Gen/Civil]

[Export]
Reactions & Displacements

[Import]
Nodal Loads &
Prescribed Displacements

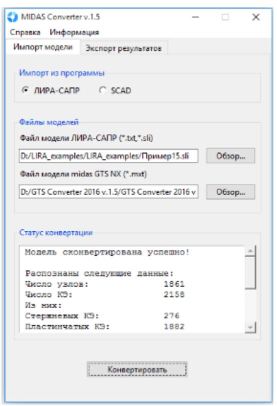


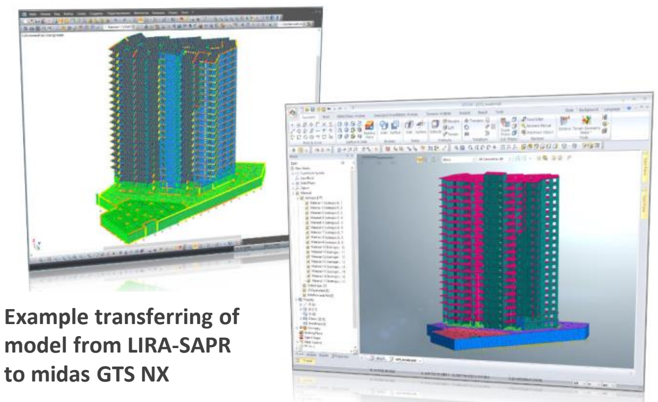
[Analysis Results from GTS NX]

2. Pre/Post Processing

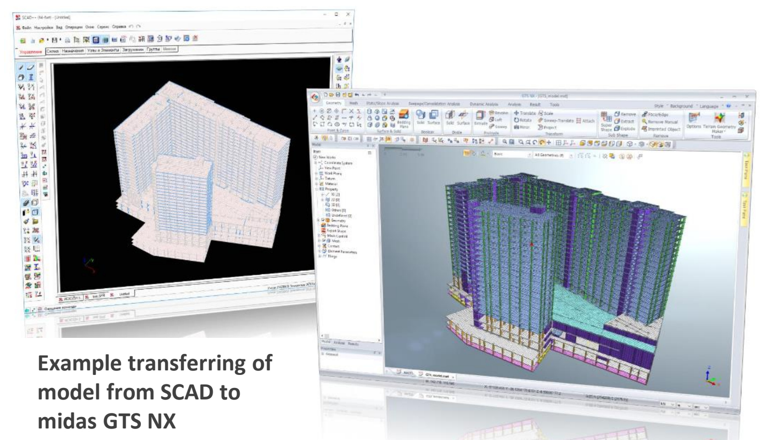
2.8 Link Between LIRA-SAPR / SCAD and midas GTS NX (Menu > Export > Execute midas Converter…)

- This feature allows to transfer the structural model from software LIRA-SAPR or SCAD into midas GTS NX. The transfer is carried out through the MIDAS Converter. This Converter transfers such structural model data as elements, materials, sections, boundaries and loads. The transferred model can be used in midas GTS NX for structure-ground coupled analysis, considering construction stage consequence.
- After coupled analysis the Converter allows to transfer the obtained results back into the LIRA-SAPR or SCAD software. The transferred results have format of Subgrade Reaction Modulus for the plate elements, Point Springs and Spatial Displacements. After performing of analysis in LIRA-SAPR or SCAD with transferred results the analysis results will be the same as obtained in midas GTS NX. This allows to make structural design in LIRA-SAPR or SCAD software with real behavior of a ground.

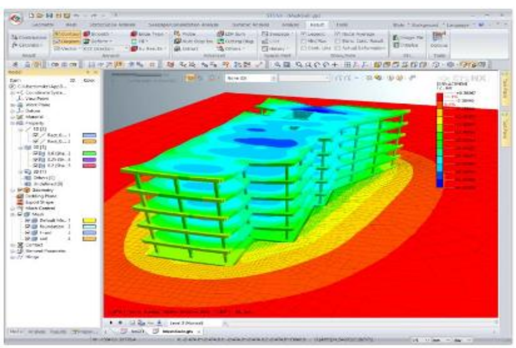




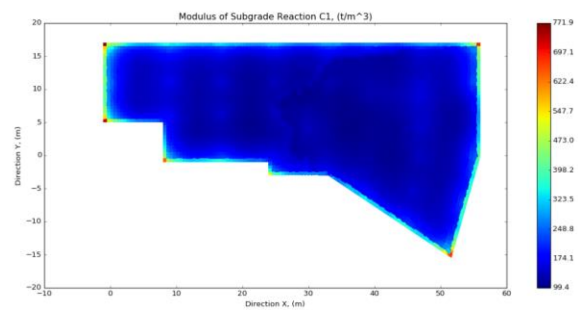
Example transferring of model from LIRA-SAPR to midas GTS NX



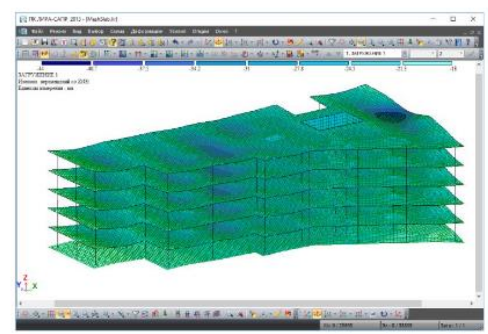
Example transferring of model from SCAD to midas GTS NX



Structure-Ground coupled analysis in midas GTS NX



Executed Subgrade Reaction Modulus in plate elements of building foundation



Analysis of model in LIRA-SAPR with transferred results