

MIDAS

GEOTECHNICAL

GEOTECHNICAL SOLUTIONS
FOR PRACTICAL DESIGN

SoilWorks[®]

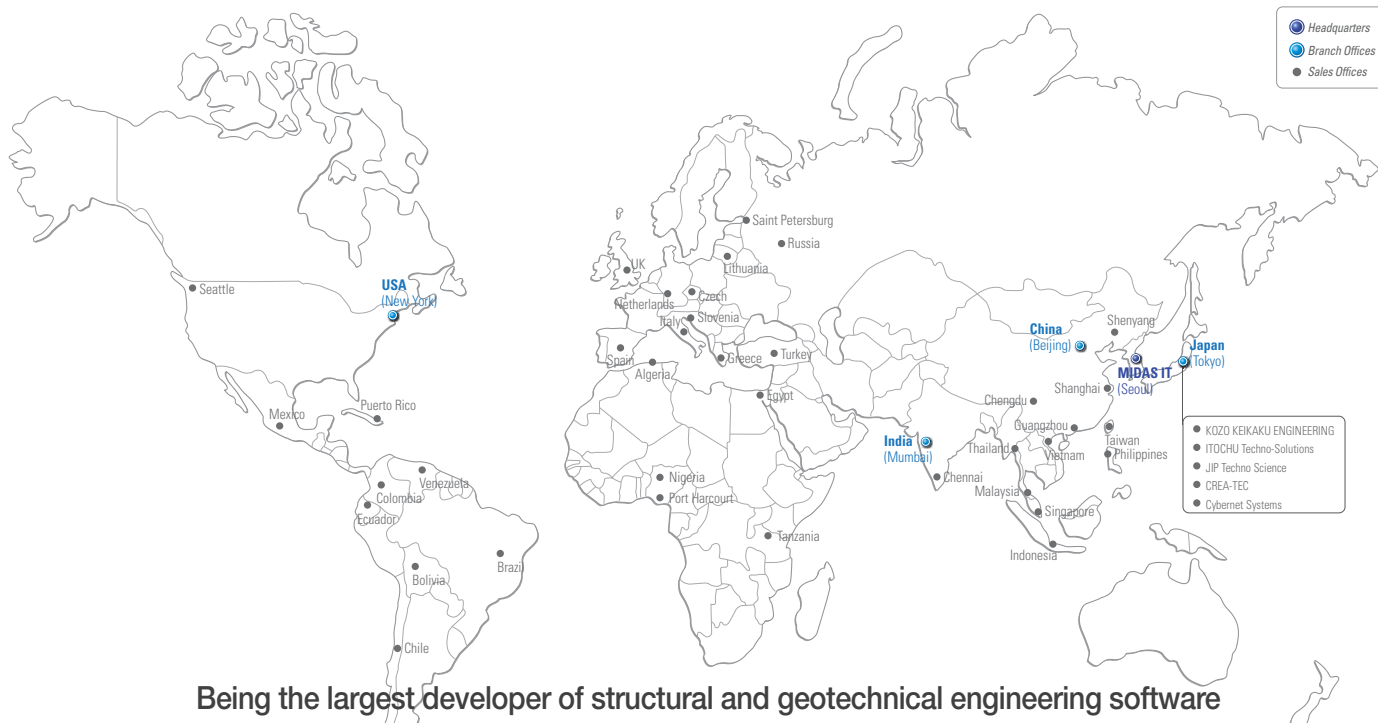
a new Paradigm for integrated Geotechnical Solutions

PRACTICAL

DESIGN

FOR SOLUTIONS

A LEADING GLOBAL Engineering Solutions Provider



Being the largest developer of structural and geotechnical engineering software with extensive research in leading technologies in the world, MIDAS has garnered global recognition through its continuous passion and devotion towards the Advancement in Civil Engineering.

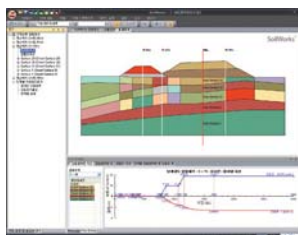
a total of over 30,000 MIDAS software licenses used worldwide in over **120** countries

a global network of engineering software distribution and technical support

over 450 engineers and professionals develop and distribute engineering software

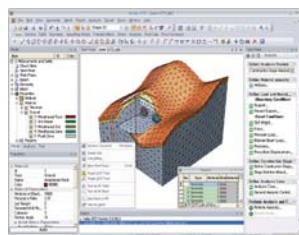
❖ Introducing geotechnical finite element programs

a New Paradigm for
Geotechnical Engineering Solutions, all in one package



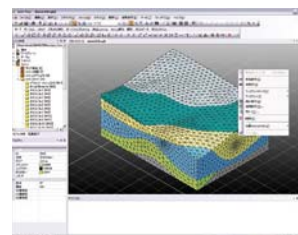
SoilWorks

2 Dimensional geotechnical analysis modules



midas GTS

3 Dimensional geotechnical analysis modules

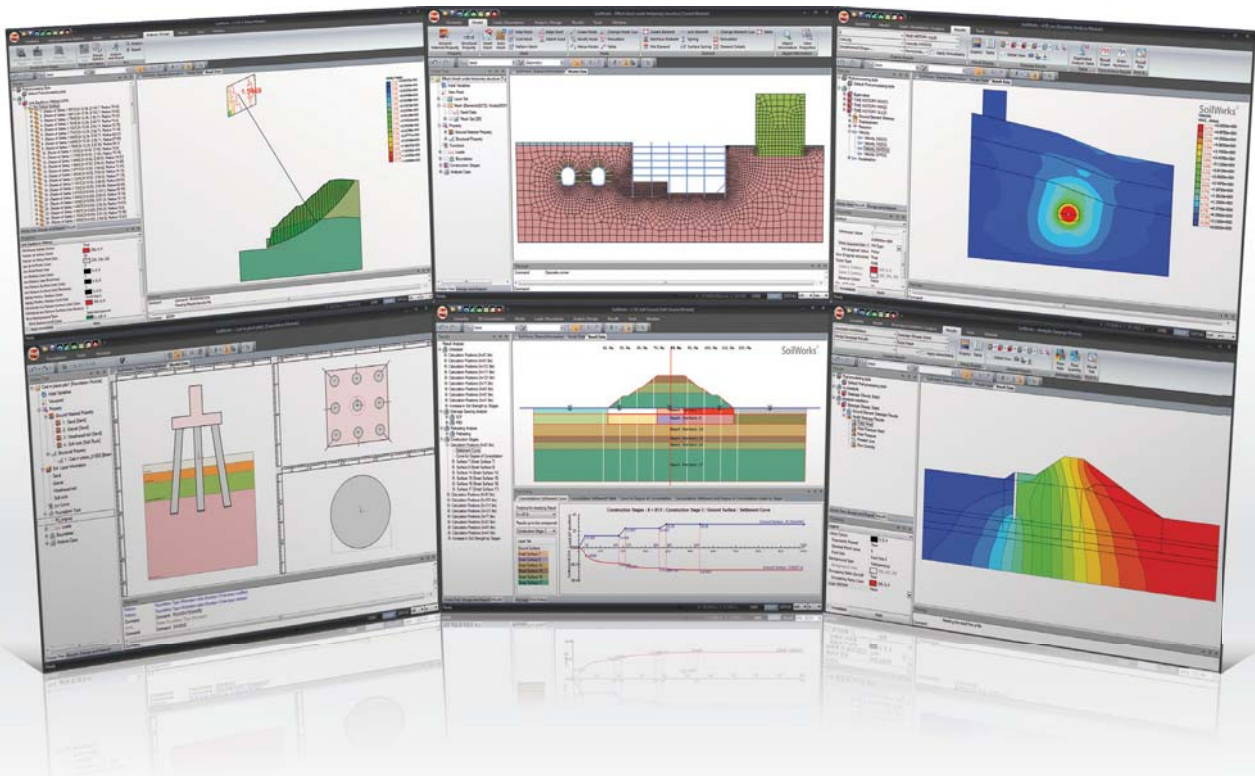


Soil+

(CTC in Japan)

SoilWorks[®]

Geotechnical Solutions For Practical Design



❖ SoilWorks Concept

Geotechnical analysis software programs available today generally handle specific types of geotechnical problems with varying degrees of limitations in functionality. SoilWorks is designed to handle any geotechnical problems encountered in the practice of soil / rock mechanics.

SoilWorks is designed for structural engineers with a background in geotechnical engineering and geotechnical engineers with a background in finite elements.

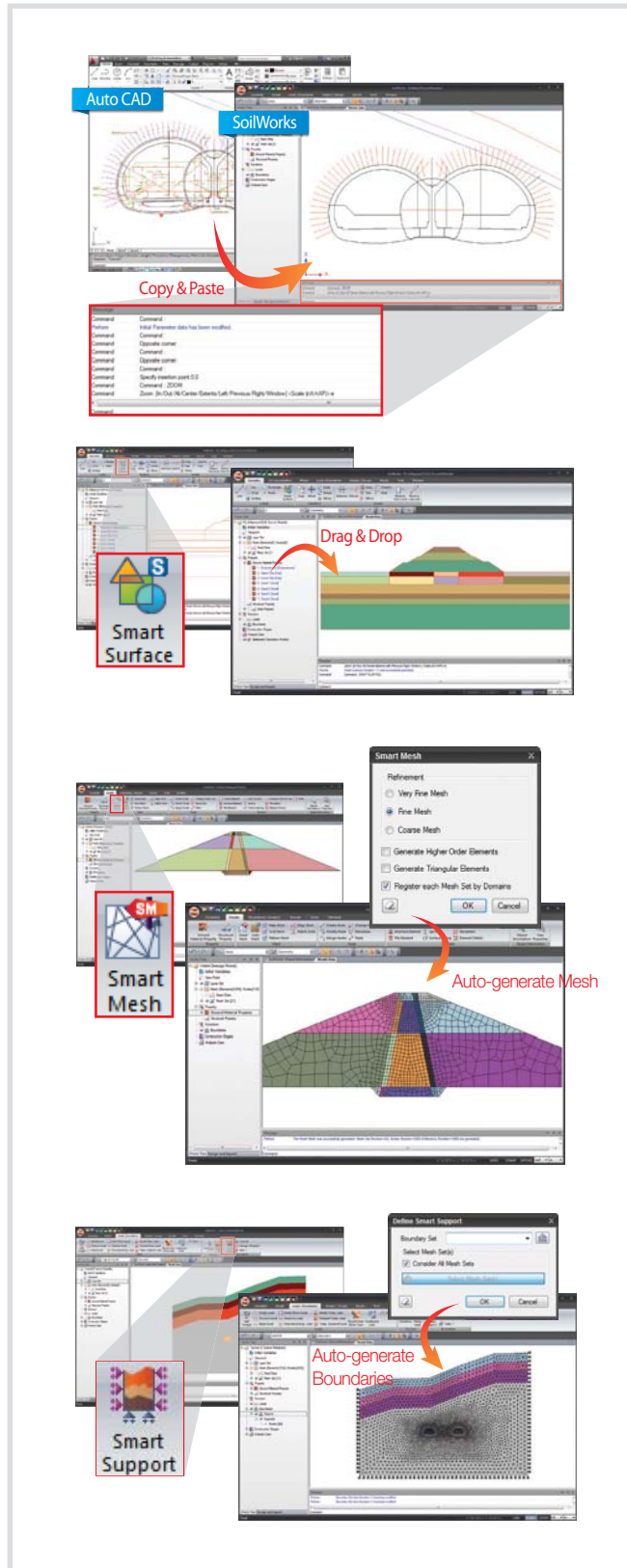
❖ SoilWorks Development Motive

In the practice of geotechnical design, 2-dimensional analysis is a very practical approach. However, the design process by and large involves repetitions of simple and complex tasks. SoilWorks has been developed to address such time-consuming and tedious tasks to drastically improve the efficiency of the design process. Also SoilWorks has been developed to handle practically all types of geotechnical problems – Tunnels, Slopes, Soft Grounds, Foundations, Seepage and Dynamic Analysis. Each module has been implemented to meet the needs of and comply with the design process used by the practicing engineers.

7Smart Main Distinct Features

SoilWorks uses **Smart Functions** built into the entire process from modeling to the analysis of results.

The program enables structural engineers as well as geotechnical engineers to easily extract high quality results.



1 S·M·A·R·T **Modeling** CAD based Operating Environment

- Import & open CAD Files and Copy & Paste selectively
- Use commands & short-cut keys identical to those of CAD Commands
- Create analytical models in simple and convenient ways as in drafting work
- Solve real life geotechnical problems immediately with an extremely short learning curve
- Increase work productivity with modeling time shortened and repetitions eliminated

2 S·M·A·R·T **Surface** Auto-generation of Surfaces for enclosed domains

- Search enclosed domains and create surfaces automatically
- Assign material properties intuitively by Drag & Drop
- Eliminate cumbersome tasks of coordinate input for defining domains

3 S·M·A·R·T **Mesh** Auto-generation of Mesh

- Auto-generate mesh on the geometry irrespective of complexity
- Generate mesh easily without having the in-depth knowledge on mesh generation, mesh density and mesh shapes
- Prevent inaccuracy in mesh generation and input errors in advance

4 S·M·A·R·T **Support** Auto-generation of Boundary Conditions

- Search the model boundaries and assign boundary conditions automatically
- Auto-generate elastic/viscous boundaries without having to calculate complex equations
- Eliminate all the problems associated with defining boundary conditions
- Check the displayed boundary assignment intuitively and detect errors visually

Smart functions in Software implemented for ground analysis and design

5 S·M·A·R·T Technical Review Technical Review to prevent analysis errors

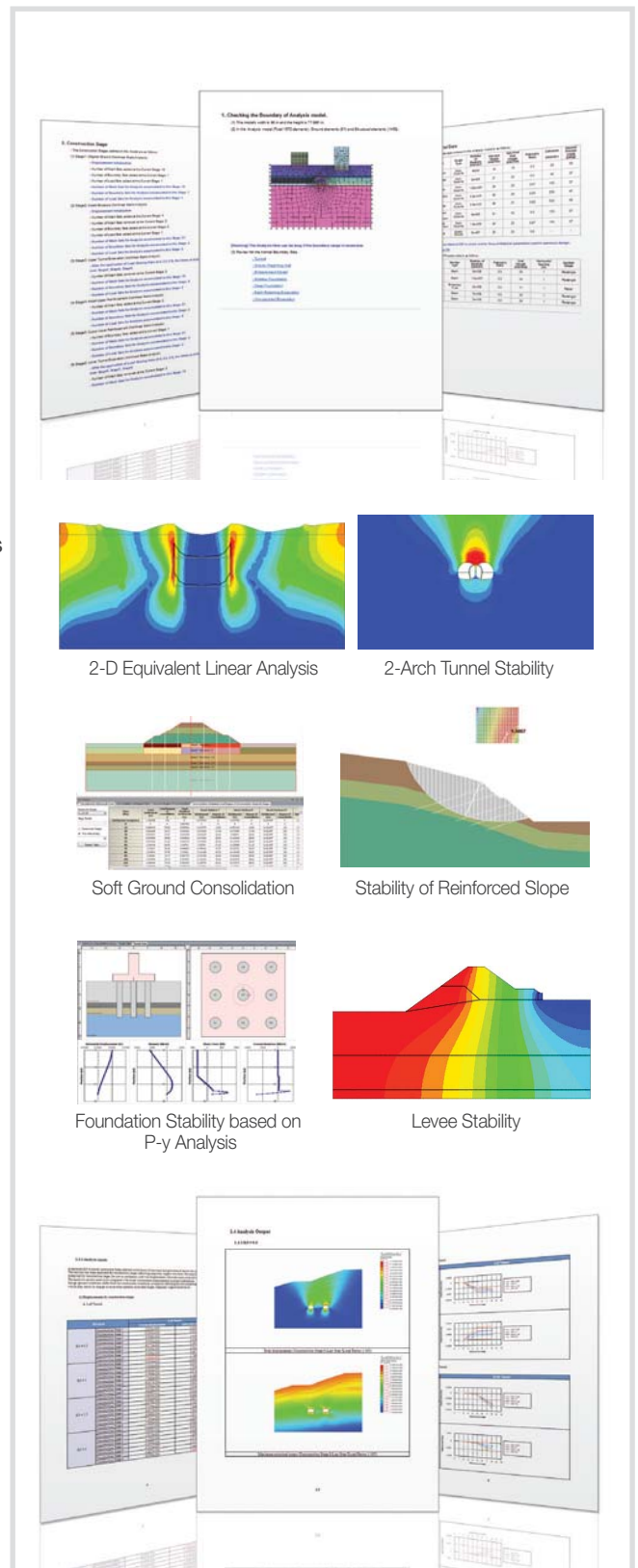
- Check errors pertaining to all the aspects associated with the analytical model
 - Geometry Check: check the geometric shape such as the width and height of the model
 - Mesh Check: check the total numbers of nodes & elements, mesh quality report, analysis results due to mesh quality and the accuracy of mesh
 - Material Check: check the general range and selected database of ground materials and structural properties
 - Boundary Check: check the boundary conditions and change in material properties
 - Construction Stage Check: check the summary of entire construction stages and load distribution ratios
- Enhance analytical skills with the prevention of errors from mistakes
- Extract utmost quality of results irrespective of abilities in the use of the program or analytical skills

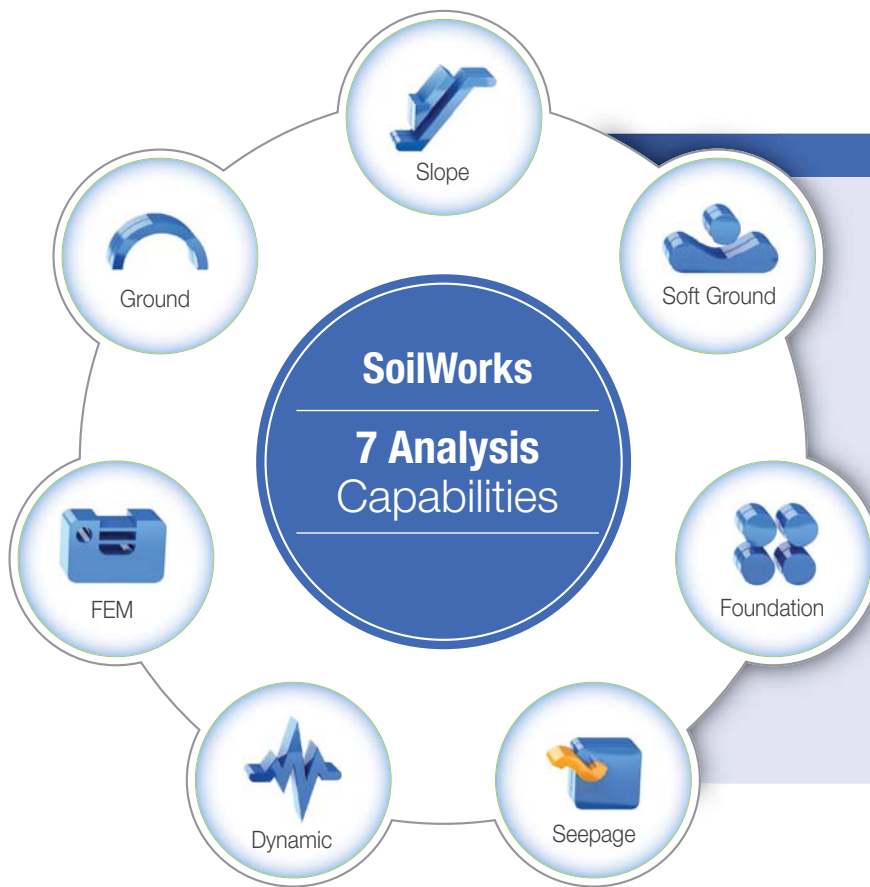
6 S·M·A·R·T Analysis Parametric Analysis & Data Interface between Modules

- Optimize design through various parametric analysis functions
 - Tunnel: parametric analysis through change in K_0
 - Slope: simultaneous analysis of reinforced/unreinforced slopes in dry/rainy seasons and in earthquake conditions
 - Soft Ground: parametric analysis for variations in drainage spacing & types and preloading heights
 - Foundation: comparison of bearing capacities and settlements by foundation types, configurations and construction methods
- Undertake stress-seepage coupled analysis & slope stability analysis reflecting changes in ground water level
- Reflect increase in the strength of soft ground for limit equilibrium analysis
- Interface model data automatically retrieved among different modules

7 S·M·A·R·T Results High Quality Report auto-generation

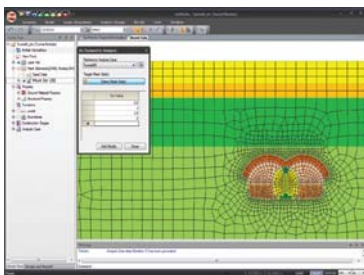
- Define check items in the modeling process to be included in the auto-generated report
- Auto-generate calculation report for bearing capacity
- Simplify the work process by eliminating repetitive work to produce the summary of results
- Increase the productivity of preparing project deliverables
- Build up the work efficiency to counter frequent design changes



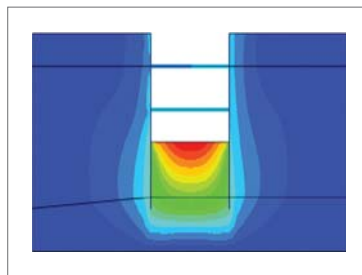


Application Areas

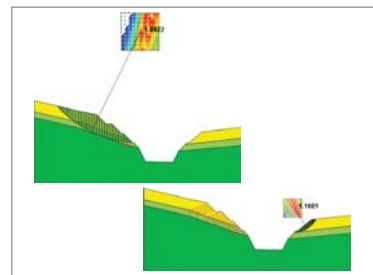
- Stability checks for tunnel construction stages
 - Seepage & flux analysis
- Tunnel lining analysis
- Construction stage analysis for temporary structures
 - Stability checks for adjacent structures
 - Designing pump capacity during excavation
 - Ground-pile interface considered
- Bridge abutment construction stage analysis
 - Stability check for lateral displacement including piles
 - Structural displacement & pile reaction checks
- Slope stability analysis (LEM, SRM & SAM)
 - Construction stages considered
 - Dry & rainy seasons and at earthquake
 - Precipitation intensity considered



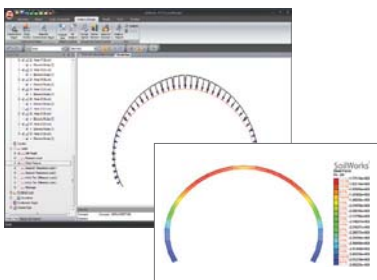
Generation of Multiple Analysis Cases through Variable K_0



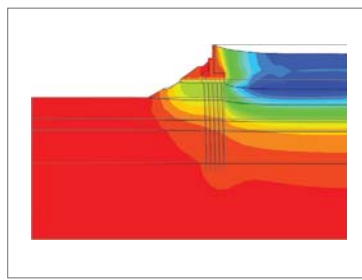
Final Ground Deformation at the Last Excavation Stage



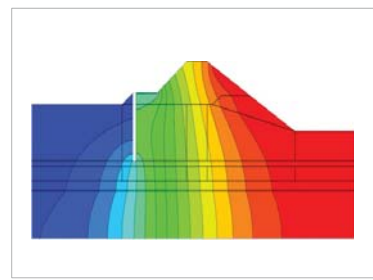
Limit Equilibrium Analysis of Slopes at a Gallery Entry



Loading acting on a Tunnel Lining & Analysis Results



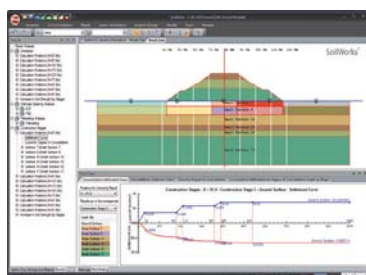
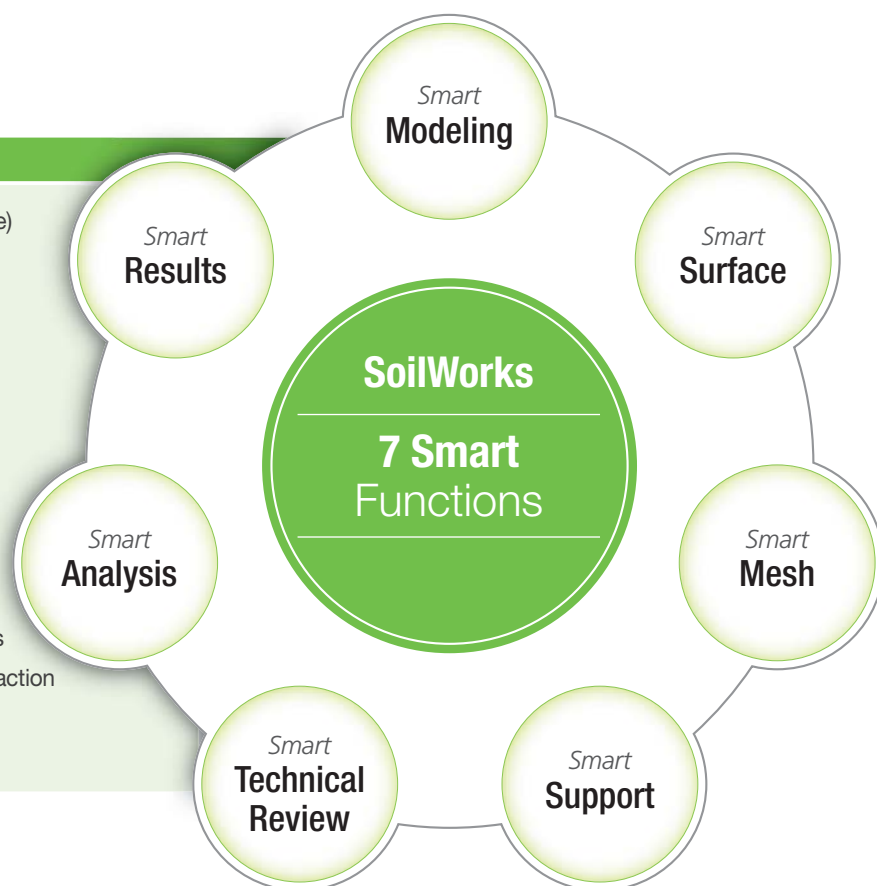
Lateral Movement of a Bridge Abutment



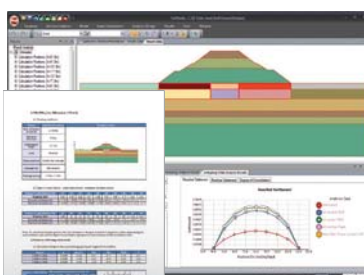
Seepage Analysis Results due to a Cut-off Wall

Application Areas

- Dam (levee) seepage analysis at a full water level (flood line) and at a sudden drop in water level
- Cut-off wall design
- 1D & 2D consolidation settlements and immediate settlement in sand
- Accelerated consolidation construction check
- Preloading height design
- Calculation of limit embankment height considering the increase in strength
 - Slope stability coupled analysis
- Vertical/horizontal stability checks for pile foundations
- Calculation of foundation displacements and pile reactions
- 2-D equivalent linear analysis reflecting soil-structure interaction
- Time history analysis reflecting train vibration loads

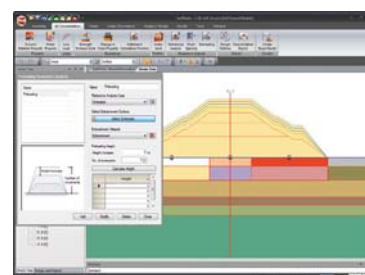


Analysis Results of Consolidation Settlements in Construction Stages

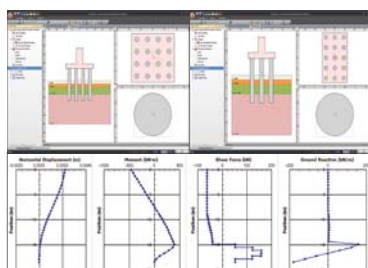


Soft Ground Design Check Report

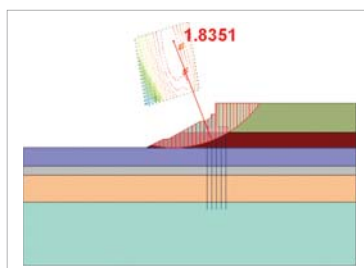
Total Settlements by Engineering Methods



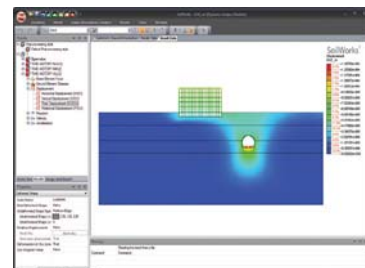
Setting Parametric Analysis for Preloading Heights



Offshore Pile Foundation Check



Limit Equilibrium Analysis considering Piles

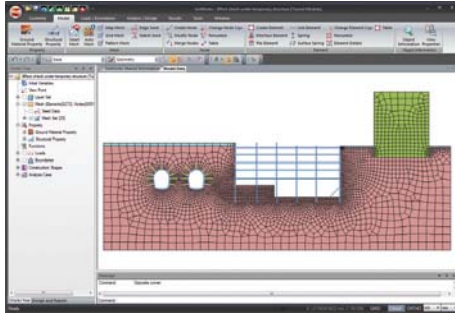


Evaluation of Adjacent Structure under Train Moving Load

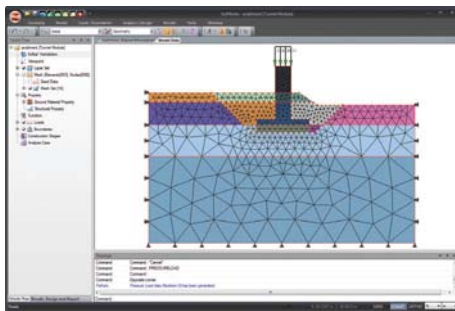


Ground Stress Analysis

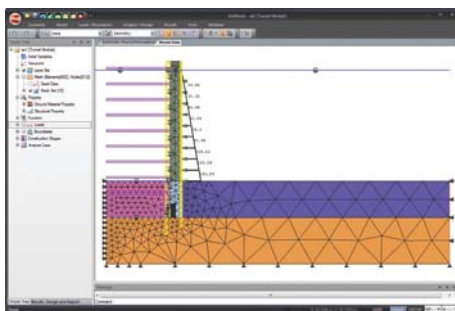
Finite Element Analysis based Exclusive 2 dimensional Software



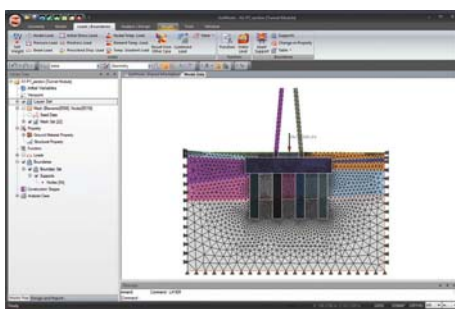
Modeling Excavation with Temporary Structures in Construction Stages



Modeling a Bridge Pier Foundation in Construction Stages



Modeling a Temporary Cut-off Wall in Construction Stages



Modeling a Structure's Foundation in Construction Stages

✿ Design Application Areas

- Evaluation of effects on adjacent structures during construction
- Stability checks for bridge foundations in construction stages
- Lateral displacements of bridge abutment piles
- Stability checks for temporary structures by construction stages
- Stability checks for underground structures by construction stages
- Stability checks due to seepage force by construction stages

✿ Analysis

- Construction stage analysis
- Static nonlinear analysis
- Advanced material models such as Elastic/Mohr-Coulomb /Hoek-Brown/Duncan-Chang
- Analysis coupled with seepage analysis results
- Technical review to check the suitability of analytical models

✿ Results & Design

- Menu system to streamline the analysis & design process
- Production of combined forces & stresses in members
- Generation of a report including tables and diagrams of main result items
- Built-in allowable displacement criteria for adjacent structures
 - Allowable angular displacement by Bjerrum
 - Skemton & MacDonald
 - Sower
 - Wilun & Starzewski
 - Boscardin & Cording

Practical Application Cases

※ Construction stage analysis of a temporary structure

- Stability check for a temporary structure
- Number of construction stages: 9 stages
- Strength checks for temporary structure members
- Checking displacements of adjacent structures by construction stages
- Total time taken for modeling & analysis: 30 min.
- Time taken to optimize structural members: 1 hr.

※ Evaluation of effects on adjacent structures due to temporary excavation

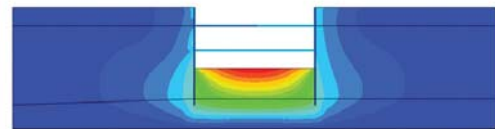
- Stability checks for adjacent structures due to temporary excavation
- Number of construction stages: 9 stages
- Displacement checks for adjacent structures for each construction stage
- Total time taken for modeling & analysis: 30 min.

※ Stability check for a box structure under construction stages

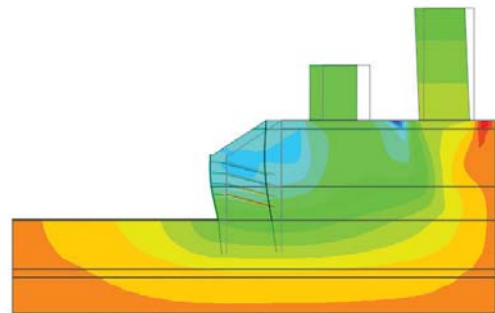
- Stability check for a box structure for each construction stage
- Number of construction stages: 5 stages
- Total time taken for modeling & analysis: 40 min. (including seepage analysis)

※ Bridge abutment construction stage analysis

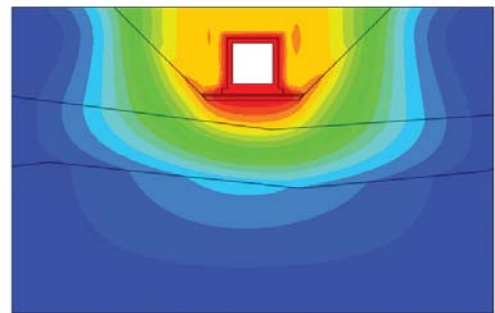
- Stability check against lateral displacement of an abutment due to a high embankment
- Number of construction stages: 4 stages
- Checking displacements of the structure and pile forces
- Total time taken for modeling & analysis: 30 min.



Extent of Effects on an Offshore Structure due to Staged Excavation

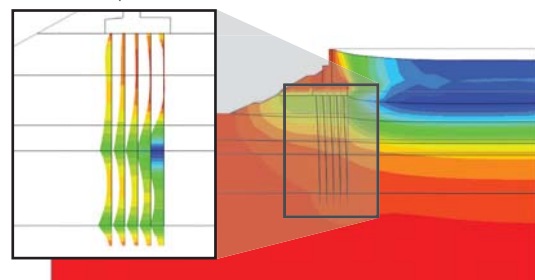


Deformed Shape of Ground due to Temporary Excavation



Final Settlement after Backfilling an Underground Structure

Flexural Compressive Stress of Piles

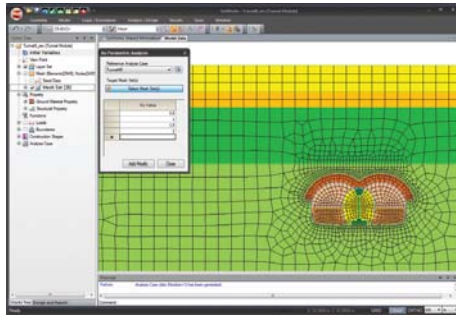


Lateral Displacement of Abutment Foundation
Flexural Compressive Stresses of Piles



Tunnel Design

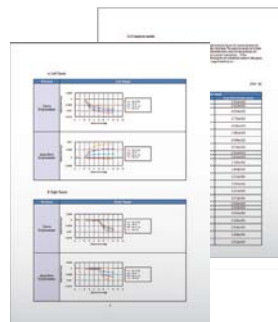
Software Optimized for Tunnel Design & Check



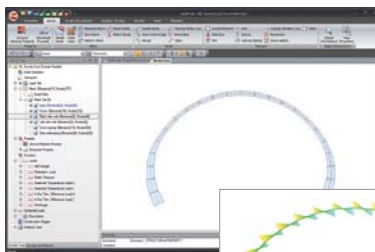
Generation of Multiple Analysis Cases through Variable K_0



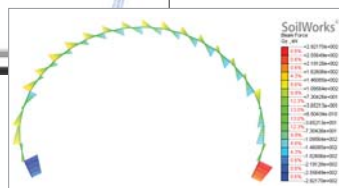
Allowable Displacement & Member Forces of Tunnels



Total Output of Results for K_0 Parametric Analysis



Tapered Sections to accurately Model Lining Shape



Lining Analysis Graphic Results

✿ Design Application Areas

- Stability checks for tunnel reinforcement methods with variation in support patterns
- Lining analysis
- Stability assessment of adjacent structures during construction
- Stability checks due to seepage force by construction stages

✿ Analysis

- Convenient parametric analysis through change in K_0
- Lining analysis reflecting non-prismatic tapered sections
- Construction stage analysis
- Static nonlinear analysis
- Advanced material models such as Elastic/Mohr-Coulomb/Hoek-Brown/Duncan-Chang
- Analysis coupled with seepage analysis results
- Technical Review for checking proper modeling of tunnels

✿ Results & Design

- Menu system tailored to the tunnel analysis & design process
- Auto-reporting of comprehensive results for K_0 parametric analysis
- Production of combined forces & stresses in members
- Generation of a report including tables and diagrams of main result items
- Built-in allowable displacement criteria for adjacent structures
 - Allowable angular displacement by Bjerrum
 - Skemton & MacDonald
 - Sower
 - Wilun & Starzewski
 - Boscardin & Cording

Practical Application Cases

※ Tunnel reinforcement pattern checks

- Tunnel construction stage analysis & rock bolt pattern checks
- Rock Class III, rock bolt pattern 3
- Number of construction stages: 9 stages
- Total time taken for modeling & analysis: 30 min.

※ Evaluation of settlement effects on adjacent structures due to tunnel excavation

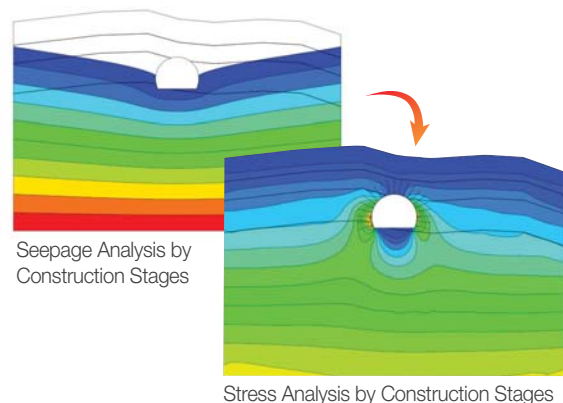
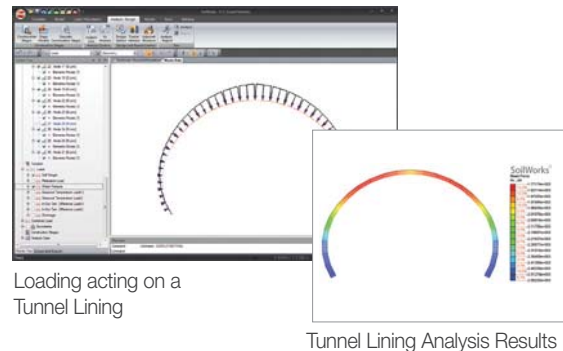
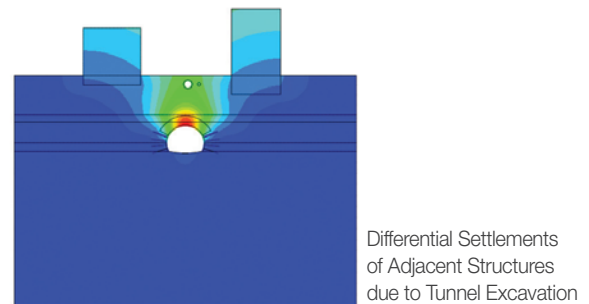
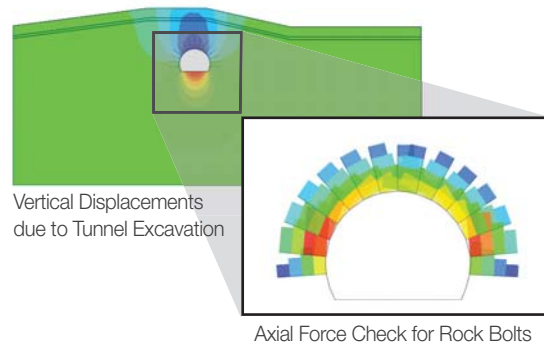
- Checking settlements of existing structures under which a tunnel is excavated
- Distance between the structures and the tunnel crown: 16m
- Number of construction stages: 10 stages
- Total time taken for modeling & analysis: 30 min.

※ Tunnel Lining Analysis

- Structural analysis of tunnel lining for section design
- Static nonlinear analysis (beam & spring model)
- Generation of load combinations and service loads for structural design
- Evaluation of lining for adequacy
- Total time taken for modeling & analysis: 30 min.

※ Seepage-Stress Coupled Analysis

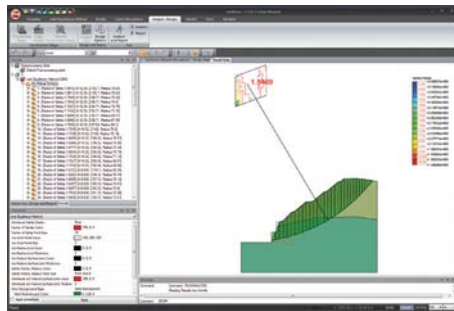
- Checking rock bolts reflecting changes in ground water level during tunnel excavation
- Number of construction stages: 8 stages
- Checking displacements & member forces of tunnel reinforcement & rock bolts
- Total time taken for modeling & analysis: 40 min. (including seepage analysis)



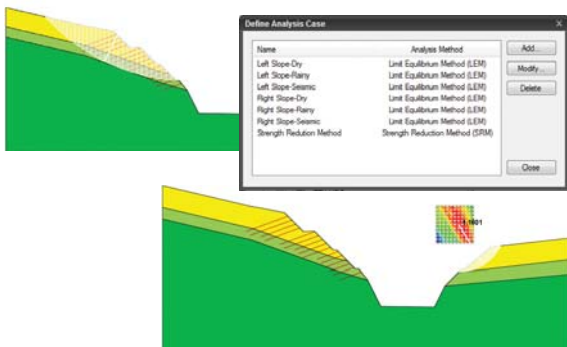


Slope Analysis & Design

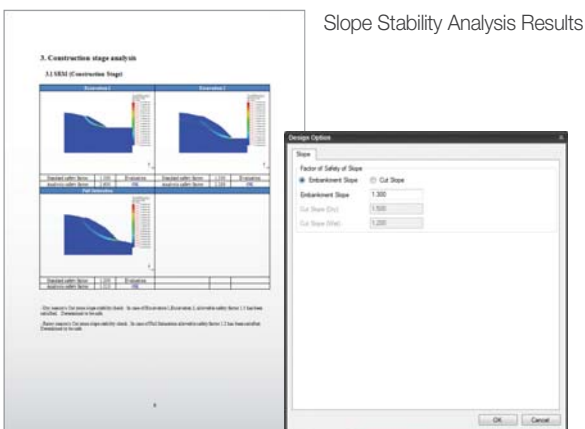
Various Analysis Methods Implemented for Optimal Design of Slopes



Limit Equilibrium Analysis of a Cut Slope



Limit Equilibrium Analysis of Slopes at a Gallery Entry



Estimation of safety factor considering slope formation condition

Design Application Areas

- Stability checks for cut slopes
- Stability checks for banked slopes
- Checking limit embankment heights underlain by soft grounds
- Lateral movement of a bridge abutment foundation reflecting the effect of piles
- Slope stability checks considering the intensity of precipitation
- Stability check for dams/levees

Analysis

- Simultaneous analyses for dry/rainy seasons and in earthquake conditions
- Expected failure surface intuitively checked prior to performing analysis
- Auto-generation of circular arc sliding surface, non-circular arc sliding surface and automatic failure surface
- Simultaneous calculations of safety factors for limit equilibrium analysis and shear strength reduction analysis within a same model
- Calculation of safety factors reflecting changes in stress by construction stages
- Technical Review for checking proper modeling of slopes
- Limit equilibrium analysis reflecting the intensity of precipitation or seepage effects
- Limit equilibrium analysis reflecting the increase in strength due to 1D consolidation
- Practical reinforcement materials (Nail/Pile/Anchor/Strip/Strut)

Results & Design

- Effectively simplified repetitive tasks of compiling results using Smart Results
- Simultaneous analyses of various conditions for reinforced /unreinforced slopes and dry/rainy seasons
- Generation of a report including tables and diagrams of main result items
- Evaluation of stability check results considering slope formation condition

Practical Application Cases

※ Construction stage analysis

- Evaluation of slope stability for each excavation stage
- Simultaneous analyses of limit equilibrium/strength reduction for a given slope section
- Calculations of safety factors by construction stages
- Total time taken for modeling & analysis
 - Limit Equilibrium Method analysis (LEM): 5 min.
 - Strength Reduction Method analysis (SRM): 15 min.

※ Evaluation of lateral movement of a bridge abutment (piles considered/un-considered)

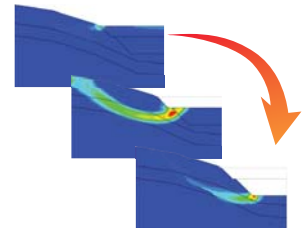
- Lateral displacements of an abutment with and without the presence of piles
- Analyzed by Limit Equilibrium Method (LEM) & Strength Reduction Method (SRM)
- Total time taken for modeling & analysis
 - Limit Equilibrium Method analysis (LEM): 5 min.
 - Strength Reduction Method analysis (SRM): 10 min.

※ Evaluation of slope stability reflecting the intensity of precipitation

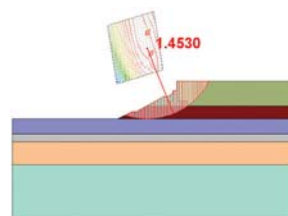
- Seepage analysis reflecting the intensity of precipitation
- Limit equilibrium analysis coupled with seepage analysis results
- Slope stability checks by strength reduction method due to seepage forces
- Total time taken for modeling & analysis
 - Seepage analysis: 10 min.
 - Limit Equilibrium Method analysis (LEM): 5 min.
 - Strength Reduction Method analysis (SRM): 15 min.



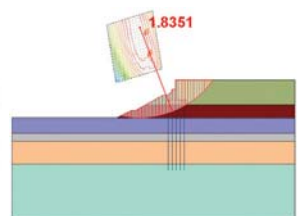
Changes in Safety Factors by Construction Stages (LEM)



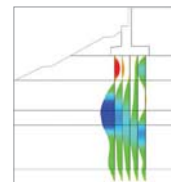
Changes in Failure Surfaces by Construction Stages (SRM)



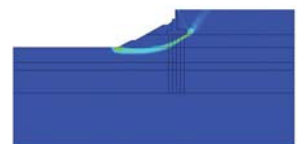
Limit Equilibrium Analysis without the Effects of Piles



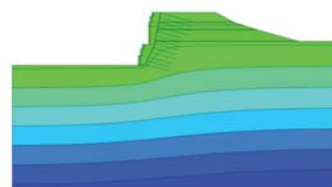
Limit Equilibrium Analysis with the Effects of Piles



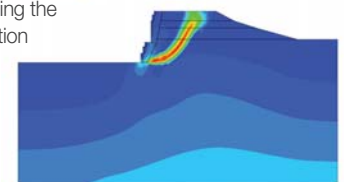
Flexural Compressive Stresses of Piles



Strength Reduction Analysis with the Effects of Piles



Seepage Analysis reflecting the Intensity of Precipitation

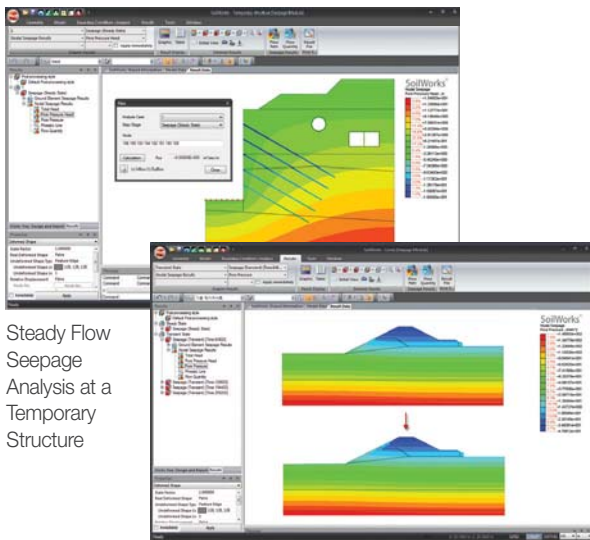


Slope Stability Check using Seepage Analysis Results



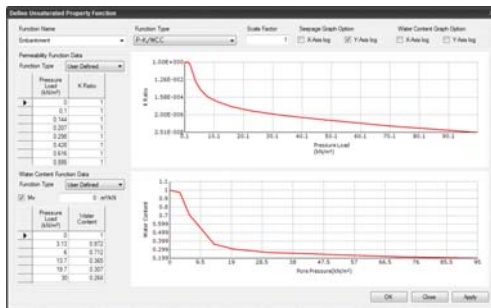
Seepage Analysis & Design

Software Coupling Seepage Analysis Results with All Other Analyses

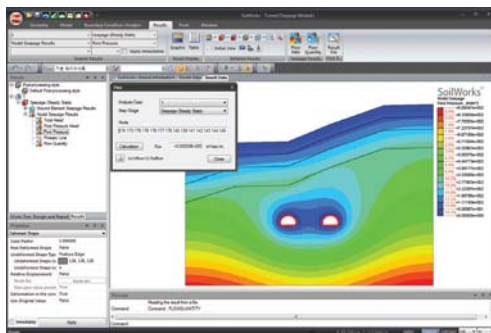


Steady Flow Seepage Analysis at a Temporary Structure

Transient Flow Seepage Analysis for a Levee



Unsaturated Function Property Curves



Flux Analysis due to Tunnel Excavation

✳ Design Application Areas

- Seepage & flux analysis for tunnel construction stages
- Seepage analysis for a cut slope reflecting the intensity of precipitation
- Seepage analysis for dams & levees at a flood water level and at a suddenly dropped water level
- Evaluation for suitability of cut-off wall construction
- Pump capacity design for excavation for temporary structures and foundations

✳ Analysis

- Various permeability coefficient functions and function property curves
- Consideration of saturated & unsaturated grounds
- Steady flow seepage analysis
- Transient seepage analysis
- Reflection of upward/downward seepage forces
- Construction stage analysis & slope stability analysis coupled with pore water pressure & effective stress calculated from seepage analysis

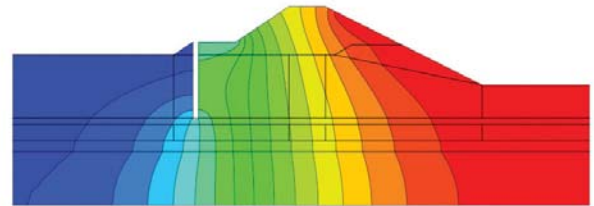
✳ Results & Design

- Calculation of drainage capacity for seepage into tunnels
- Calculation of ground water drawdown and outflow flux due to excavation
- Prediction of changes in ground water level due to the intensity of precipitation
- Prediction of ground water level & calculation of current speed in a levee at the flood water level
- Prediction of changes in ground water level in a dam at the full water level
- Calculation of ground water level to be coupled with stress analysis or limit equilibrium analysis

Practical Application Cases

※ Cut-off wall driven depth check

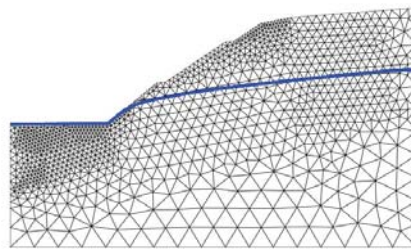
- Checking the optimal embedded depth of a sheet pile
- Checking the outflow speed at the protected side of a levee after construction
- Total time taken for modeling & analysis: 20 min.



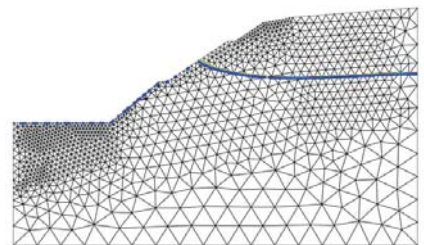
Seepage Analysis Results due to the Cut-off Effect

※ Calculation of ground water level reflecting the intensity of precipitation at a cut slope

- Checking slope stability after predicting the ground water level due to the intensity of precipitation
- Prediction of changes in ground water level by different intensities of precipitation
- Total time taken for modeling & analysis: 20 min.



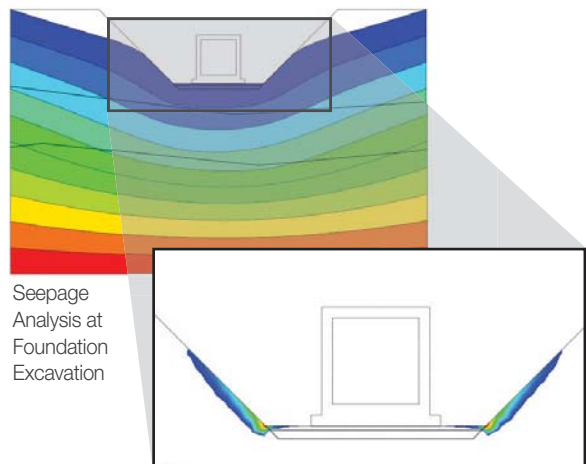
Change in Ground Water Level at a Cut Slope



Change in Ground Water Level due to Intense Precipitation

※ Checking outflow flux during foundation excavation

- Calculation of outflow flux during excavation for foundation constructed near a river
- Calculation of the number of pumps and capacity based on the prediction of outflow flux during construction
- Total time taken for modeling & analysis: 20 min.



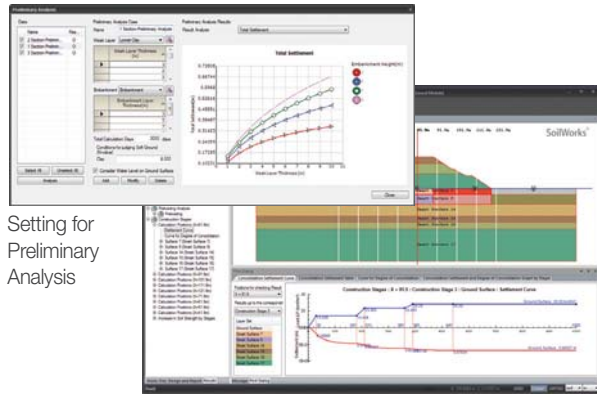
Seepage Analysis at Foundation Excavation

Outflow Flux at the Base of Foundation



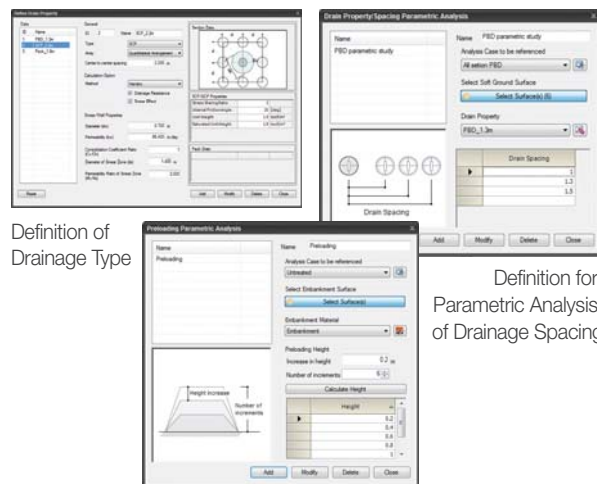
Soft Ground Analysis & Design

Effective Software for Optimal Design of Soft Ground



Setting for Preliminary Analysis

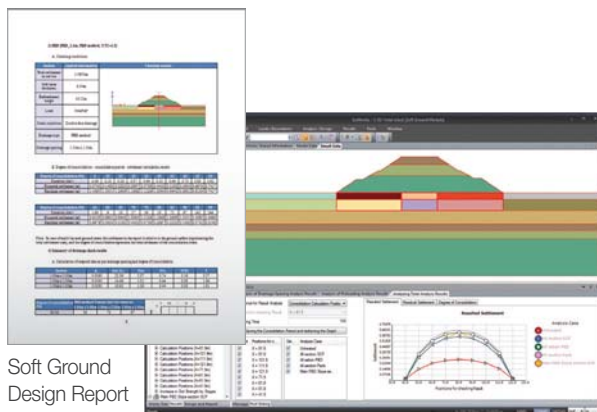
Consolidation Settlement Results for Construction Stages



Definition of Drainage Type

Definition for Parametric Analysis of Drainage Spacing

Definition for Parametric Analysis of Preloading Height



Soft Ground Design Report Generation

Analysis of Total Settlement Results by Construction Methods

Design Application Areas

- Calculations of primary & secondary consolidation settlements in soft clay
- Calculation of immediate settlements in sandy soils
- Checking accelerated consolidation by improvement methods
- Calculation of preloading heights
- Calculation of construction periods of staged embankments as per consolidation management
- Calculation of limit embankment heights (slope coupled analysis) reflecting the strength increase for each staged embankment
- Checking drainage functionality & drivability of equipment
- Stability checks for adjacent structures using FEM consolidation analysis by construction stages

Analysis

- Preliminary analysis of settlement pertaining to soft layer thickness – embankment height
- Primary consolidation settlement analysis pertaining to construction stages and one time embankment
- Parametric analysis for drainage types and spacing
- Parametric analysis for preloading heights
- Calculation of the increase in the strength of soft ground for each construction stage
- Calculation of an immediate settlement of soft sandy soils
- Simultaneously checking the 1-D consolidation theory & finite element analysis
- Advanced soft ground material models such as MCC model & S-O model
- Supporting practice oriented drainage (PBD, SCP, GCP, SD, Pack Drain, CD & Fiber)
- Technical Review for checking proper modeling of soft grounds

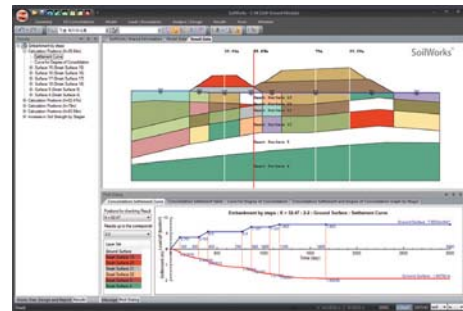
Results & Design

- Effectively simplified repetitive tasks of compiling results using Smart Results
- Comparative analysis of the results of various improvement methods intuitively
- Stability checks for adjacent structures by FEM consolidation analysis
- Design option function for evaluating the allowable residual settlements of soft grounds
- Calculation of construction periods of staged embankments as per consolidation management

Practical Application Cases

※ 1-D consolidation analysis for staged embankment

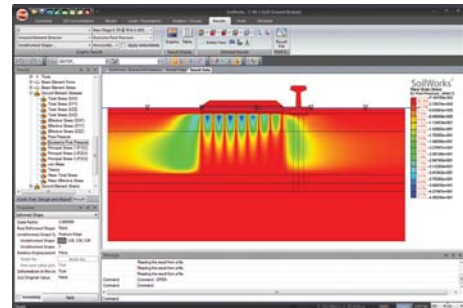
- Checking time-settlement based on staged embankments
- Settlement check due to additional embankment for road widening
- Applied improvement method: PBD+SCP
- Number of embankment stages: 4 stages
- Total time taken for modeling & analysis: 10 min.



Results of Construction Stage Consolidation Analysis (Time – Settlement)

※ FEM consolidation analysis using MCC model

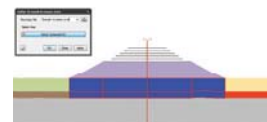
- Consolidation analysis in construction stages using Modified Cam Clay model
- Checking the settlement effect of an existing road due to additional embankment
- Checking a settlement prevention method using sheet piles
- Total time taken for modeling & analysis: 30 min.



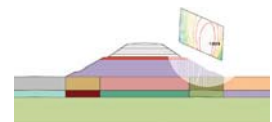
Excess Pore Water Pressure Distribution

※ Checking limit embankment heights reflecting the increase in strength

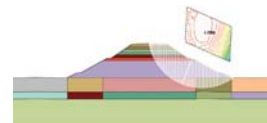
- Increase in strength calculated for each embankment stage
- Limit equilibrium analysis performed to calculate the limit embankment height at each stage
- Total time taken for modeling & analysis: 30 min.
 - 1-D consolidation analysis: 10 min.
 - Limit equilibrium analysis: 20 min.



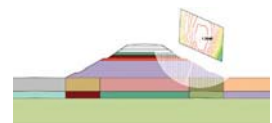
Defining Zones to be Considered for Increases in Strength



Slope Stability Analysis for an Additional Embankment of 1m in Height



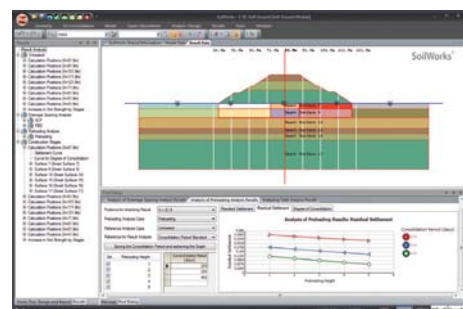
Slope Stability Analysis for an Additional Embankment of 6m in Height



Slope Stability Analysis for an Additional Embankment of 3m in Height

※ Calculation of pre-loading height

- Residual settlement checks based on pre-loading heights
- Pre-loading heights: 0.5m / 1.0m / 1.5m
- Total time taken for modeling & analysis: 10 min.

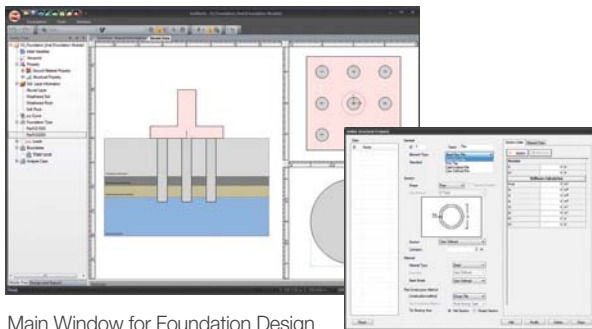


Analysis of Results for Residual Settlement Checks for Varying Pre-loading Heights



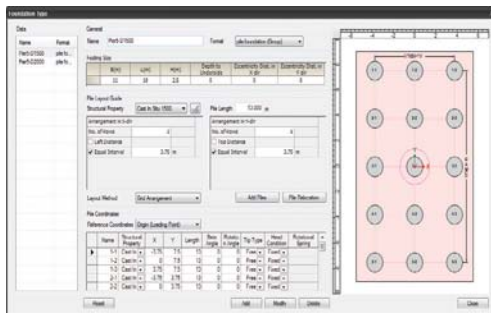
Foundation Analysis & Design

Selection of Practical Foundation Type & Deliverables Oriented

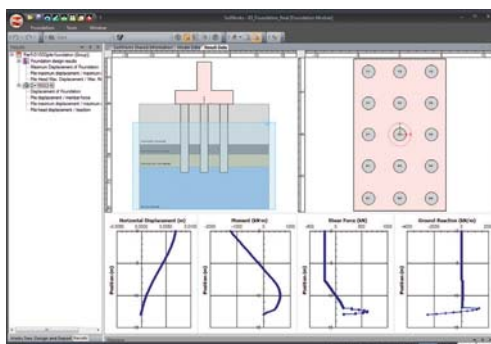


Main Window for Foundation Design

Steel Pipe Pile
Section Database



Definition of Pile Spacing



Pile Arrangement & Analysis Results

Design Application Areas

- Vertical stability checks for pile foundations
- Horizontal stability checks for pile foundations
- Pile foundation design based on P-y analysis (single/group piles)

Analysis

- Settlement checks simultaneously performed for various foundation types & sizes under given ground conditions
- Pile foundation displacement checks using P-y analysis (single/group piles)
- Analysis reflecting pile head conditions (fixed/hinged)
- Preliminary analysis using the ground and structural material database and structural section database built into the program

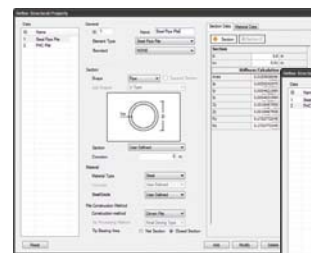
Results & Design

- Calculation of pile member forces by P-y analysis
- Auto-generation of report for the results of P-y analysis
- Flexible manipulation of pile layout in group piles
- Report of result analysis due to the difference between the pile specification and construction method
- Intuitive graphical results for pile member forces and ground reactions

Practical Application Cases

❖ Comparison of single pile member forces between piles of different specifications

- Checking member forces for determining pile type/shape/size/material for a single pile
- Steel pipe pile D=508mm, t=12mm vs PHC pile D=500mm, t=80mm
- Total time taken for modeling, analysis & report generation: 20 min.



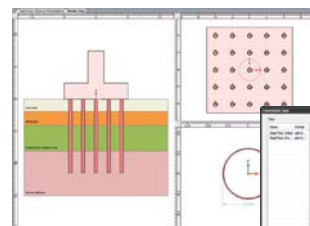
Steel Pipe Pile Selected



PHC Pile Selected

❖ Comparison of displacements between different pile construction methods

- Comparison of displacements for steel pipe piles under different construction methods
- Steel pipe pile D=508mm, t=12mm @ 5x5 spacing
- Comparison of displacements between driven and augered piles
- Total time taken for modeling, analysis & report generation: 20 min.



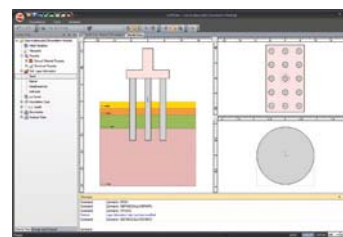
Steel Pipe Pile Layout



Pile Layout Dependent of Construction Method

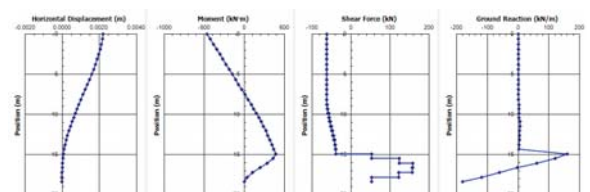
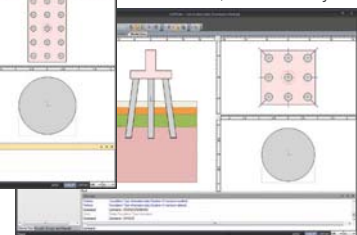
❖ P-y analysis for exposed offshore piles

- Checking for selection of pile type/shape/size/material & optimal layout of offshore pile foundation
- 15 Driven piles with D=1,500mm vs 9 driven piles with D=2,000mm
- Horizontal stability check by P-y nonlinear analysis for each pile
- Total time taken for modeling, analysis & report generation: 30 min.



15 - 1,500 Dia. Layout

9 - 2,000 Dia. Layout

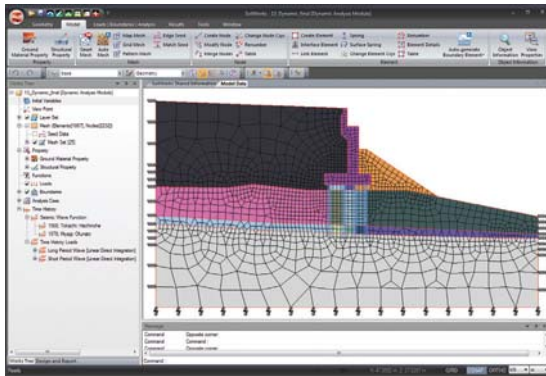


Offshore Pile Foundation Check

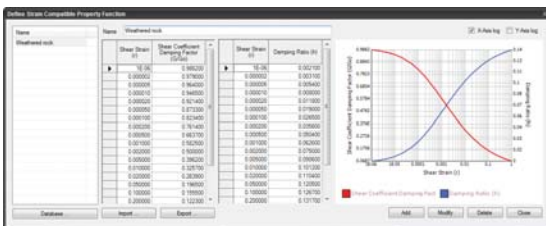


Dynamic Analysis & Seismic Design

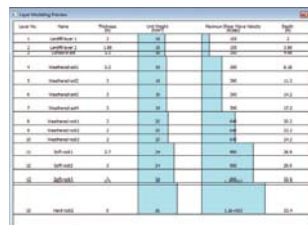
Software for Setting the Standard for Advanced Dynamic Analysis



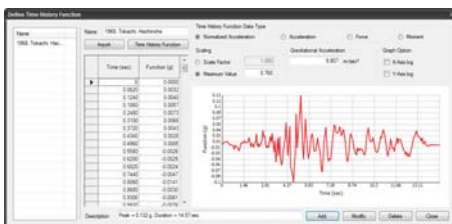
Seismic Design Check for Abutment Foundation



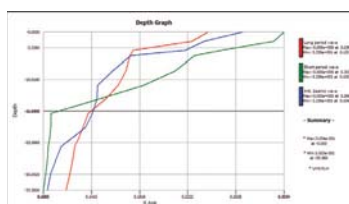
Dynamic Nonlinear Properties of Ground



Composition of Ground Layers for Analysis



Database of Historical Seismic Waves



Checking Maximum Accelerations for Ground Layers through Depths

Design Application Areas

- Calculation of maximum accelerations for ground layers through depths for checking liquefaction of soft sands
- Seismic analysis using various earthquake history records and artificial seismic waves
- 2-D equivalent linear analysis reflecting soil-structure interaction
- Time history analysis reflecting train vibration loads
- Evaluation of vibration effects due to blast loads

Analysis

- 1-D ground response analysis
- 2-D equivalent linear (SSI) analysis
- Time history dynamic analysis (linear)
- Response spectrum analysis
- Auto-generation of elastic boundary elements for ground springs
- Auto-generation of viscous boundary elements for damping constants
- Auto-generation of response spectrums
- Built-in historical seismic waves (long period & short period waves) for practical design
- Built-in database of worldwide earthquake records & auto-generation of seismic waves

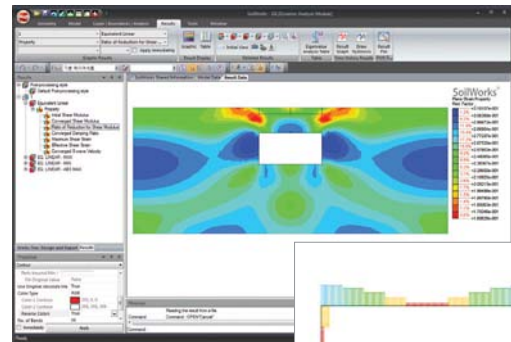
Results & Design

- Calculation of maximum accelerations for ground layers through depths by 1-D ground response analyses
- Calculation of member forces of underground structures by 2-D equivalent linear (SSI) analysis
- Seismic analyses of slopes & bridge foundations using design seismic waves
- Calculation of maximum vibrations of adjacent structures due to blast & vibration loads
- Calculation of maximum displacements of structures under design using seismic waves

Practical Application Cases

❖ Evaluation of seismic performance of underground structure using SSI analysis

- Soil-structure interaction analysis of underground structure performed
- Applied load: historical seismic wave (long period wave)
- Total time taken for modeling & analysis: 30min.
 - Modeling: 20 min.
 - Analysis: 10 min.



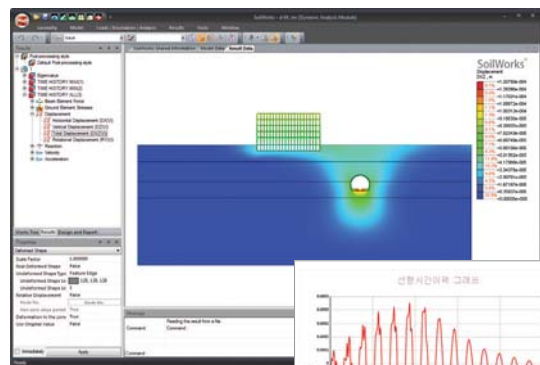
Shear Modulus Damping Ratio due to Soil-Structure Interaction



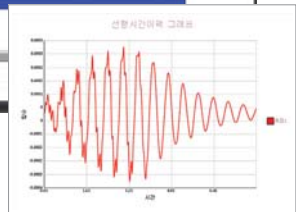
Structural Member Forces

❖ Evaluation of vibration effects on adjacent structure due to train vibration

- Vibration on adjacent structure due to new subway construction
- Applied load: time history load for train vibration
- Total time taken for modeling & analysis: 30min.
 - Modeling: 20 min.
 - Analysis: 10 min.



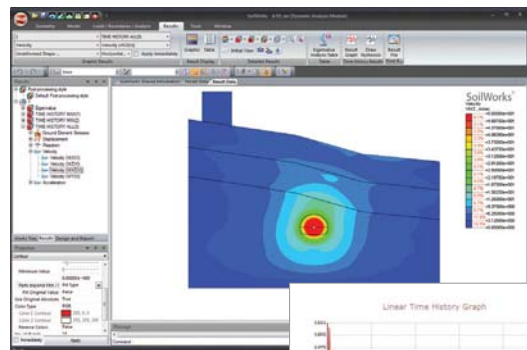
Evaluation of Adjacent Structure under Train Moving Load



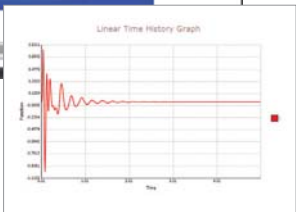
Vibrations of Structure Base with Time

❖ Evaluation of vibration effects on adjacent structure due to blast loads

- Effects on adjacent structure due to rock blasting for tunnel construction
- Applied load: blast load
- Total time taken for modeling & analysis: 30min.
 - Modeling: 20 min.
 - Analysis: 10 min.



Evaluation of Blast Vibration of Adjacent Structure



Vibrations of Structure Base with Time

Coupled Analyses in Various Fields

Software Optimized for Flexible & Rational Coupled Analyses

Practical Application Cases

- Optimal design performed by simulating in-situ conditions and ground conditions
 - Reflect changes in ground stress from changes in ground water level during excavation
 - Evaluate slope stability accounting for increases in strengths of underlying ground layers due to embankments
- Coupled analyses in various application fields share common data for geometry, mesh and ground & structural properties, requiring no additional modeling process.

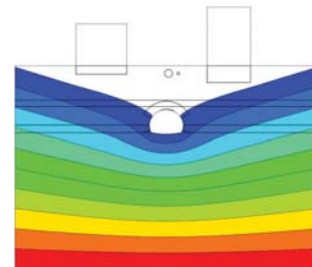


Seepage-Stress Coupled Analysis

- Stability & strength checks for reinforcement reflecting changes in ground water level during tunnel excavation
- Pore water pressures & seepage forces at steady/transient states considered
- Number of construction stages: 10 stages
- Checking displacements & member forces of temporary reinforcement, rock bolts, lining, etc.
- Total time taken for modeling & analysis: 40 min. (including seepage analysis)



SEEPAGE



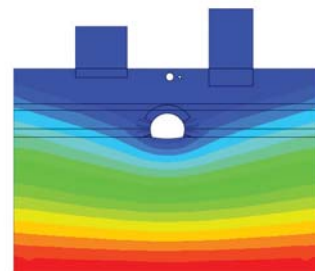
Perform Seepage Analysis for Tunnel Excavation



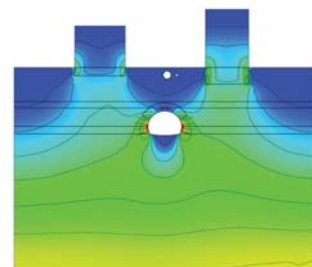
GROUND



Extract Pore Water Pressure from Seepage Analysis



Reflect Pore Water Pressure Results into Stress Analysis



Ground Effective Stress Calculated

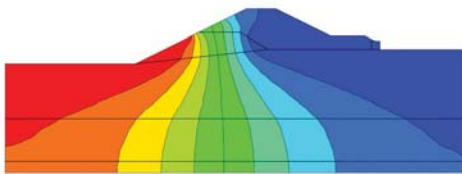


Slope Stability Check reflecting Changes in Water Level

- Seepage analysis performed reflecting changes in water level
- Limit equilibrium analysis coupled with seepage analysis results
- Slope stability check by strength reduction method reflecting seepage forces
- Total time taken for modeling & analysis
 - Seepage analysis: 10 min.
 - Limit Equilibrium Method analysis (LEM): 5 min.
 - Strength Reduction Method analysis (SRM): 15 min.



SEEPAGE



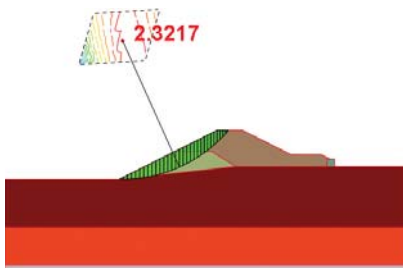
Perform Seepage Analysis for Changes in Water Level



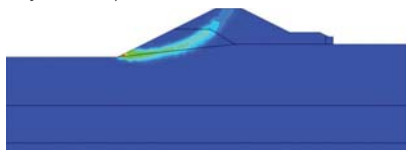
SLOPE



Extract Pore Water Pressure from Seepage Analysis



Reflect Pore Water Pressure Results into
LEM Analysis of Slope



Reflect Pore Water Pressure
Results into SRM Analysis of Slope

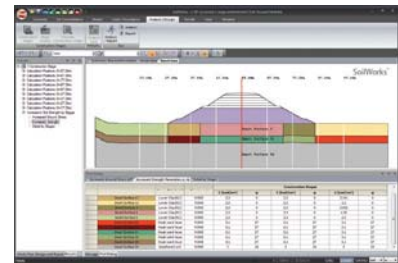


Limit Embankment Height Check reflecting Increases in Strengths

- Calculate increases in strengths for each embankment stage
- Perform limit equilibrium analysis in order to calculate limit embankment height for each stage
- Total time taken for modeling & analysis
 - 1-D consolidation analysis: 10 min.
 - Limit Equilibrium Method analysis (LEM): 10 min.



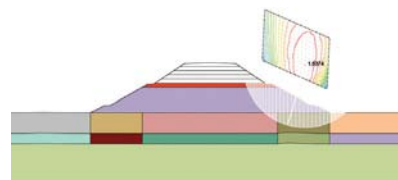
SOFT
GROUND



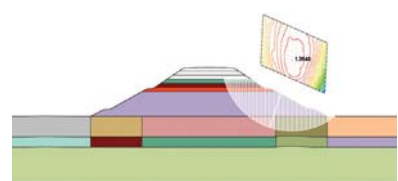
Increase in Strength for each Ground Layer
after Consolidation Analysis



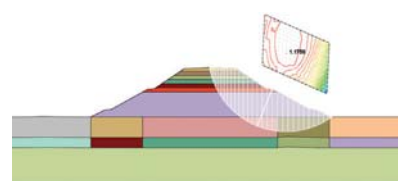
SLOPE



Slope Stability Analysis for an Additional
Embankment of 1m in Height



Slope Stability Analysis for an Additional
Embankment of 3m in Height



Slope Stability Analysis for an Additional
Embankment of 6m in Height

a total satisfaction support system

“e-Learning Webinars & Fast Technical Support”

SoilWorks eliminates significant efforts to learn various different software programs of different user interfaces to solve a wide range of geotechnical problems. One user interface is common to all the analysis modules to handle any type of geotechnical problems. SoilWorks streamlines the technical support and the maintenance of the software, and further, data exchange and management are consistent because one company has developed all the modules.

SoilWorks is designed to cater to geotechnical engineers as well as structural engineers, which provides the opportunity to expand the areas of solving geotechnical problems. It also enables the engineers to address soil-structure interaction.



E-mail Technical Support

The user may send any technical questions to eSupport@MidasUser.com. Response will be provided within 24 hours.



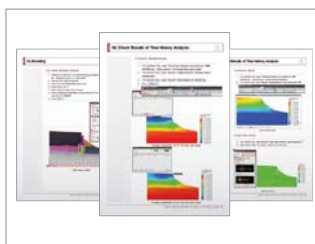
Online Technical Support

Upon request of the user, an arrangement will be made to guide/instruct/demonstrate the use of the software online through a web session.



Technical Webinars

Regularly scheduled webinars are provided to cover various subjects of geotechnical and/or structural problems in interaction. Recordings will be made available for those who wish to review or missed the sessions.



Technical Materials

Various subjects on technical materials and tutorials are provided to help the user become familiar with technical subjects and the use of the software.



For any enquiries on the functionality and sales support,
contact: sales@MidasUser.com

M E M O

SoilWorks[®]
Geotechnical Solutions for Practical Design

GEOTECHNICAL SOLUTIONS FOR PRACTICAL DESIGN

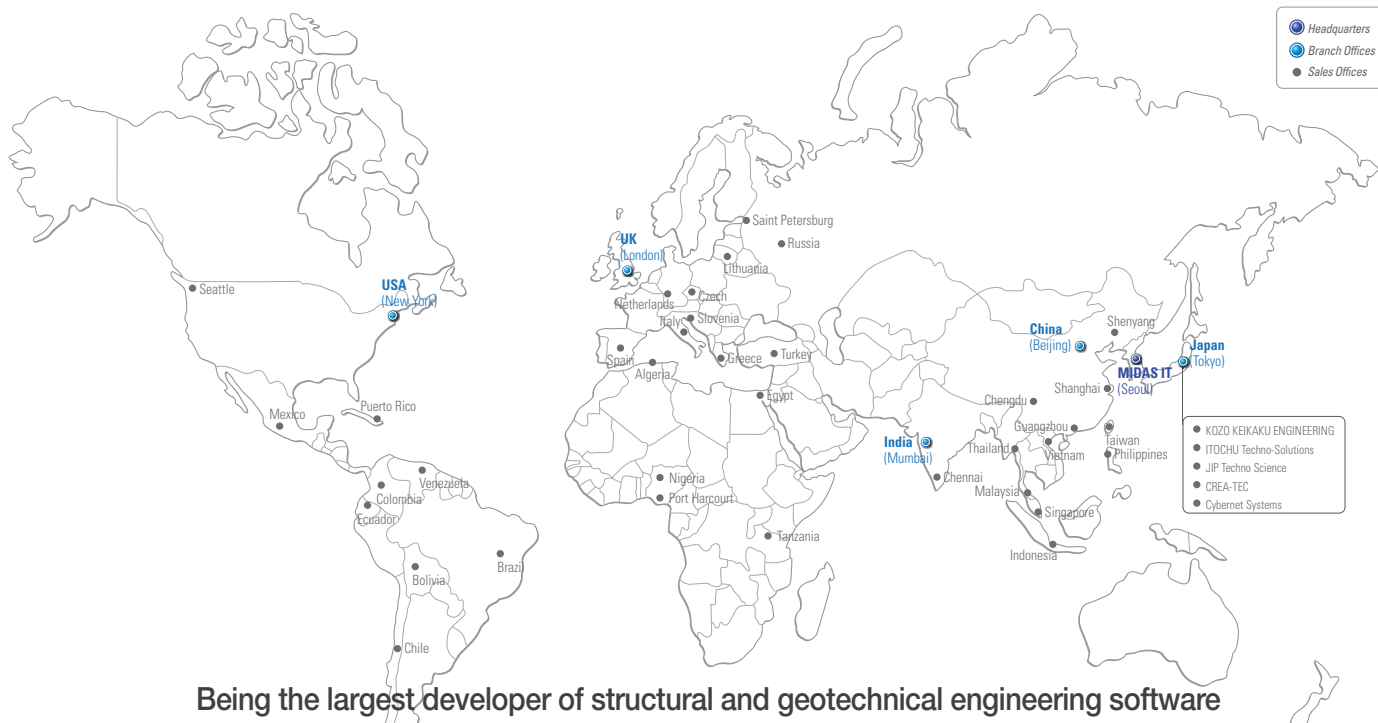
<http://en.midasuser.com>

SoilWorks

SLOPE PACKAGE

GEOTECHNICAL SOLUTION
FOR PRACTICAL DESIGN

A LEADING GLOBAL Engineering Solutions Provider



Being the largest developer of structural and geotechnical engineering software with extensive research in leading technologies in the world, MIDAS has garnered global recognition through its continuous passion and devotion towards the Advancement in Civil Engineering.

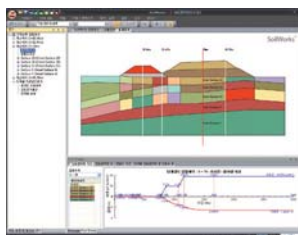
a total of over 30,000 MIDAS software licenses used worldwide in over **120** countries

a global network of engineering software distribution and technical support

over 450 engineers and professionals develop and distribute engineering software

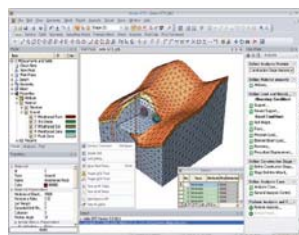
❖ Introducing geotechnical finite element programs

a New Paradigm for
Geotechnical Engineering Solutions, all in one package



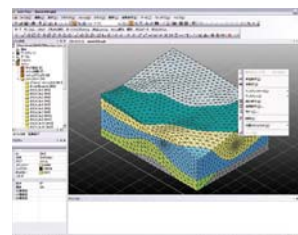
SoilWorks

2 Dimensional geotechnical analysis modules



midas GTS

3 Dimensional geotechnical analysis modules



Soil+

(CTC in Japan)

Slope Package



Applications

- 01 Slope Stability (LEM / SRM / SAM)
 - Stability with construction stage
 - Seepage – Slope coupled analysis
- 02 Lateral displacement of pier and abutment
- 03 Steady state / Transient seepage analysis
- 04 Design impermeable wall for embankment
- 05 Critical height of embankment considering increase in strength of softground
- 06 Stability of rock slope – stereographic analysis of discontinuities
- 07 Plane / Wedge failure of rock slope
- 08 Reinforcement / Improvement method check for slope and softground
- 09 Settlement of softground with parametric study (Drain spacing / Preloading)
- 10 Seepage-Softground-Slope coupled analysis

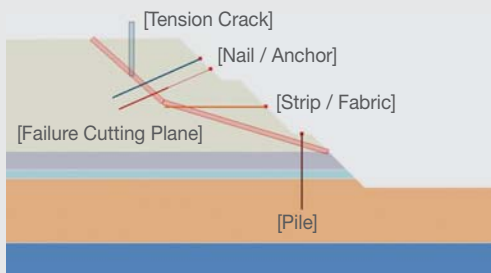


SoilWorks Slope

Slope Stability Analysis

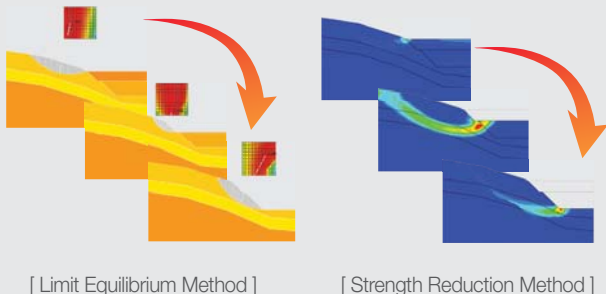
Limit Equilibrium Method

- Define composite failure surfaces
- Reinforcing effect by reinforcement types and behavior
- Various analysis method for accurate result



Staged Slope Stability Analysis

- Staged analysis for cut / fill slope
- Stress / strain distribution of ground
- Design reinforcement force



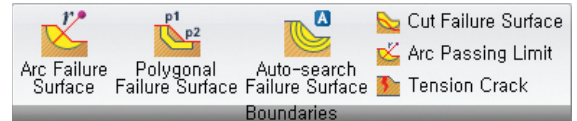
Report Generation

- Result summary for all of analysis cases
- Provide result tables and images in single document

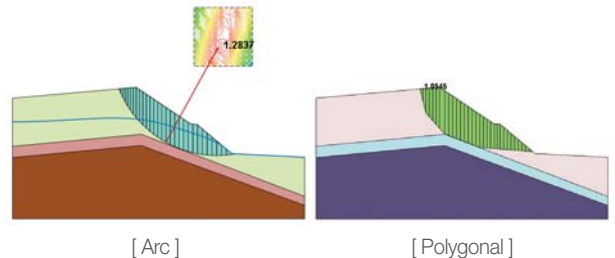


1. Define Failure Surfaces

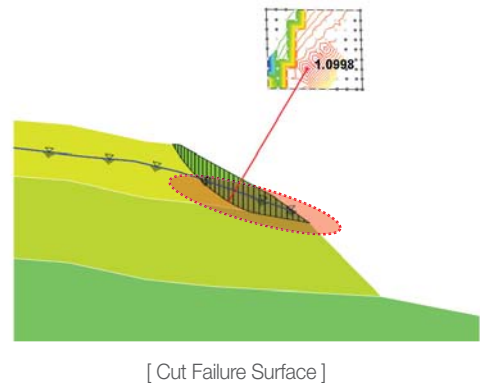
| Composite Failure Surfaces



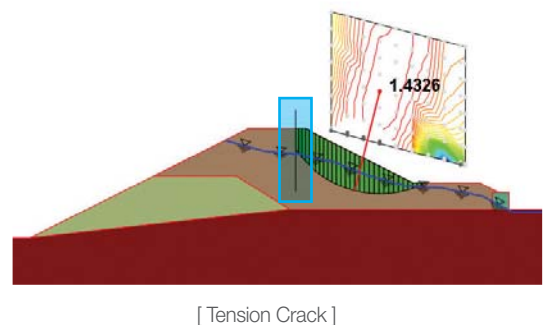
- Arc / Polygonal / Auto-search failure surface



- Cut failure surface / Arc passing limit



- Tension crack (Auto Search)
- Water pressure acting on tension crack

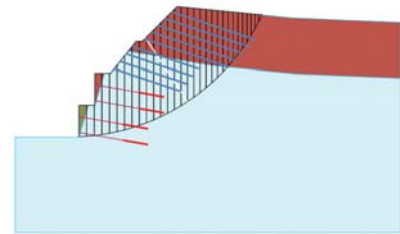




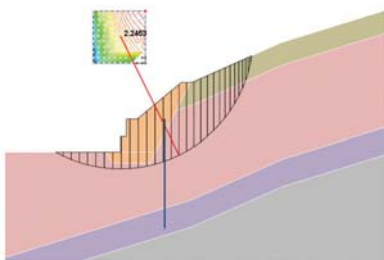
2. Reinforcement

Define Reinforcing Effect with Reinforcement Types

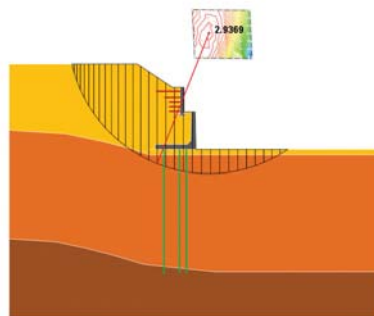
- Nail / Pile / Anchor / Fabric (Geogrid) / Strip / Strut
- Tensile force / Pullout force / Shear force / Frictional resistance / Compressive force
- Consider rigid or flexible behavior



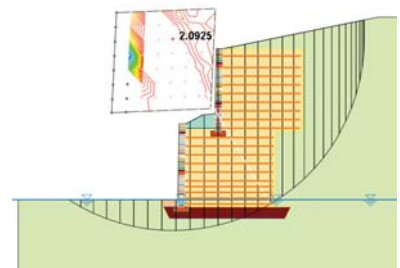
[Nail + Anchor]



[Pile]



[PHC Pile]



[Geogrid]

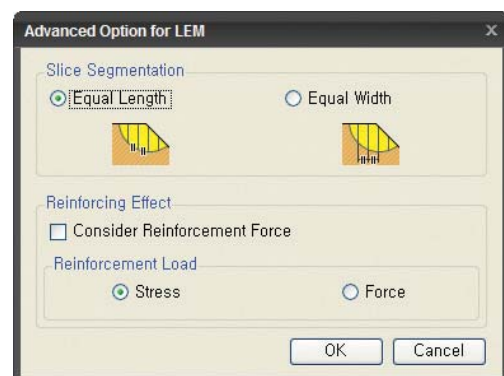
3. Analysis Methods / Options for LEM

Advanced Analysis Methods

- Simplified methods : Bishop / Fellenius / Janbu
- Advanced methods : Spencer / Morgenstern – Price / Sarma
 - Satisfy force (Vertical / Horizontal) and moment equilibrium

Advanced Analysis Options

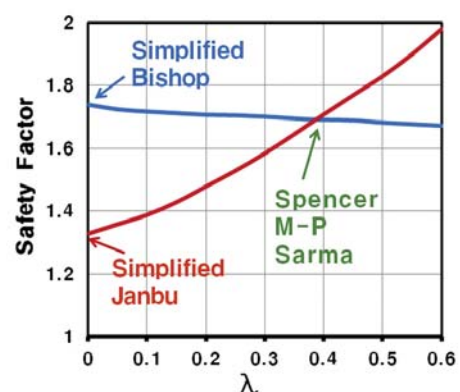
- Slice segmentation – Equal length / Equal width
- Reinforcement load – Stress / Force



[Advanced Option for LEM]

Analysis Method	Strength	Weakness
Simplified Bishop	• Short analysis time • Applicable to arc / Polygonal	• Inaccurate result when horizontal force is acting (i.e., seismic load)
Simplified Janbu	• Short analysis time • Suitable for shallow slope	• More conservative result
Spencer	• Applicable to arc / Polygonal • More accurate safety factor	• Longer analysis time • More sensitive convergence
Morgenstern-Price	• Predictable internal normal force • More accurate safety factor	• Longer analysis time • More sensitive convergence
Sarma (vertical)	• Suitable for rock slope analysis • More accurate safety factor	• Longer analysis time • More sensitive convergence • Assumption needed for cohesive strength and friction angle

[Comparison of Analysis Methods]



[Variation of FS with the ratio of Ver. to Hori. Slice Force]



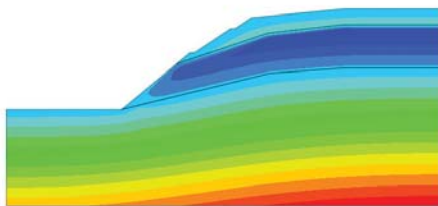
SoilWorks Slope

4. Coupled Analysis for Slope Stability

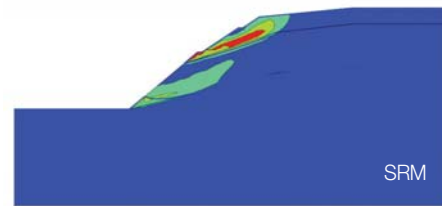
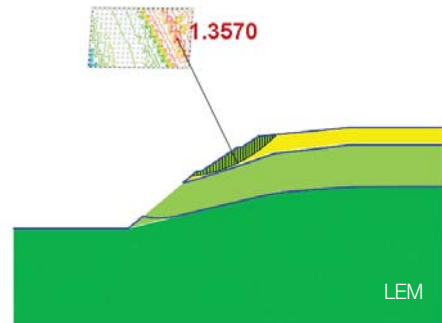
| Seepage-Slope Coupled Analysis



- Effect of rainfall intensity and duration
- Limit Equilibrium Method : P.W.P from seepage analysis
 - Safety factor according to the failure surfaces
- Strength Reduction Method : P.W.P from seepage analysis
 - Maximum shear strain and stress with safety factor



[Distribution of Pore Water Pressure]

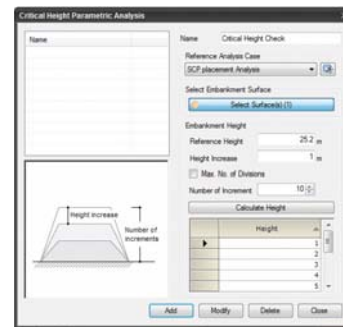


[Slope Stability during and after Rainfall]

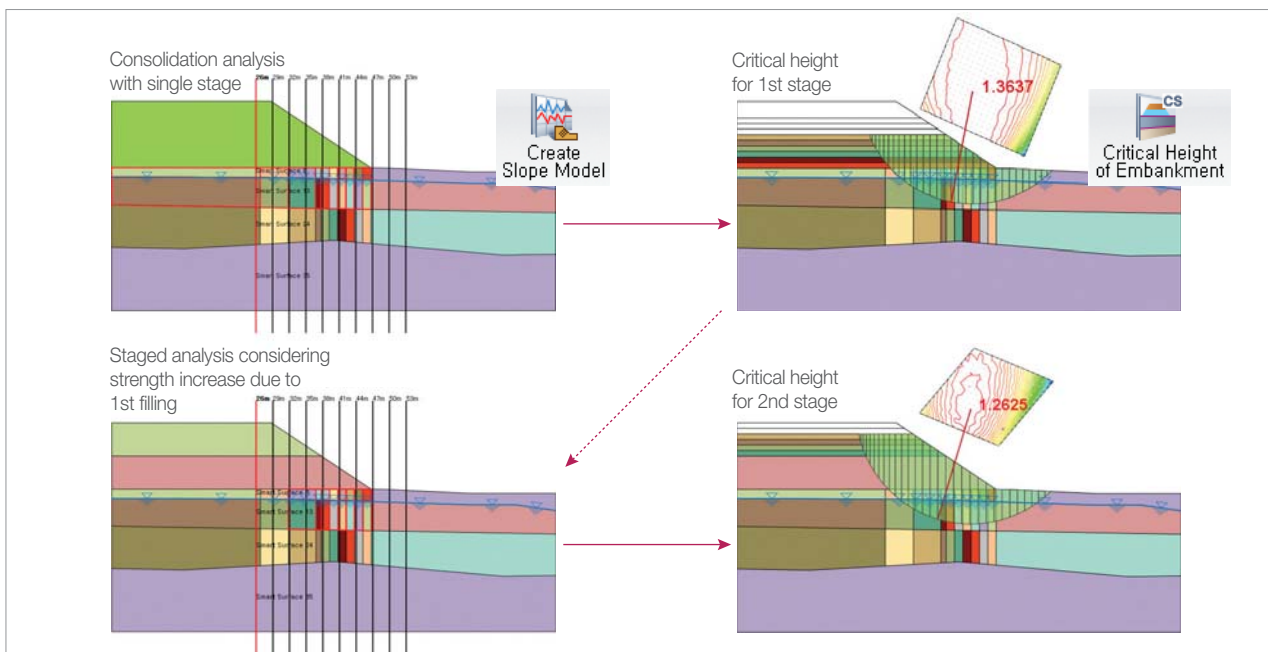
| Softground-Slope Coupled Analysis



- Check critical height of embankment over softground
 - Divide surface and create analysis case for each increase of embankment automatically
 - Take account of strength increase of softground
 - Check critical height for each construction stage



[Critical Height of Embankment]



[Check Critical Height for Each Construction Stage]



SoilWorks Seepage

1. Seepage Analysis

| Effect of Rainfall with Infiltration Rate

- Define unit flux with seepage rate
- Seepage rate according to the slope inclination
 - Slope inclination vs Seepage rate (Unit flux reduction factor)

Surface Flux

Value: m³/sec/m²

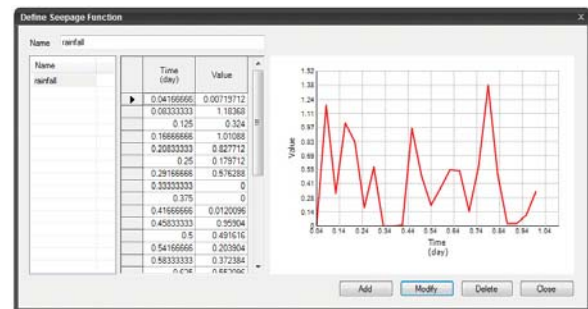
Function:

Seepage Rate

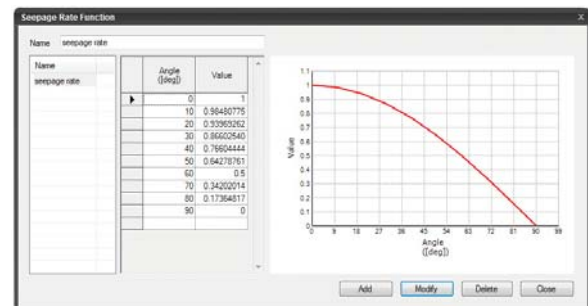
Value:

Function:

[Unit Flux / Seepage Rate]



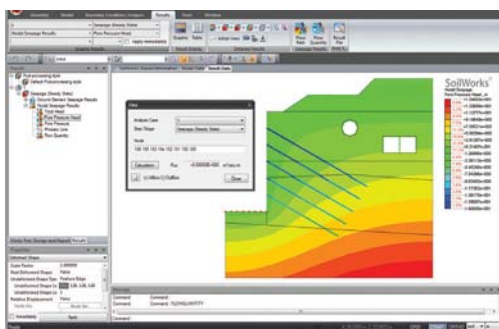
[Seepage Function (value with time)]



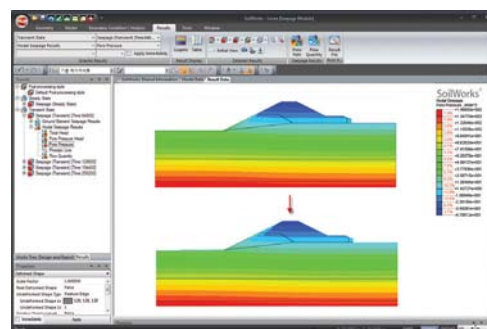
[Seepage Rate Function (value with degree)]

| Application of Seepage Analysis

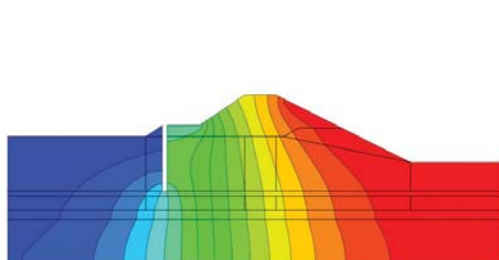
- Saturated / Unsaturated property of ground
- Variation of water level with time
- Seepage force effect
- Seepage-Slope coupled analysis
- Earth Dam / Embankment stability
- Design impermeable wall for embankment
- Design pump capacity during excavation



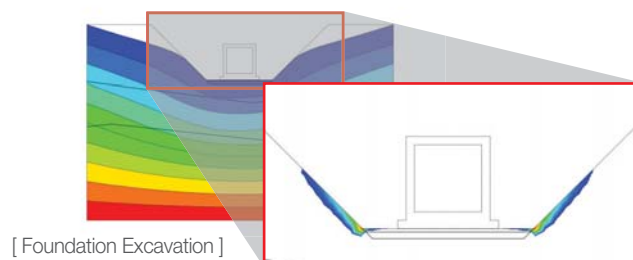
[Retaining Wall]



[Transient Analysis]



[Impermeable Wall]



[Foundation Excavation]

[Outflow Discharge]

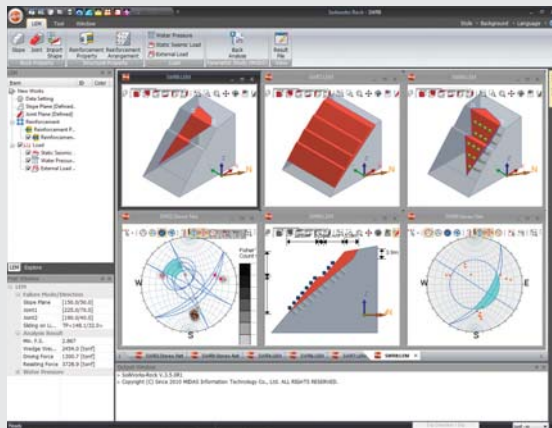


SoilWorks Rock

Rock Slope Stability Analysis

Total Solution for Rock Slope

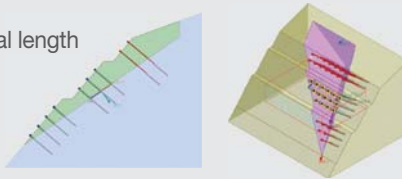
- Project file manager – multi document system
- Stereographic Analysis / Limit Equilibrium Analysis
- StereoNet – LEM coupled analysis



[Framework Configuration]

Slope Modeling Wizard / Automatic Reinforcement Arrangement

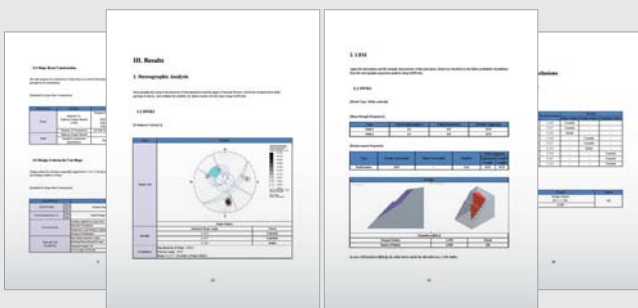
- Slope modeling wizard
- Reinforcement type (Rockbolt / Rockanchor)
- Automatic reinforcement arrangement
- Calculate the total length of reinforcement



[Slope Modeling / Reinforcement]

Design Option / Report Generation

- Select design criteria – Minimum factor of safety
- Report generation - Set report format (style, font)



[Report]

Stereographic Analysis

1. Stability of Discontinuities

| Possibility of Failure

- Weighting option to account for the sampling bias introduced by scanline

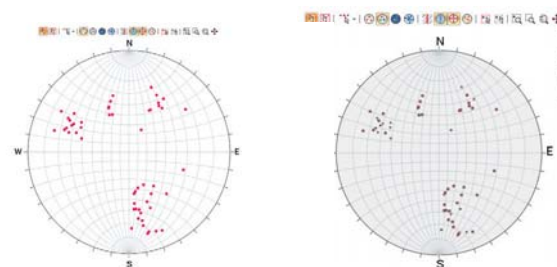
Discontinuity							
Global Orientation		Dip Direction / Dip		Declination		Scanline	
ID	Direction	Angle	Quantity	OxWeight	Type	Scanline	Set
1	352.0	67.0	1	1.165	Joint	1	4
2	110.0	58.0	1	1.513	Joint	1	1
3	349.0	69.0	1	1.197	Joint	1	4
4	115.0	64.0	1	1.573	Cleavage	1	1
5	164.0	60.0	1	3.864	Joint	1	2
6	349.0	63.0	1	1.127	Fault	1	4
7	349.0	73.0	1	1.257	Joint	1	4
8	340.0	55.0	1	1.064	Joint	1	4

[Apply Weighting Option]

- Data visualization with the various plot
 - Pole / Symbol / Contour / Rosette

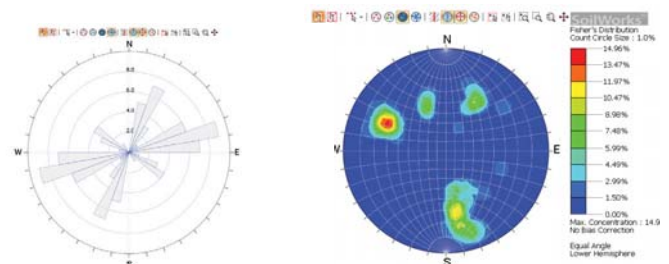


[View Tool Bar]



[Pole Plot]

[Symbol Plot]

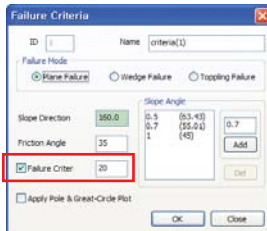


[Rosette Plot]

[Contour Plot]



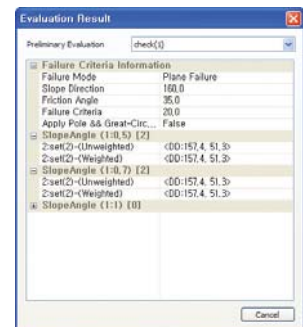
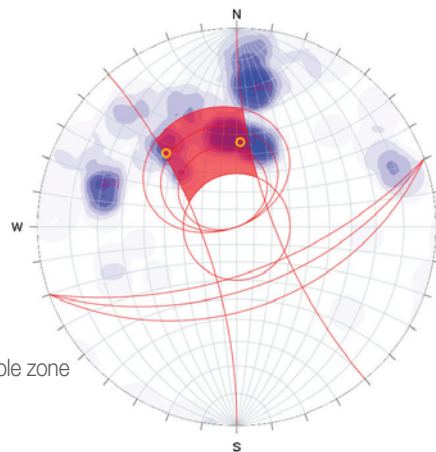
2. Preliminary Evaluation for Failure Modes | Auto-Search for Unstable Zone



- Select failure mode and input slope information
- Create line, plane, cone and daylight automatically
- Multi – Slope inclination



- Auto-search for unstable zone of each failure mode
- Auto-search for unstable discontinuities

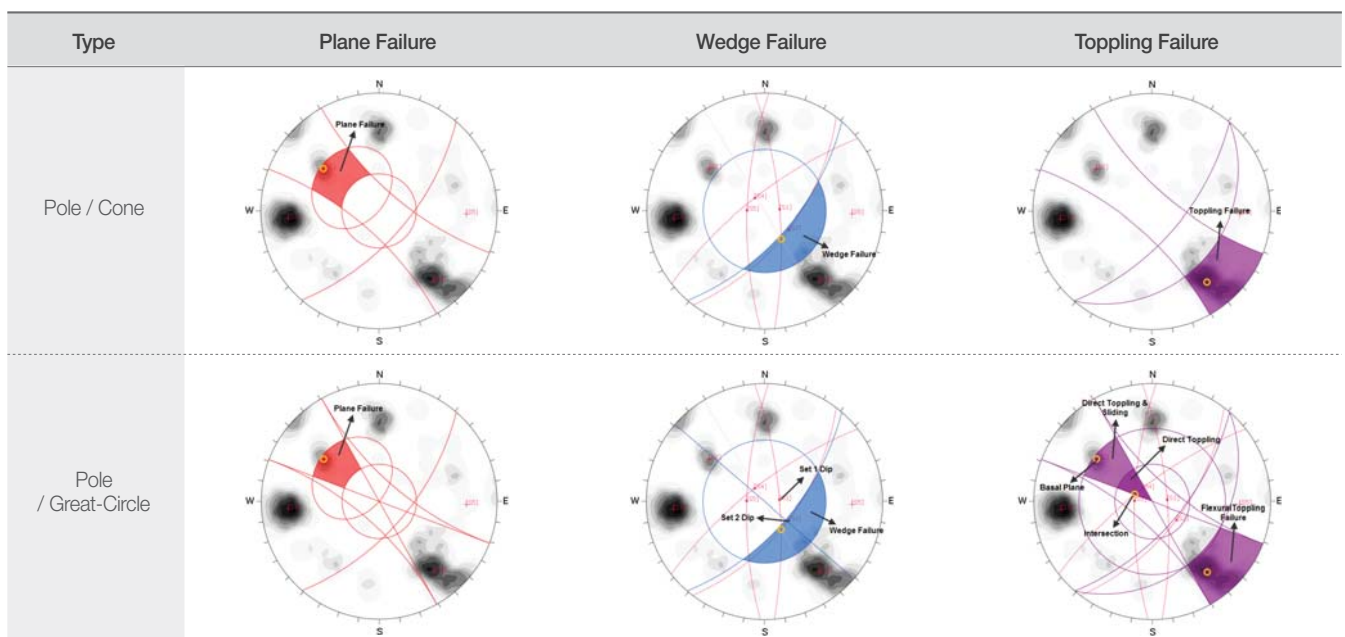


- Evaluation Result (Orientation of Discontinuities)

3. Advanced Option for Stereographic Analysis

Pole & Great-Circle Plot

- Plane failure – Adjust over-estimated zone
- Wedge failure – Sliding on single plane / Sliding on intersection line
- Toppling failure – Direct toppling & sliding / Flexural toppling



3. Design Optimization

Minimum Anchored Length of Reinforcement

- Auto-calculate of minimum anchored length of reinforcement
- Auto or manual input of anchored length
- Quantity of required reinforcement

Length

Grouted Length m

Ungouted Length m

☐ Min. Anchored Length

Length

Grouted Length m

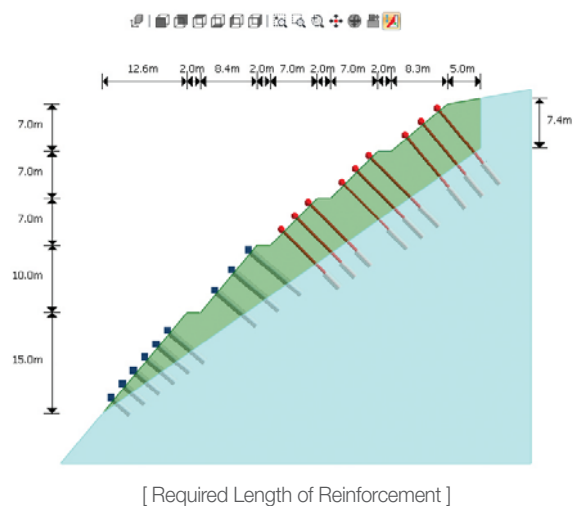
Ungouted Length m

☒ Min. Anchored Length

Margin Length m

☒ Auto ☐ Manual m

[Manual Input] [Auto]

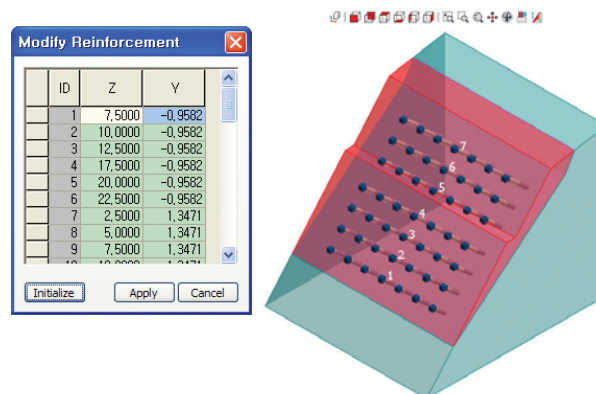
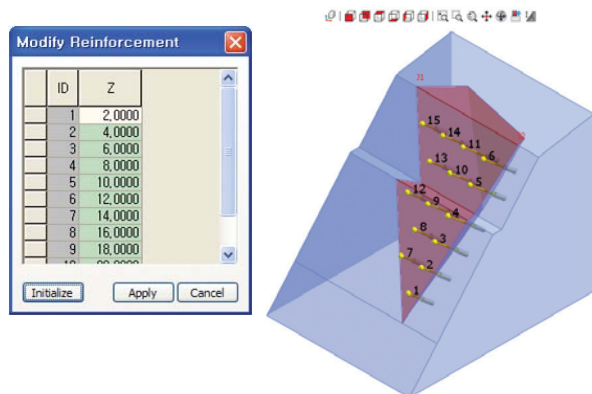


Type	Tensile Force(tonf)	Tensile Force(tonf)	Quantity	Total Length (m)	
				Ungouted Length	Grouted Length
Rockbolt (Plane Failure)	20.0	10.0	2.3 (/m)	–	11.1
Rockanchor (Wedge Failure)	20.0	–	29	89.9	73.8

[Report – Reinforcement Table]

Reinforcement Arrangement

- Edit coordinates of reinforcement
- Add / Delete reinforcement through table
- Check factor of safety in real time



Limit Equilibrium Analysis

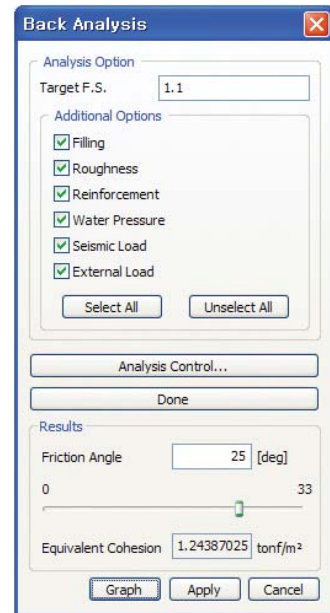
4. Back Analysis

Estimate Shear Strength Parameters of Discontinuities

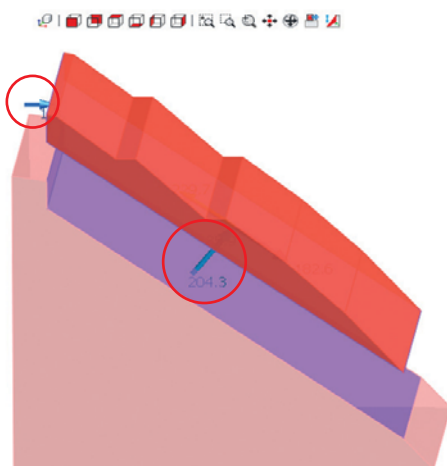
- Output equivalent cohesion and friction angle of joints
- All combinations of cohesion and friction angle by target factor of safety
- Graphic result and export to excel

Additional Analysis Options

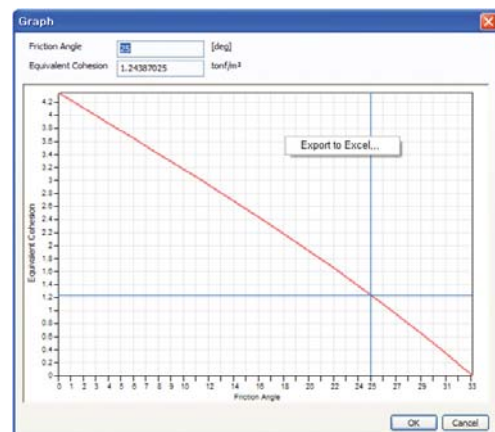
- Including or excluding site conditions
 - Filling materials and roughness of discontinuities
 - Water pressure / Seismic load / External load
 - Before and after reinforcement arrangement



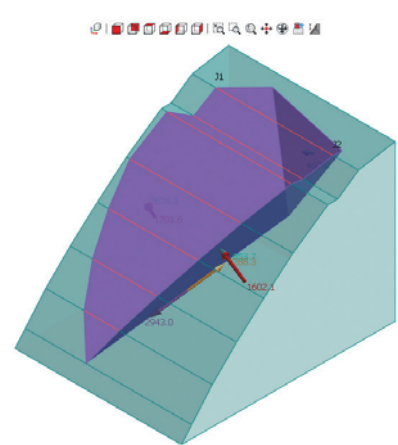
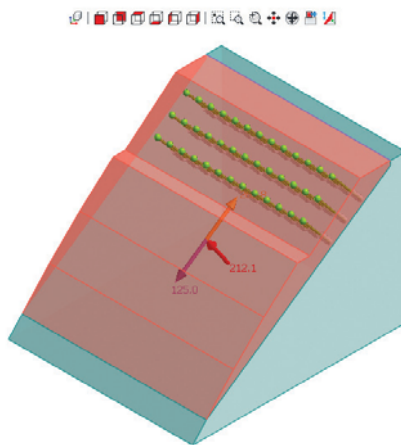
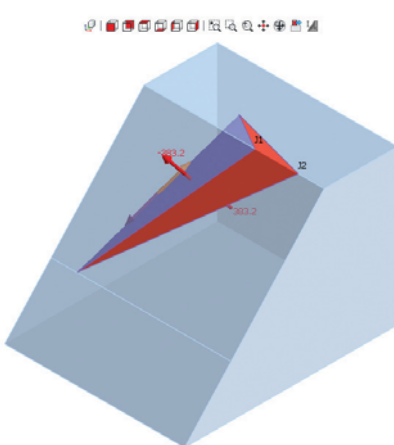
[Back Analysis]



[Slope Modeling with Target F.S.]



[Analysis Result]



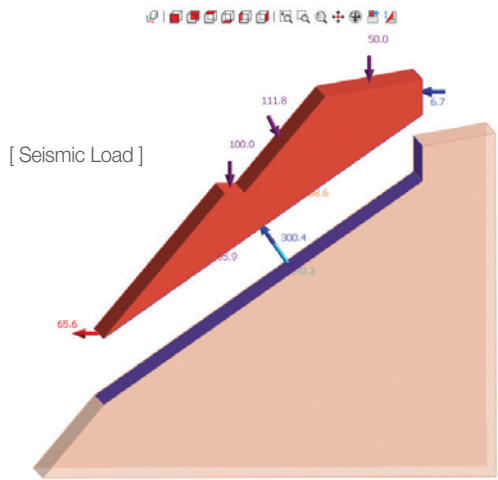
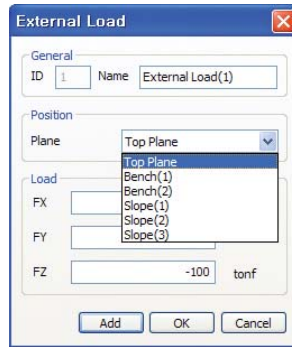
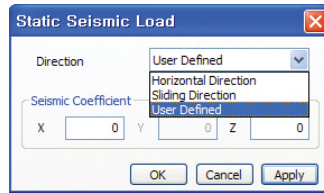
[Apply Back – Calculated Shear Strength Parameters]



5. Loading Conditions

Water Pressure / Static Seismic Load / External Load

- Define water level and distribution of water pressure
- Define seismic coefficient and direction
 - Horizontal / Sliding / User-defined
- External loads
 - Multiple loads with different position

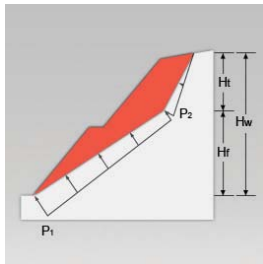


[Seismic Load]

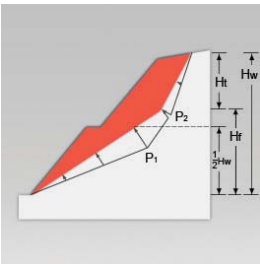
[External Load]

[Define External Loads]

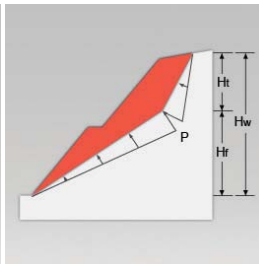
Distribution of Water Pressure



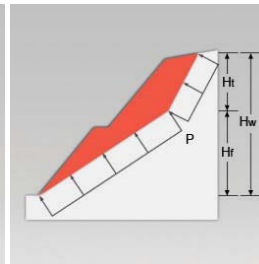
[Linear]



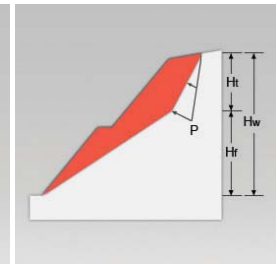
[Triangle]



[Uniform]



[Tension Crack]

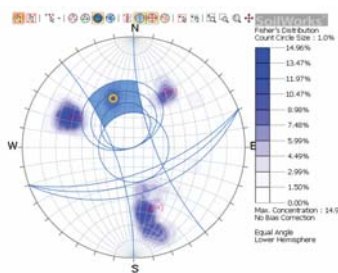


[No Failure Plane Pressure]

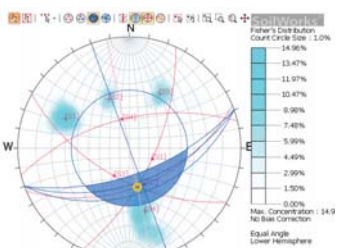
6. Import from StereoNet

Auto-Generation of Slope Model

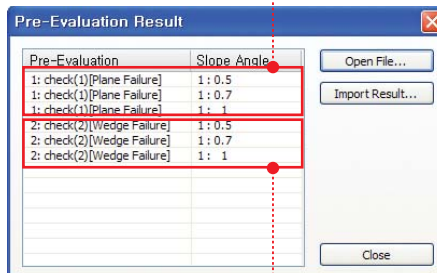
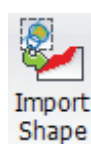
- Import joint information in unstable zone
- Automatic generation of slope and failure block



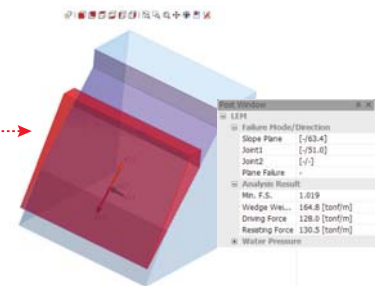
[Plane Failure]



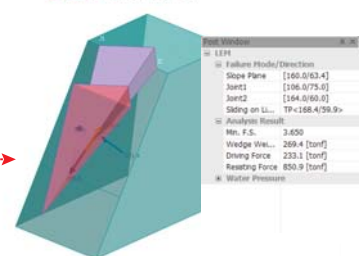
[Wedge Failure]



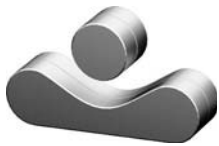
[Import Shape]



[Plane Failure]



[Wedge Failure]

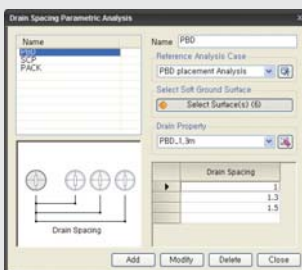


SoilWorks Soft Ground

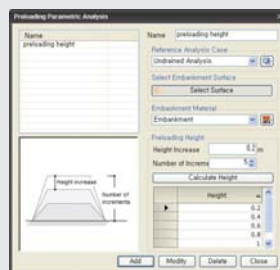
Analysis & Design Soft Ground

Parametric Analysis

- Preliminary Analysis
- Drain property and spacing check
- Minimum preloading height
- Softground – Slope coupled analysis
 - Auto-create slope model
 - / Critical height of embankment by limit equilibrium analysis



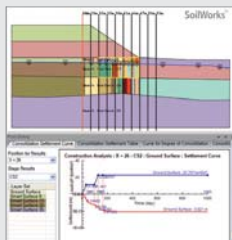
[Drain Spacing]



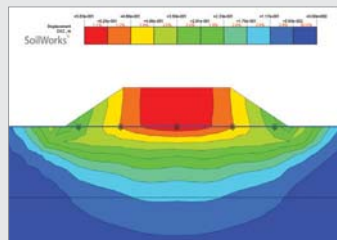
[Preloading]

Analysis Methods (1D / 2D Consolidation)

- Consolidation analysis with construction stage
- 1D consolidation analysis
- 2D (FEM) consolidation analysis



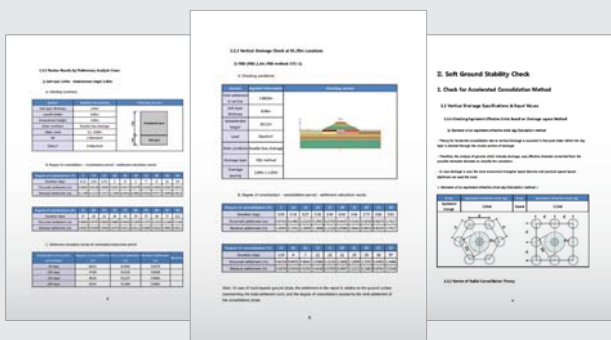
[1D Consolidation]



[FEM Consolidation]

Design Option / Report Generation

- Built-in design option for allowable settlement
- Report generation for parametric analysis



[Report]

1. Parametric Study



Preliminary Analysis

- Consolidation – Settlement curve with different site conditions
- Report generation



[Preliminary Analysis]



Drain Spacing

- Evaluate the maximum drain spacing
- Result analysis with different drain spacing / report generation

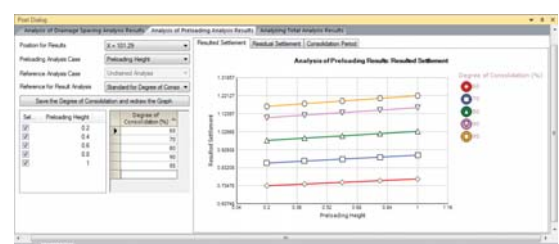


[Drain Spacing]



Preloading

- Evaluate the minimum preloading height
- Result analysis for each increment of embankment / report generation



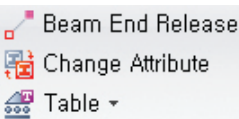
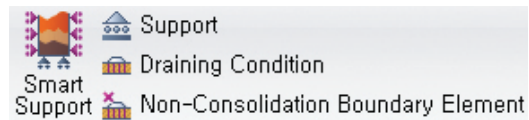
[Preloading]



2. Modeling & Analysis

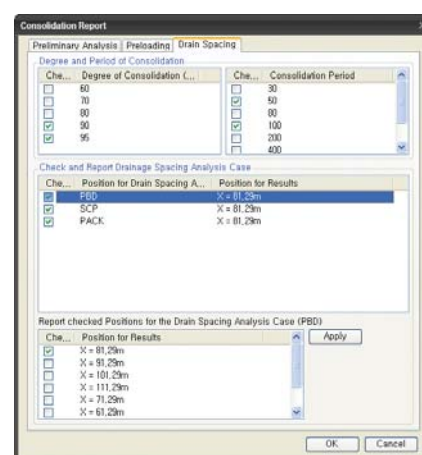
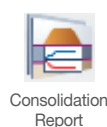
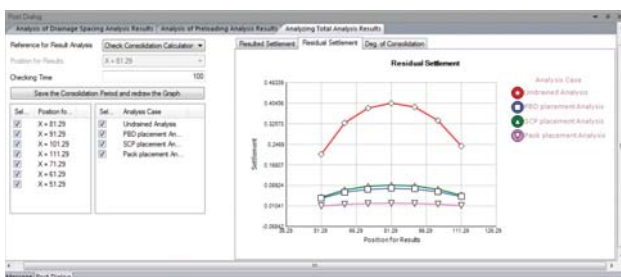
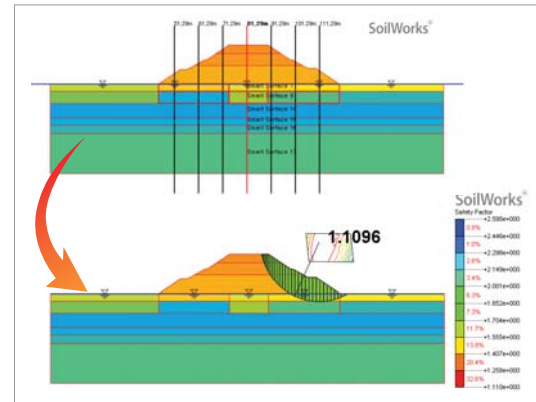
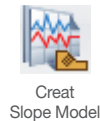
| 1D Consolidation and FEM Consolidation

- Settlement by Terzaghi 1D-Consolidation theory
 - Primary and secondary consolidation
 - Initial settlement for sand
 - Multi-stage consolidation analysis
 - Auto-calculate of leave time for staged consolidation analysis
 - Improvement method (PBD, SCP, GCP, SD, Pack Drain, CD, Fiber)
 - Strength increase of softground for each construction stage
- FEM Consolidation
 - Modified Cam Clay model
 - Sekiguchi-Ohta model (Elasto-Plastic / Elasto-Visco Plastic)
 - Boundary condition (Drain / Non-consolidation boundary)



3. Result Analysis / Coupled Analysis

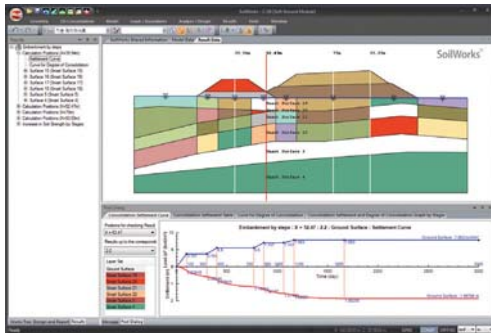
- Analyzing all result data for multi-analysis cases
- Settlement / Residual settlement / Degree of consolidation
- Stability of embankment with coupled analysis
- Check critical height of embankment for each construction stage



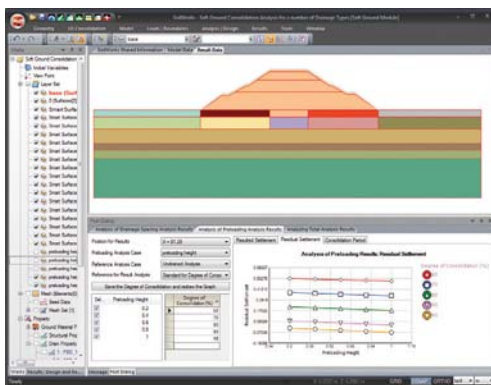


4. Applications

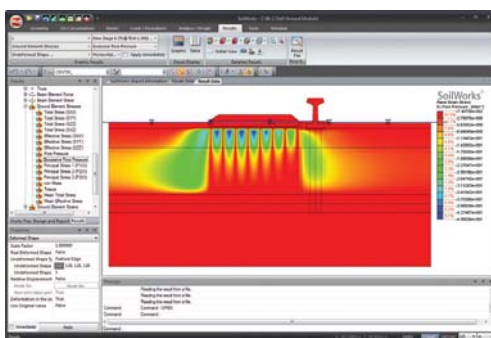
| Design Approach



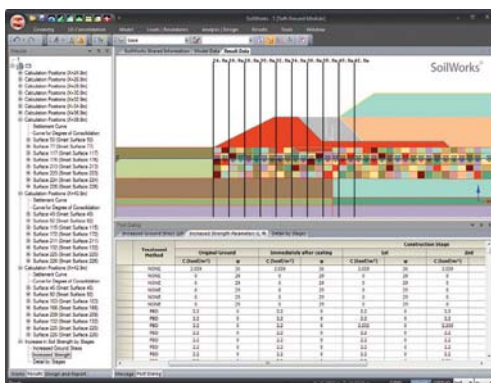
[Staged Consolidation Analysis]



[Preloading Parametric Study]



[Dissipation of Excess P.W.P.]



[Increase in Strength of Soft ground]

■ Multi-stage 1D-Consolidation Analysis

- Settlement curve with time for each construction stage
- Settlement check with additional fill of embankment
- Selection of improvement method with different drainage

■ Evaluate Minimum Preloading Height

- Residual settlement with increment of embankment
- Apply additional fill to compensate settlement

■ FEM Consolidation

- Construction – Consolidation (Staged Consolidation) analysis
- Check reinforcement and member force
- Check dissipation of excess pore water pressure with time

■ Increase in Shear Strength of Soft Ground

- Strength increase with depth of soft ground
- Softground-Slope coupled analysis
- Stability of embankment with limit equilibrium analysis

a total satisfaction support system

“e-Learning Webinars & Fast Technical Support”

SoilWorks eliminates significant efforts to learn various different software programs of different user interfaces to solve a wide range of geotechnical problems. One user interface is common to all the analysis modules to handle any type of geotechnical problems. SoilWorks streamlines the technical support and the maintenance of the software, and further, data exchange and management are consistent because one company has developed all the modules.

SoilWorks is designed to cater to geotechnical engineers as well as structural engineers, which provides the opportunity to expand the areas of solving geotechnical problems. It also enables the engineers to address soil-structure interaction.



E-mail Technical Support

The user may send any technical questions to [eSupport@MidasUser.com](mailto:ESupport@MidasUser.com). Response will be provided within 24 hours.



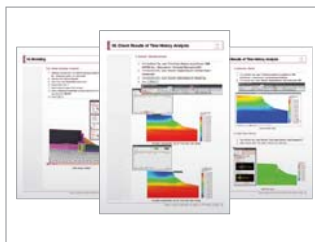
Online Technical Support

Upon request of the user, an arrangement will be made to guide/instruct/demonstrate the use of the software online through a web session.



Technical Webinars

Regularly scheduled webinars are provided to cover various subjects of geotechnical and/or structural problems in interaction. Recordings will be made available for those who wish to review or missed the sessions.



Technical Materials

Various subjects on technical materials and tutorials are provided to help the user become familiar with technical subjects and the use of the software.



For any enquiries on the functionality and sales support, contact: sales@MidasUser.com

SoilWorks

SLOPE PACKAGE

GEOTECHNICAL SOLUTION FOR PRACTICAL DESIGN



Copyright © Since 1989 MIDAS Information Technology Co., Ltd. All rights reserved.
www.MidasUser.com



for detail functionality
<http://en.midasuser.com>
esupport@MidasUser.com