Oil & Gas Gathering, Upstream and Midstream Pipelines.

Increase Productivity and Save your Time Twice with PASS/START-PROF 4.84

Dr. Alex Matveev,

START-PROF Product Owner

PIPING AND EQUIPMENT ANALYSIS & SIZING SUITE

PASS/START-PROF

PASS | PIPING AND EQUIPMENT ANALYSIS & SIZING SUITE

Smart Pipe Stress Analysis & Optimal Sizing

Presenter:

Dr. Alex Matveev

START-PROF Product Owner

Development, Training, Support of START-PROF Since 2005

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Webinar Agenda – Part 1

Introduction

- Quick introduction of PASS/START-PROF
- Supported codes for pipelines
- Underground and aboveground pipeline modeling abilities

Soil – pipeline interaction and analysis

- Soil model for dry and liquefied soil. Submerged pipelines. Buoyancy
- Soil model for horizontal, inclined, vertical pipelines
- Restrained and unrestrained zones automatic analysis
- Seismic wave propagation analysis
- Soil subsidence, frost heaving, landslide, seismic fault crossing
- Natural arch of collapse phenomena, horizontal directional drilling
- Ring bending calculation using nonlinear FEA

Webinar Agenda – Part 2

PASS/START-PROF features and usability

- Object-oriented piping model creation principle
- Piping object types: pipe, tees, bends, reducers, etc.
- Equipment objects: Tank Nozzle, Pump, Compressor
- Expansion joint objects
- Databases, wind, ice, snow, seismic loads
- Pipe and fittings wall thickness calculation
- Operation mode editor. Load cases
- Analysis reports: Stress in piping, Stress in insulation, Seismic stress, Flaw stress, Restraint loads, Equipment loads, Displacements, Expansion joints check, variable spring selection, constant spring selection, buckling analysis, flange leakage
- Special features

PASS/Start-Prof

Quick Pipe Stress Analysis & Optimal Sizing

Comprehensive pipe stress, flexibility, stability, and fatigue strength analysis with related sizing calculations

- Broad Applicability
- Unsurpassed Usability
- Powerful Capabilities
- Extensive Databases
- Flexible Configurations
- Extensive Code Support
- Widely Used

PASS
PIPING AND EQUIPMENT ANALYSIS & SIZING SUITE

PASS/Start-Prof | Broad Applicability

- Process Industry Piping
- Oil and Gas Pipelines
- Utility Network Pipelines
  - District Heating
  - Natural Gas
  - Water
- Power Generation Piping

PASS PIPING AND EQUIPMENT ANALYSIS & SIZING SUITE

PASS/Start-Prof | Broad Applicability

- Developed since 1965
- 2000+ Active users (companies). Licenses 8000+
- User interface and documentation languages: English, Chinese, Russian
- Piping codes: 32
- Wind, Seismic, Snow, Ice codes: 18

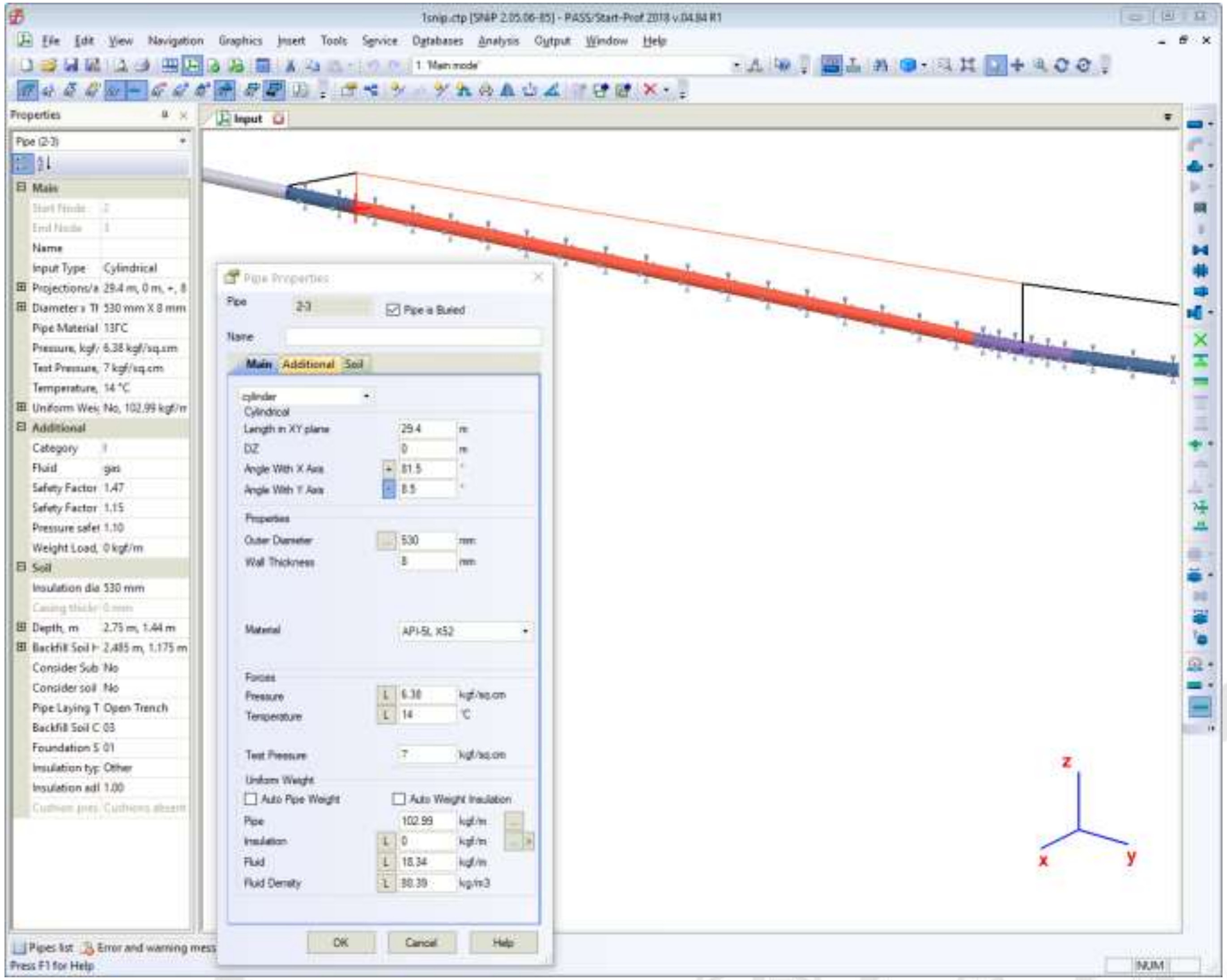
PASS/Start-Prof | Our Customers

ROSNEFT
TechnipFMC
LUKOIL OIL COMPANY
GAZPROM NEFT
GAZPROM
UNG O'ZLITINEFTGAZ
CEEC CHINA POWER ENGINEERING CONSULTING GROUP NORTHWEST ELECTRIC POWER DESIGN INSTITUTE CO., LTD.
中国石油天然气股份有限公司 PetroChina Company Limited
SNC·LAVALIN
Northern Reflections DESIGN AND DRAFTING
TRANSNEFT
КазМунайГаз
WorleyParsons resources & energy
Caspian Pipeline Consortium
中国市政工程华北设计研究总院有限公司
Tecnimont
Severstal
THE LINDE GROUP
NOVATEK
KEPCO
SIBUR
KazTransOil
SEPA MÜHENDİSLİK & MÜŞAVİRLİK ENGINEERING & CONSULTING
thyssenkrupp
E&R
DAELIM
MITSUBISHI HEAVY INDUSTRIES AMERICA, INC.

PASS PIPING AND EQUIPMENT ANALYSIS & SIZING SUITE

PASS/Start-Prof | Features

- Increase your Productivity and Save your Time
- Save your Money (we have a friendly pricing policy)
- Increase the Accuracy of Pipe Stress Analysis



PIPING AND EQUIPMENT
ANALYSIS & SIZING SUITE

PASS/Start-Prof | Features

- First hand quick response from experienced piping engineers in UK, China, Mexico, Brazil, Australia, Egypt, Turkey and others
- Direct support from developers via e-mail is available
- Easy to learn, fast and simple to work with for a new pipe stress analyst
- Due to intuitive modern object-oriented user interface, you can start working immediately. Companies can put PASS/START-PROF into application immediately after purchase, significantly reducing costs and save the time without compromising on the quality of end results

PASS/Start-Prof | Features

PASS/START-PROF is a part of PASS Suite:

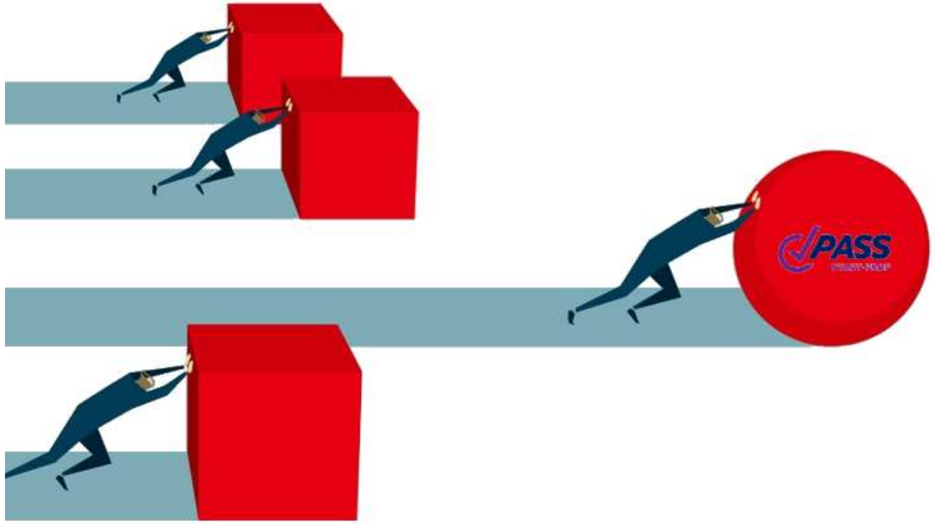
- PASS/START-PROF – Pipe Stress Analysis Software
- PASS/HYDROSYSTEM – Piping hydraulic and Thermal Analysis Software
- PASS/ NOZZLE-FEM – Nozzle to Shell Junction Finite Element Analysis Software. Calculate SIF, k-factors, Nozzle Flexibility and Stress Analysis, etc.
- PASS/EQUIP – Pressure Vessel, Column, Heat Exchanger, Tank Design and Analysis Software

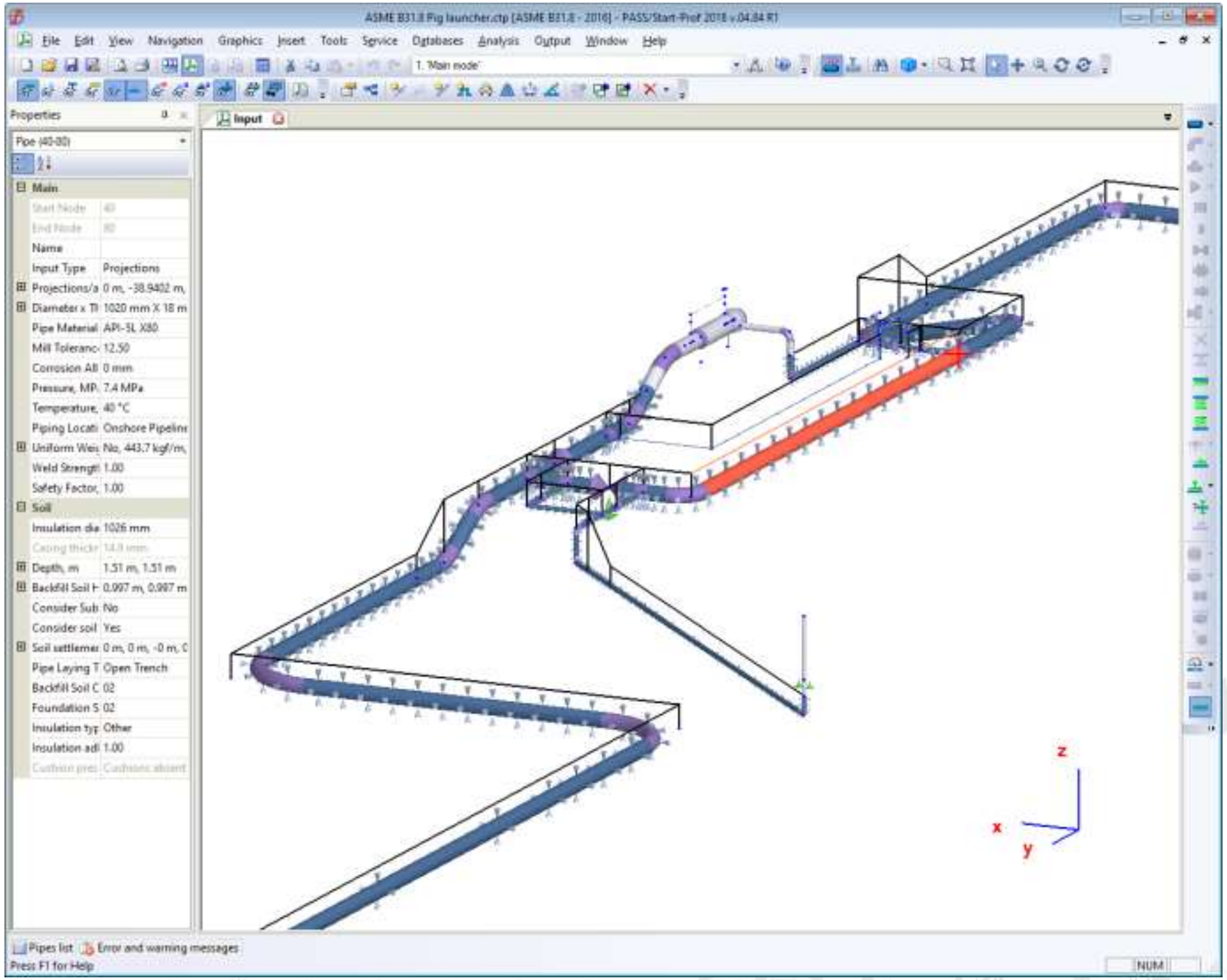
PASS/Start-Prof | Increase Productivity

PASS/START-PROF is a Professional Modern Pipe Stress Analysis Software

PASS/START-PROF Makes Complex Things Simple

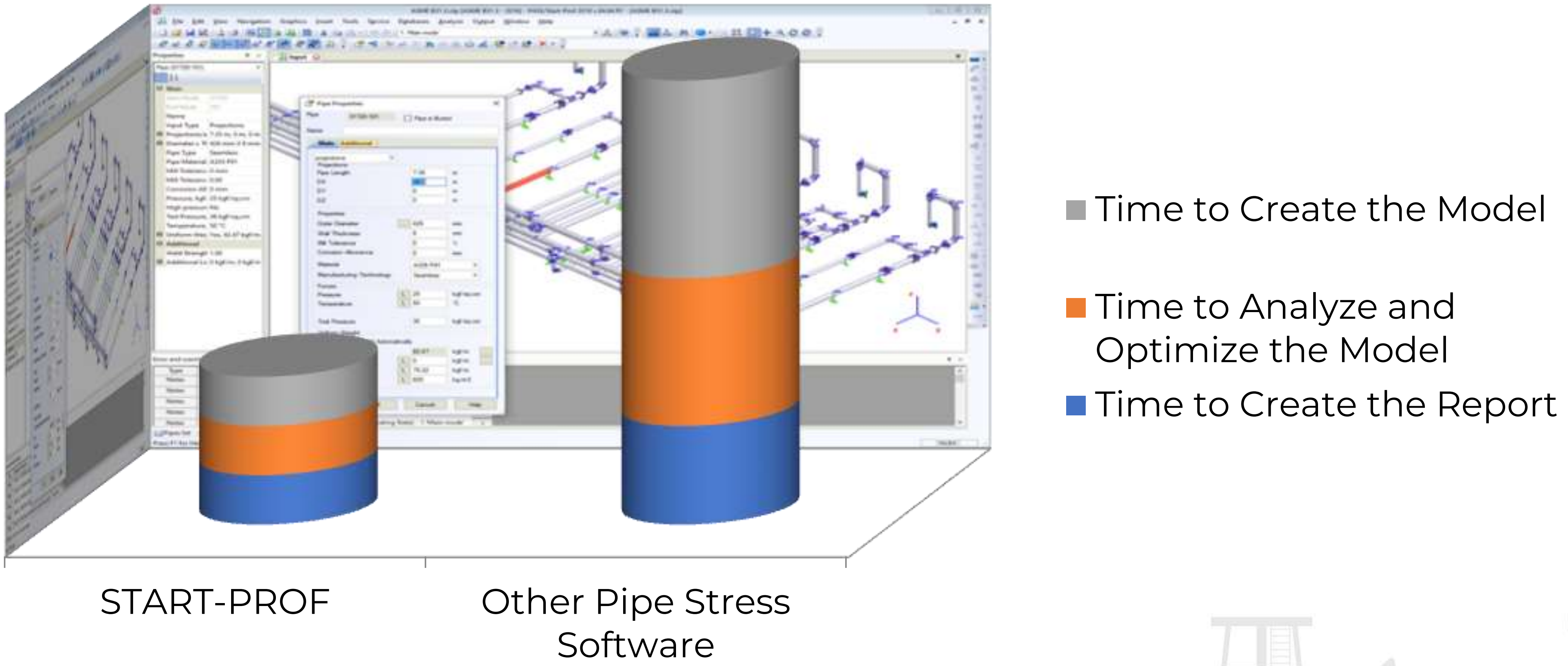
You will Get the Same Result, but Faster and Easier





PIPING AND EQUIPMENT
ANALYSIS & SIZING SUITE

PASS/Start-Prof |How START-PROF Saves your Time



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ANALYSIS & SIZING SUITE

PASS/Start-Prof | Supported Codes

PASS/START-PROF can analyze piping according to 32 piping codes.
The software contains all needed and latest codes for pipelines analysis:

- ASME B31.4 + Ch. IX, Ch. XI
- ASME B31.8 + Ch. VIII
- ASME B31.12
- CSA Z662-19 + Ch.11
- BS PD 8010-1
- BS PD 8010-2
- GB 50251
- GB 50253
- SNIP 2.05.06-85
- SP 36.13330.2012
- GOST P 55989
- GOST P 55990
- SP 284.1325800
- SP 33.13330

PASS/Start-Prof | Analysis Capabilities

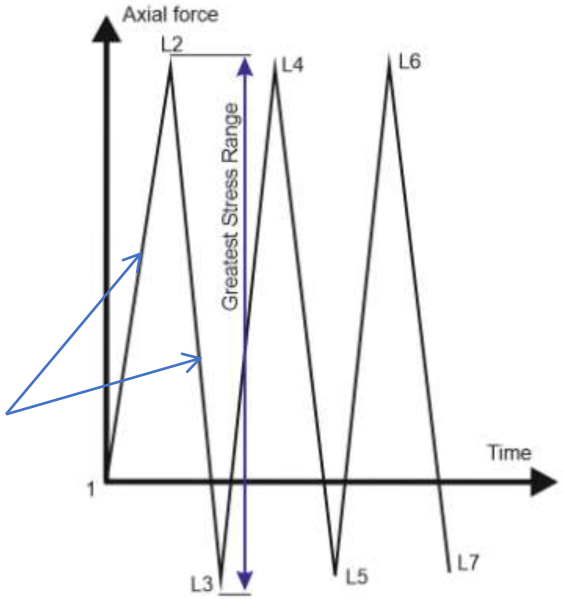
PASS/START-PROF has professional analysis abilities needed for Process and Power Piping Stress Analysis:

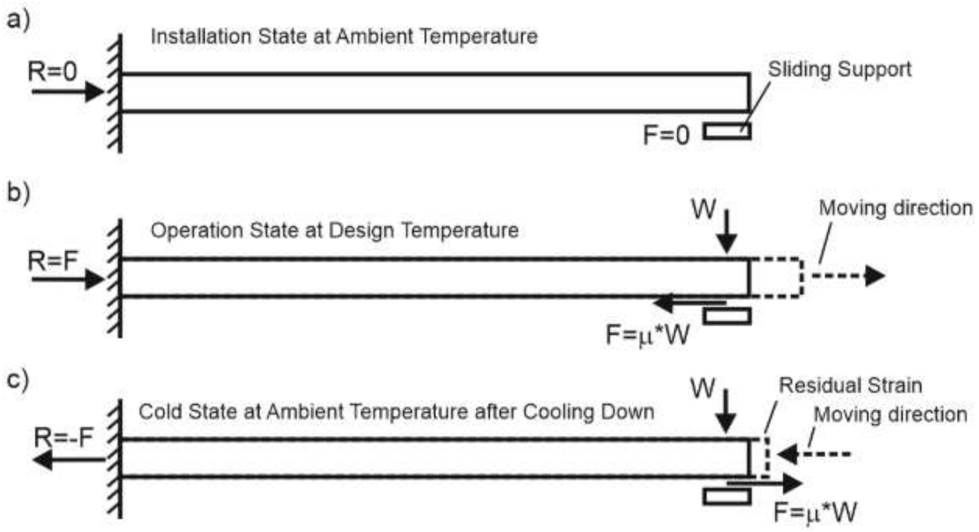
- Nonlinear analysis of gaps, friction, one-way restraints, rotating rods, etc.
- Special algorithm that improves the nonlinear model convergence on-the-fly without manual tuning (gaps and one-way restraints cycling, friction force cycling etc.). We receive from users the models that didn't converge, put it into our collection and continuously improve that algorithm for past 55 years. It allow to achieve convergence in 99.9% models
- Nozzle, tee, bend flexibilities and SIF (Code, ASME B31J, WRC 537/297, PD 5500, FEA)
- Nozzle, pump and other equipment automatic checks (API, ISO, NEMA standards)
- Optimal automatic variable and constant spring selection using manufacturers catalogue

PASS/Start-Prof | Analysis Capabilities

PASS/START-PROF calculates the cold state after cooling down from the hot state. It allows to get more realistic expansion stress range

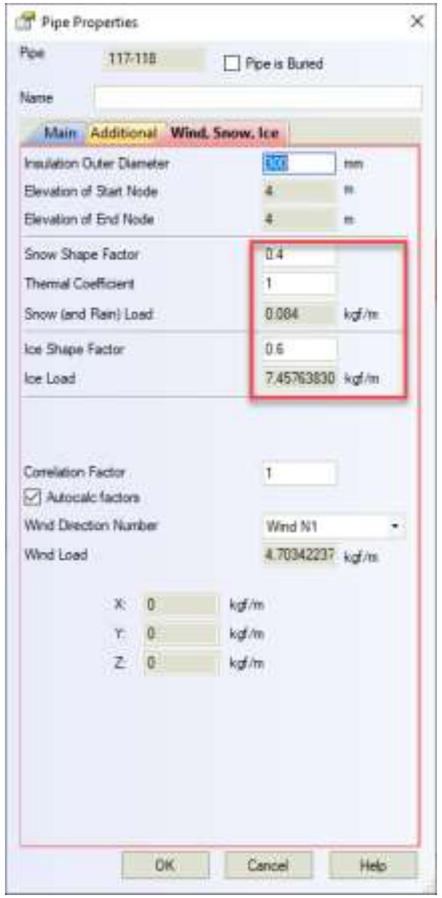
PASS/START-PROF

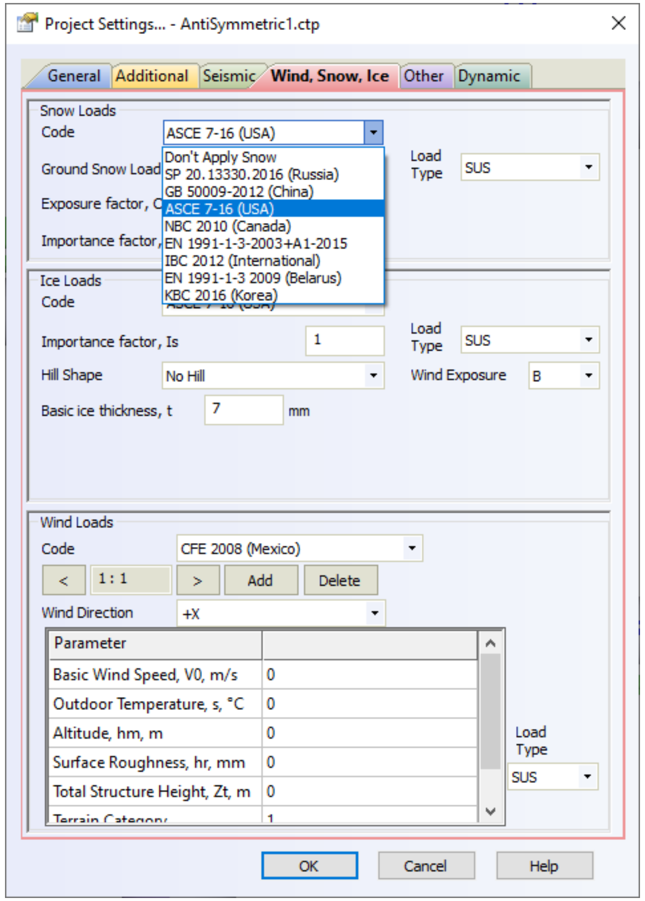


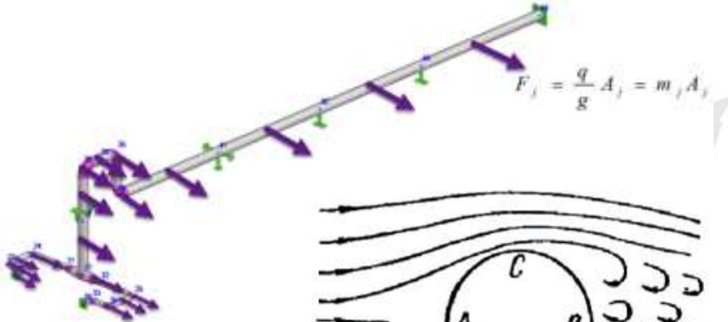


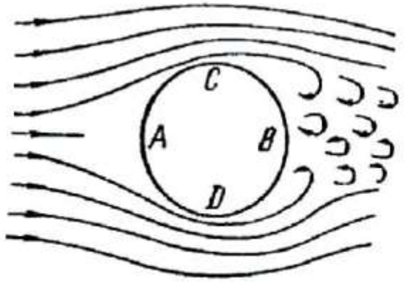
PASS/Start-Prof | Analysis Capabilities

Automatic generation of a wind, snow, ice, seismic loads according to 18 national codes









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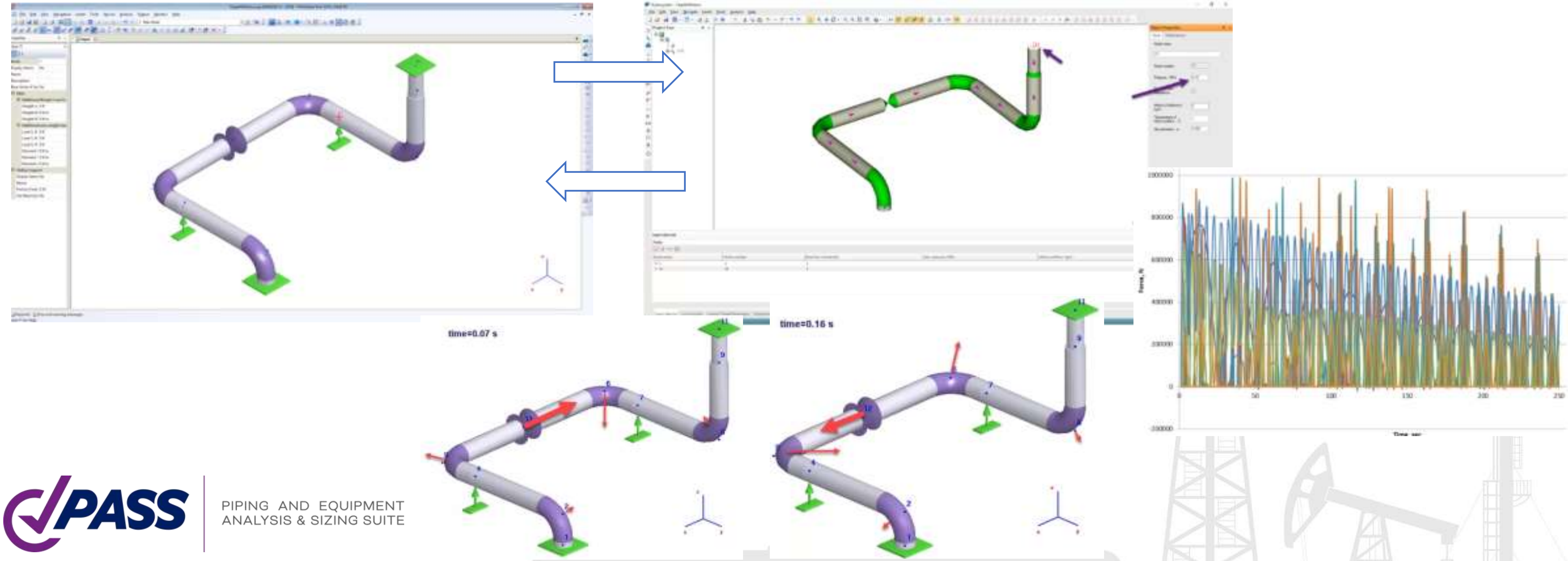
PIPING AND EQUIPMENT
ANALYSIS & SIZING SUITE

PASS/Start-Prof | Analysis Capabilities

PASS/START-PROF + PASS/HYDROSYSTEM Allows to Water Hammer Surge Analysis

- 3D piping Models converted automatically from START-PROF to HYDROSYSTEM and back
- 3D loading is converted simultaneously for all nodes in the system at the same moment of time



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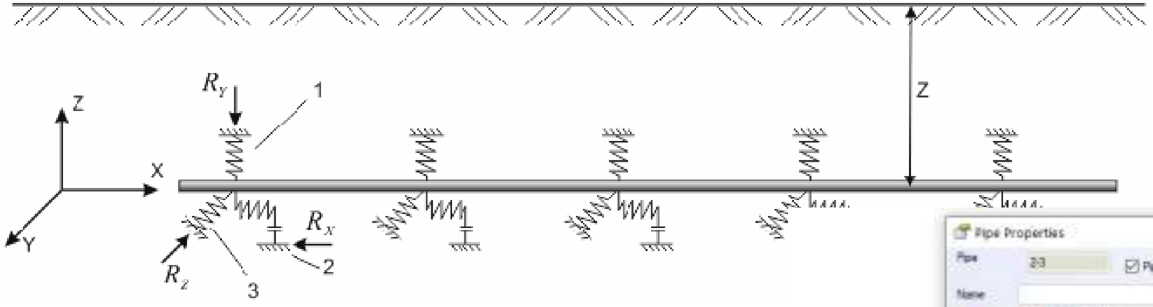
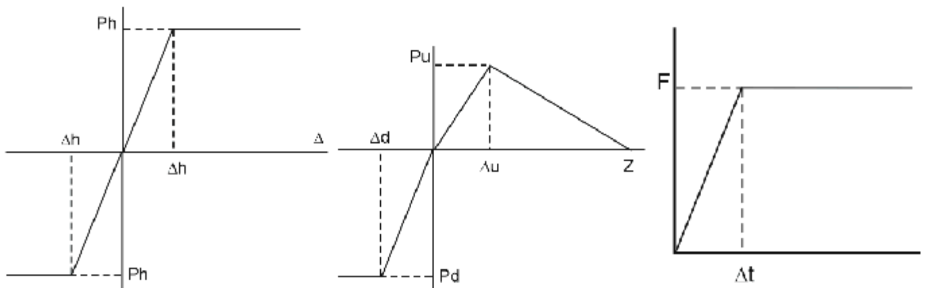
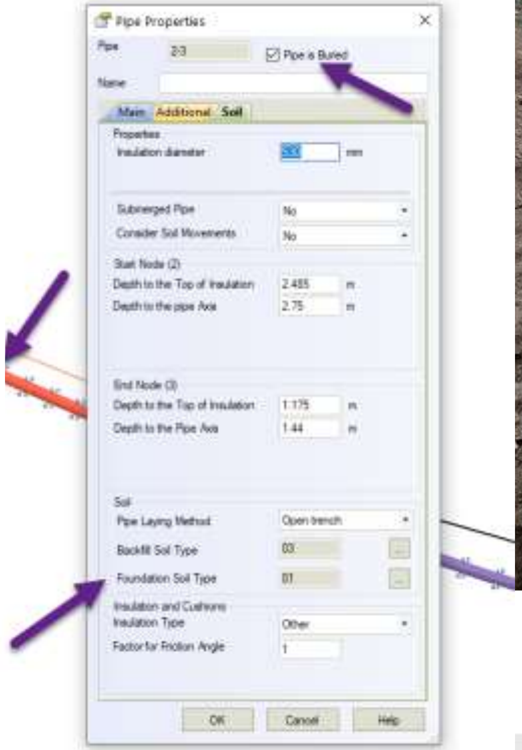
PASS/Start-Prof | Dry Soil Model

The main goal of dry soil model is to save on the number of supports in whole model to increase analysis speed without loss of result accuracy







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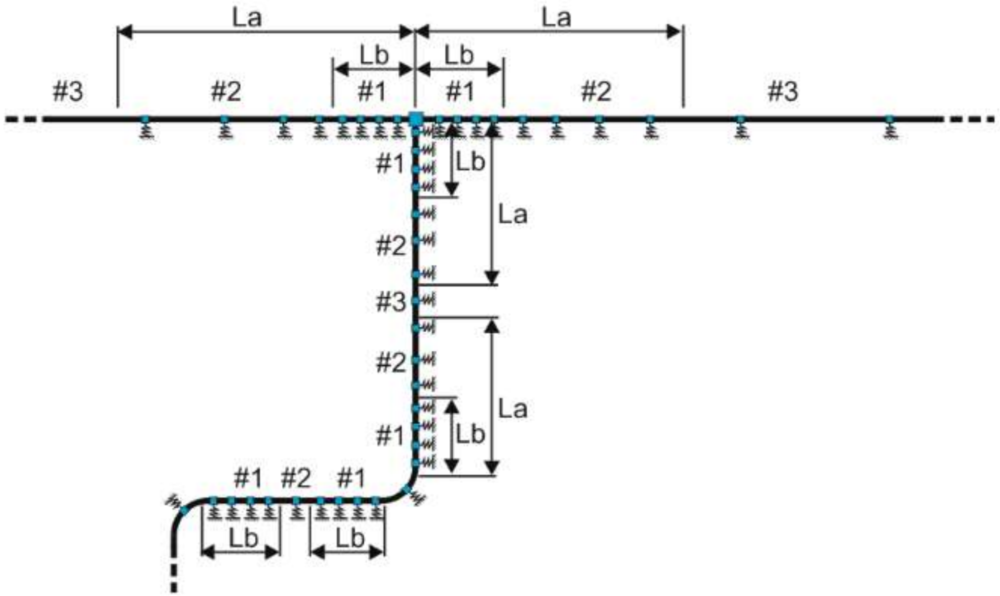
PASS/Start-Prof | Dry Soil Model

Zone #1: Lateral bearing zone (unrestrained) with the length of Lb. Four supports are placed at equal distance

Zone #2: Axial sliding zone (unrestrained) with the length of La. Four supports are placed at a distance increasing exponentially from zone #1 to zone #3

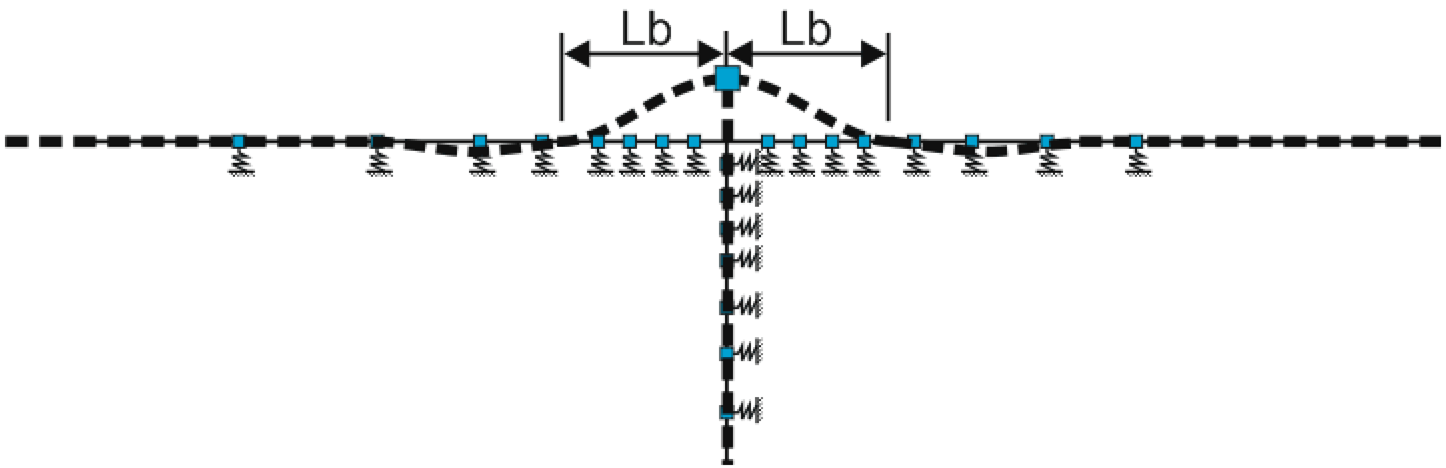
Zone #3: Restrained zone. Supports are placed at 100D spacing, where D - pipe external diameter



PASS/Start-Prof | Dry Soil Model

Zone #1: Lateral bearing zone (unrestrained) with the length of Lb. Four supports are placed at equal distance

$$L_b = \frac{3\pi}{4}\sqrt[4]{\frac{4EI}{k}}$$



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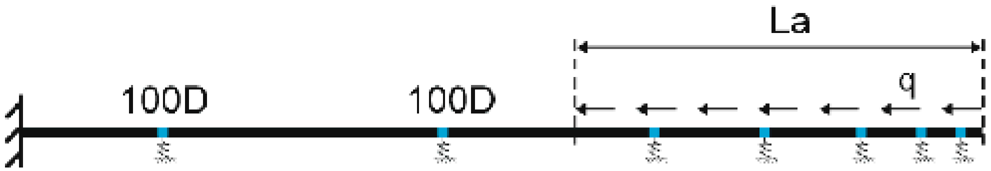
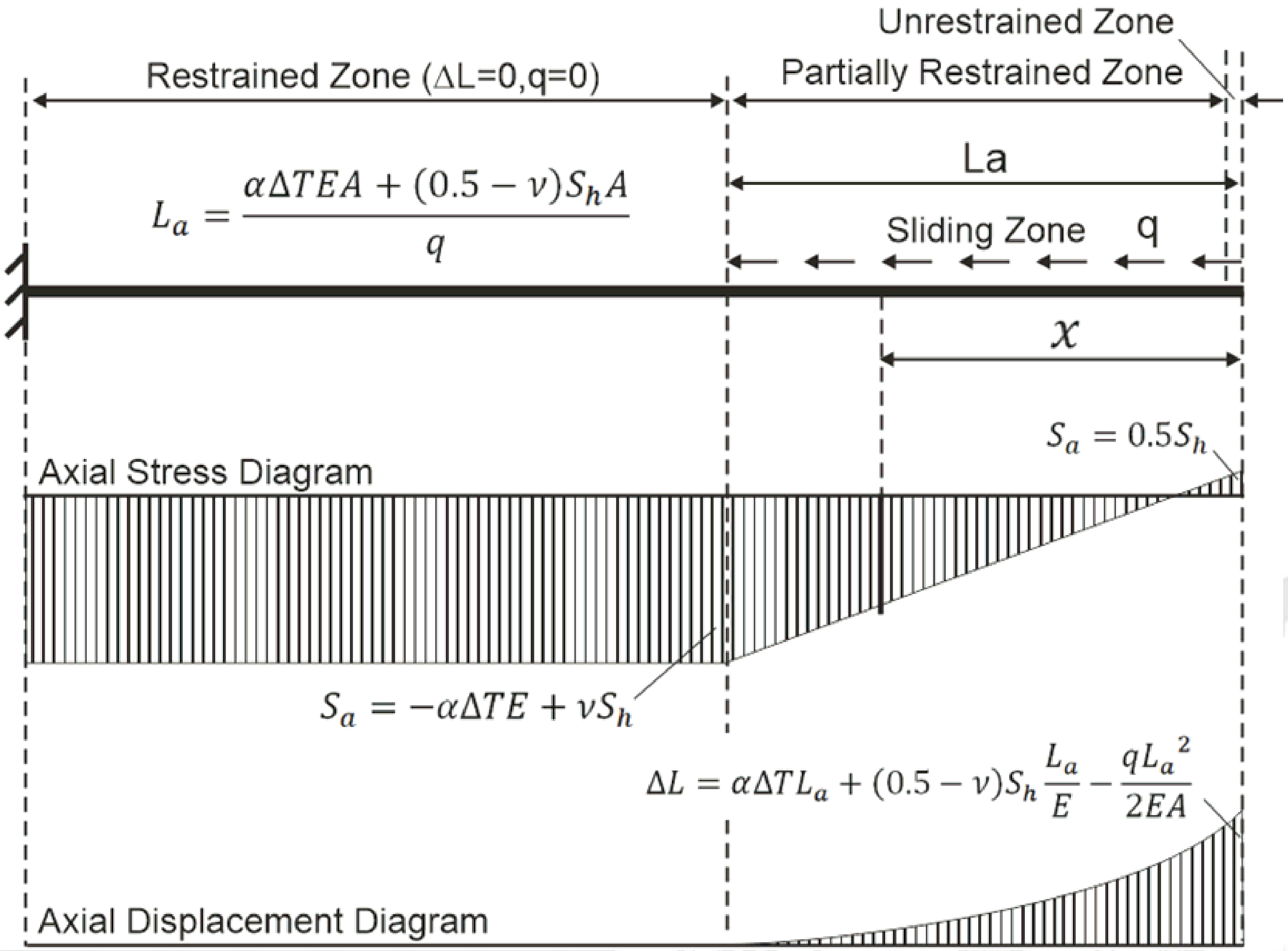
Zone #2: Axial sliding zone (unrestrained) with the length of La. Four supports are placed at a distance increasing exponentially from zone #1 to zone #3

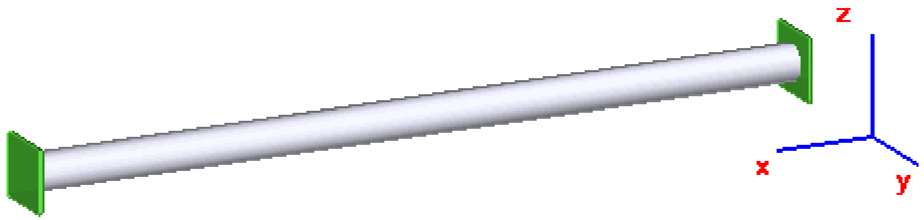


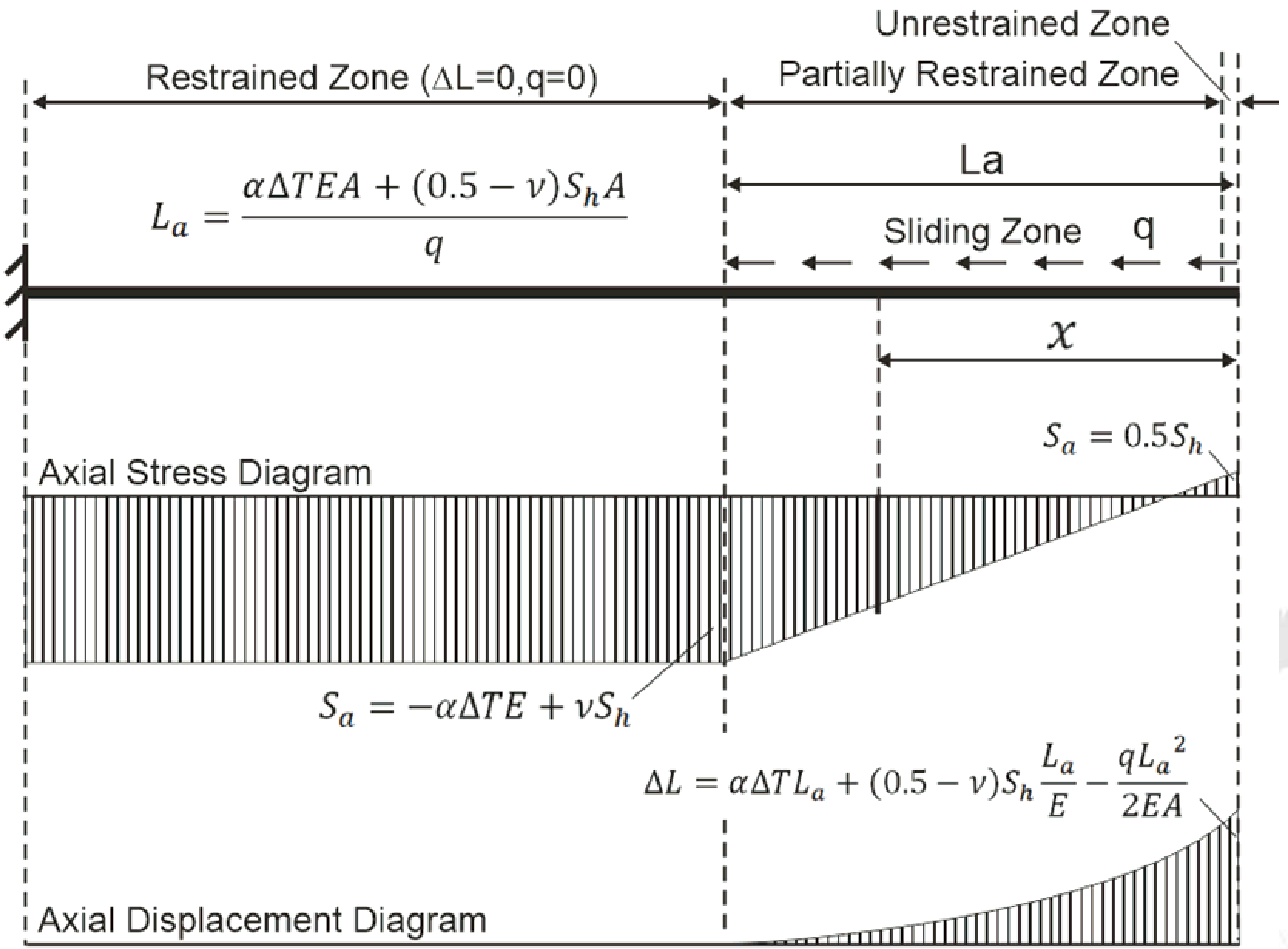
$$L_a = \frac{\alpha \Delta TEA + (0.5 - \nu) S_h A}{q} + 3\sqrt{\frac{EA}{\pi D C_{x0}}}$$



PASS/Start-Prof | Dry Soil Model

Zone #3: Restrained zone. Supports are placed at 100D spacing, where D - pipe external diameter





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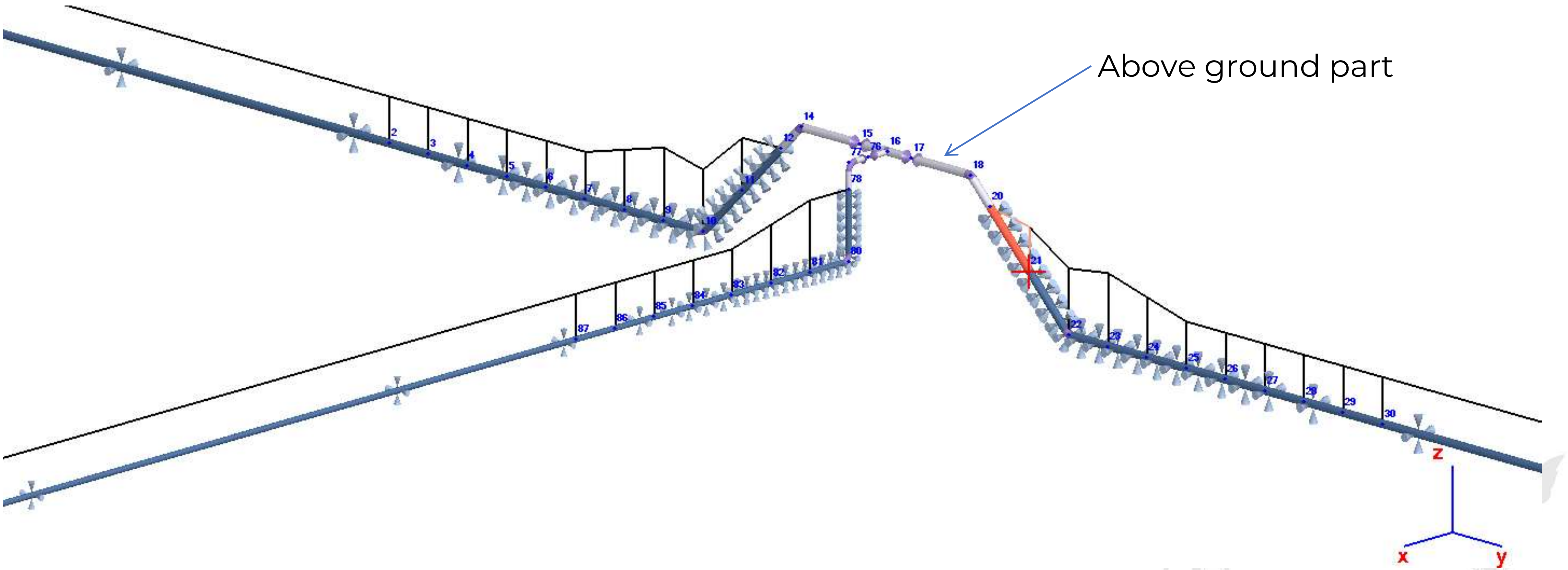
PASS/Start-Prof | Dry Soil Model



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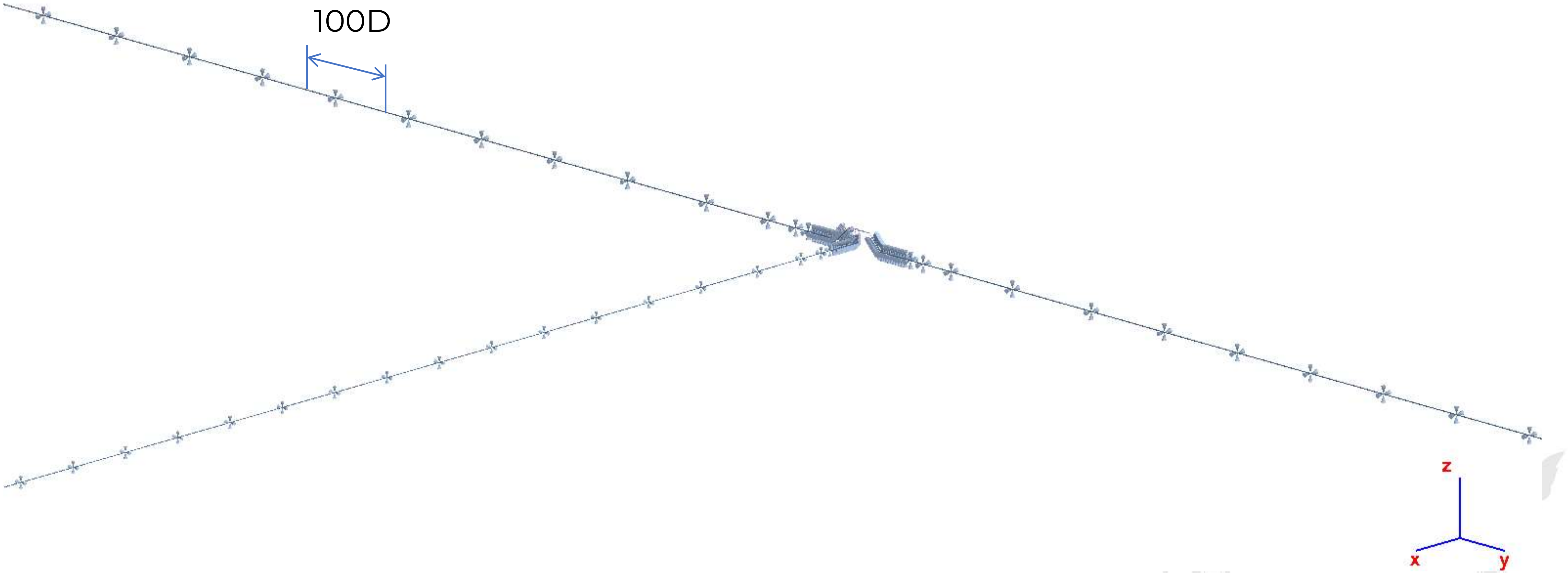

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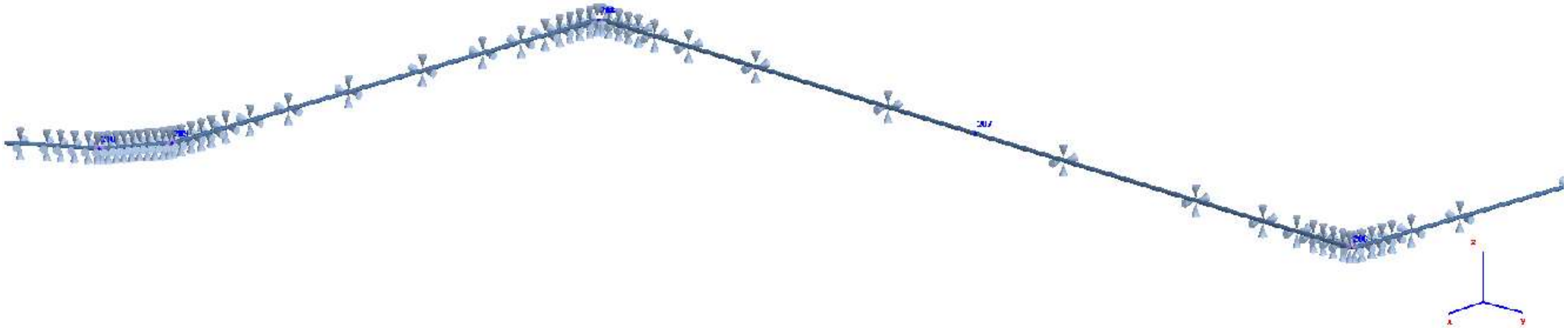
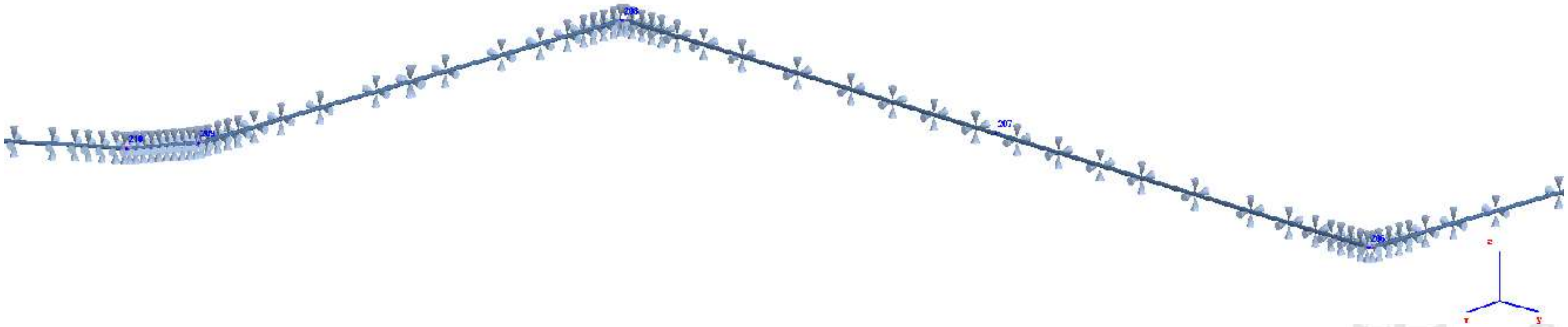
It is possible to manually increase the condensation of soil springs to increase the result accuracy:





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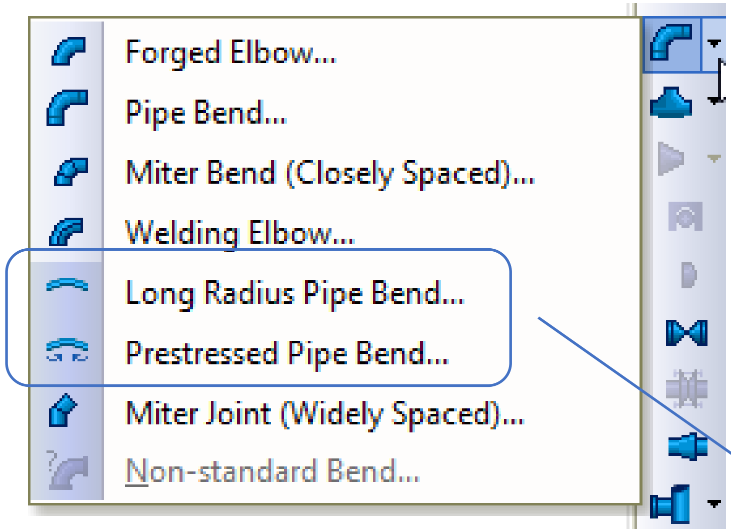
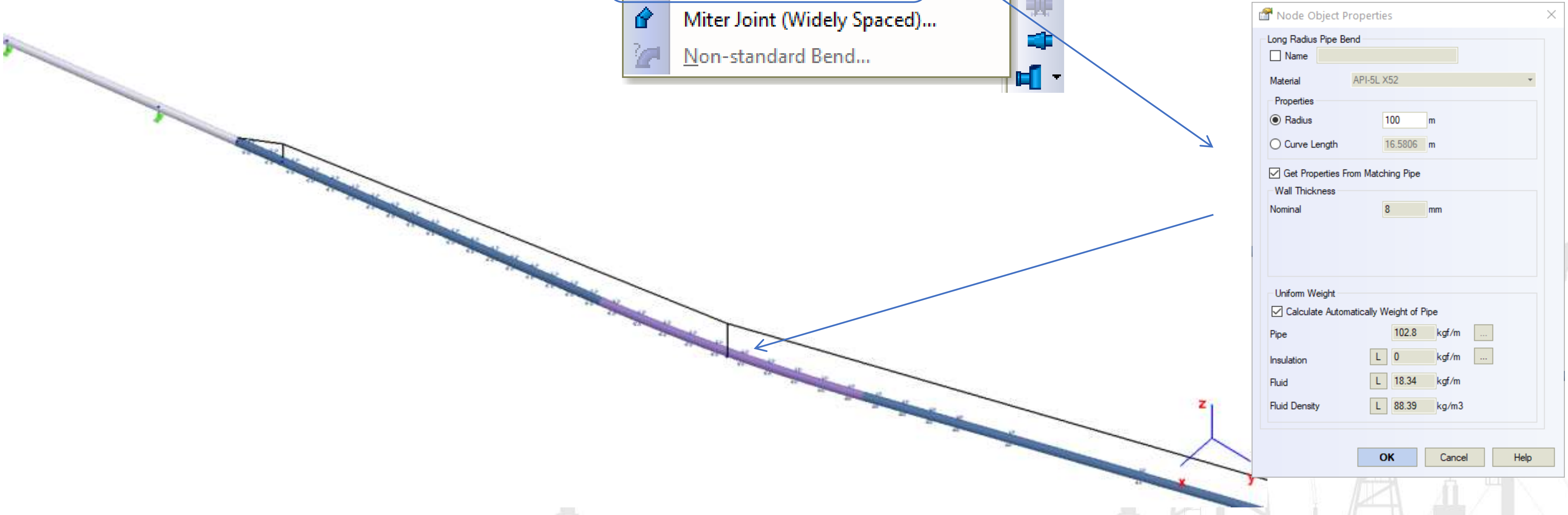
Two Long Radius Bend Objects:

- Long radius pipe bend
- Prestressed pipe bend





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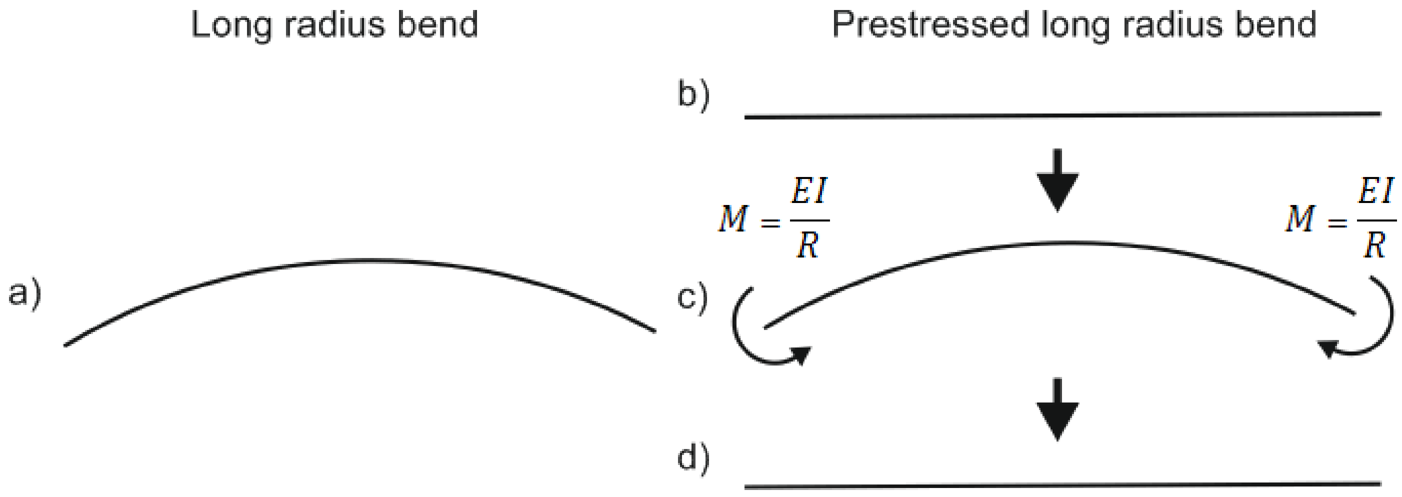
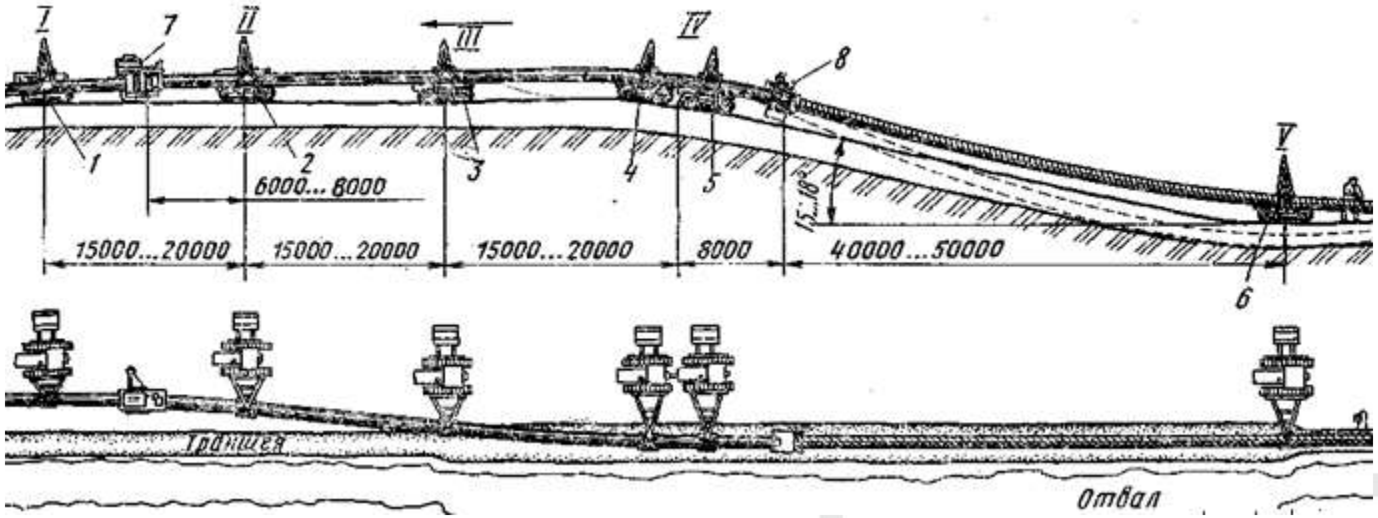
Prestressed pipe bend – Initial elastic bend curvature in vertical and horizontal plane





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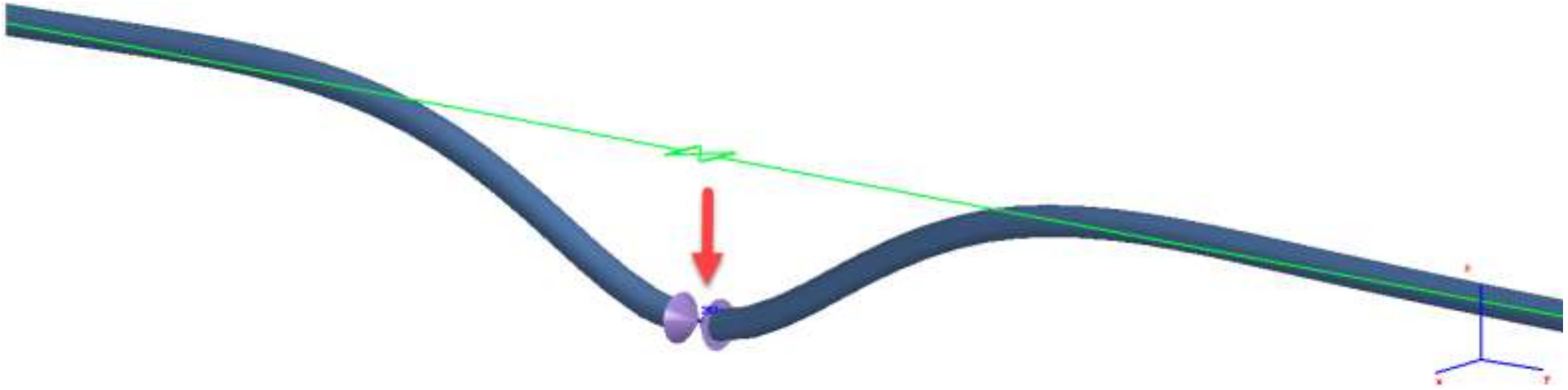
The weight of pipeline, insulation and product is automatically removed to avoid the huge deflections in 100D pipe spans (zone #3).

This the sum of pipeline, insulation, and product weights is used to calculate the soil springs properties including the friction force.

But if you will add the heavy valve on buried pipeline, the weight of the valve will be considered and you will see the deflections:



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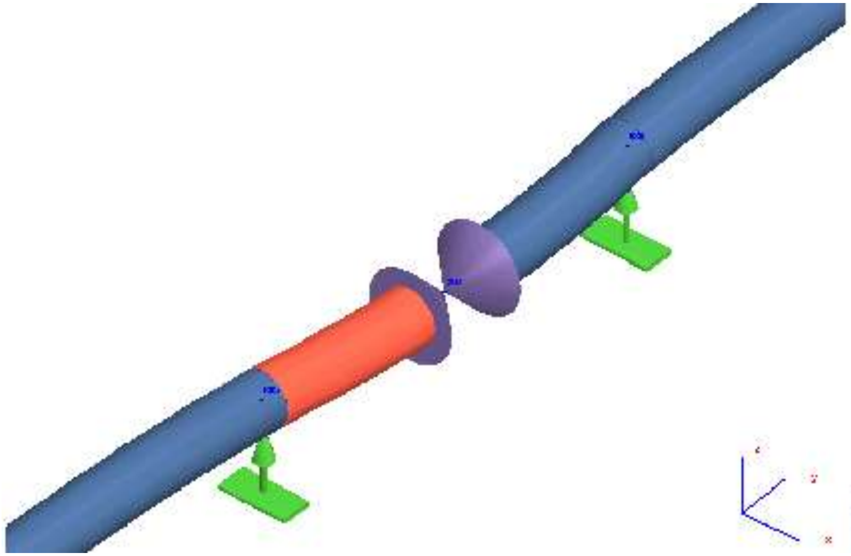
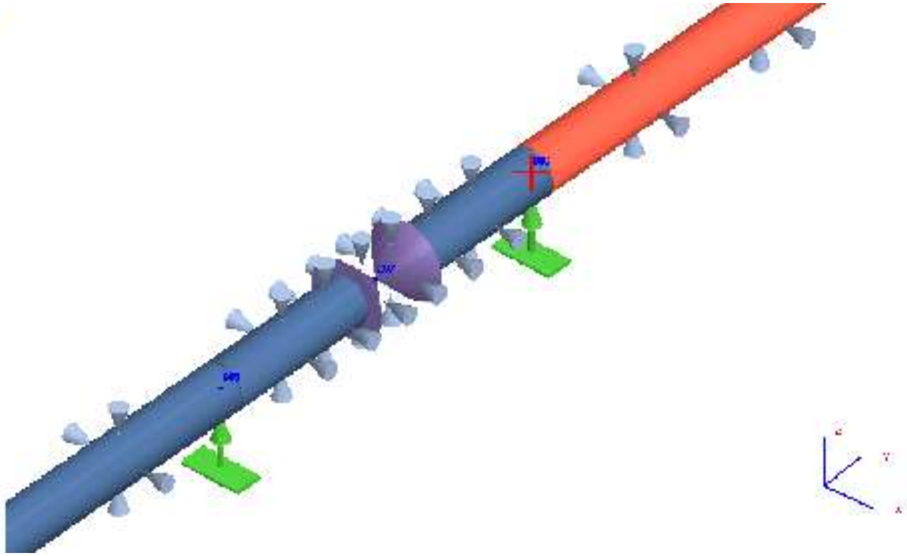
Also you can add the buried supports. It doesn't affect the accuracy of the soil model:





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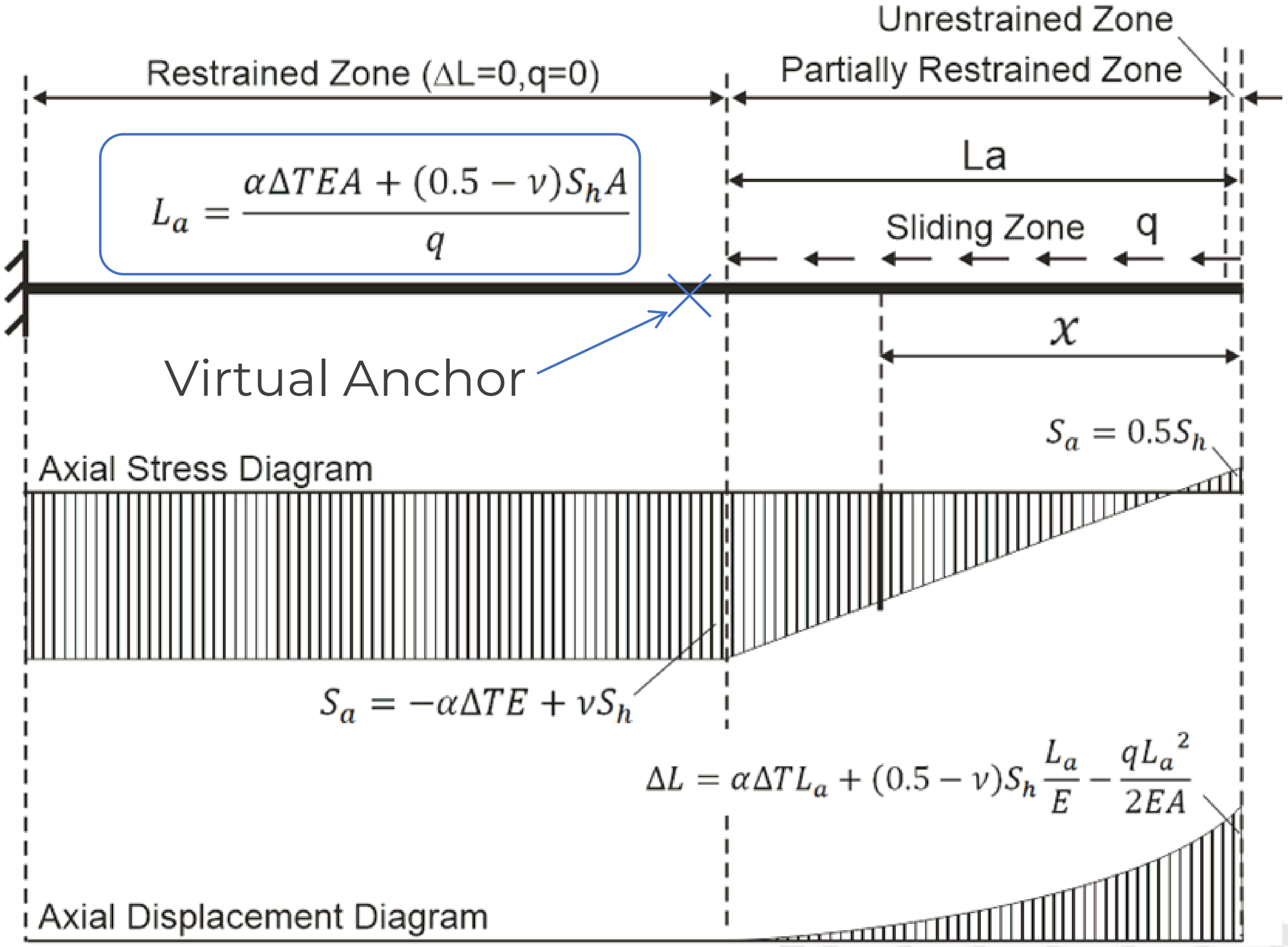
ASME B31.4, B31.8, CSA Z662, B31.12PL, BS PD 8010 codes divide pipes into Restrained and Unrestrained



Unrestrained (ASME B31.4)

$$S_L = \frac{PD}{4t} \pm \frac{iM}{A} + \frac{F_a}{A} \leq 0.75 S_y$$

Restrained (ASME B31.4)

$$S_L = S_E + \upsilon S_H \pm \frac{M}{A} + \frac{F_a}{A} \leq 0.9 S_y$$

$$S_{eq} \leq 0.9 S_y$$

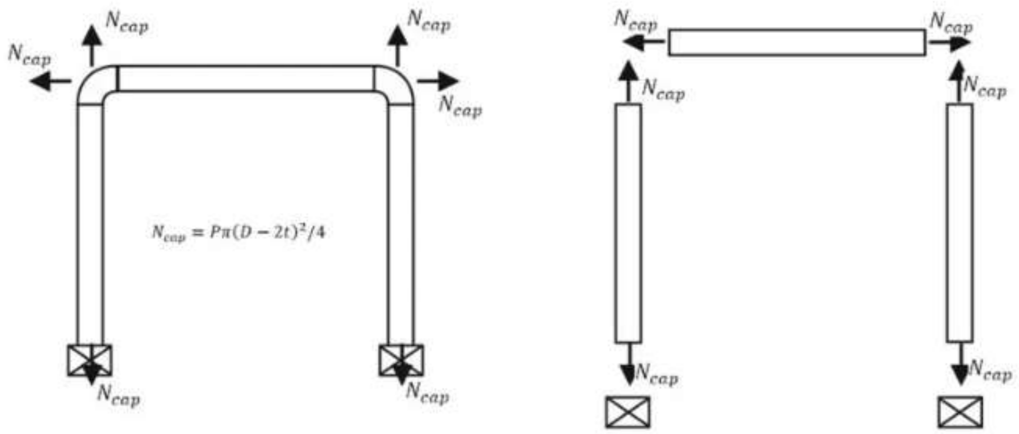
Partially Restrained Zone?
How to Check Stress???

PASS/Start-Prof | Dry Soil Model

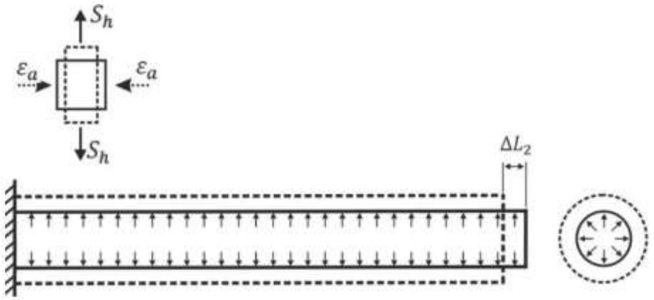
Bourdon Effect in PASS/START-PROF:

1) Pressure thrust forces applies at the ends of each pipe

$$N_{cap} = P\pi(D-2t)^2/4$$



2) Pipe shortening due to pressure load added



$$\varepsilon_a = -2\nu\frac{P}{E}\frac{(D-2t)^2}{D^2-(D-2t)^2}$$

$$\Delta L = \alpha\Delta TL - 2\nu\frac{PL}{E}\frac{(D-2t)^2}{D^2-(D-2t)^2} \approx \alpha\Delta TL - \nu S_h\frac{L}{E}$$

PASS/Start-Prof | Dry Soil Model

If you have the pipeline with zero thermal expansions, you will still get the support loads and displacements caused by pressure Bourdon effect!

Bourdon effect is always activated in PASS/START-PROF to avoid human mistakes when users forget to activate it. It is non-disabling function!

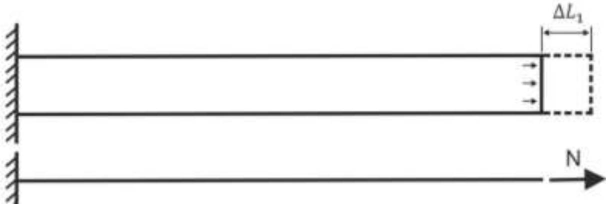
It changes results significantly for:

- High pressure piping and pipelines
- Plastic piping (PE, PP, PB, PVC)
- FRP/GRP/GRE piping

PASS/Start-Prof | Dry Soil Model

Unrestrained Pipe

$$\Delta L = \alpha \Delta T L + (1-2\nu)\frac{PL}{E}\frac{(D-2t)^2}{D^2-(D-2t)^2} \approx \alpha \Delta T L + (0.5-\nu) S_h \frac{L}{E}$$



$$S_a = \frac{N}{A} = P\frac{(D-2t)^2}{D^2-(D-2t)^2} \approx 0.5 S_h$$

$$S_a \le S_{Allow}$$

$$S_a = P\frac{(D-2t)^2}{D^2-(D-2t)^2} \approx \frac{P(D-t)}{4t} \approx \frac{PD}{4t}$$

$$S_a = \frac{PD}{4t} + \frac{M}{Z} + \frac{N}{A} \le S_{Allow}$$

If axial force already contain pressure thrust force (Bourdon effect), then stress check can be done by the following equation:

$$S_a = \frac{M}{Z} + \frac{N}{A} \le S_{Allow}$$

PD/4t should be removed. Bourdon effect automatically gives you this value!

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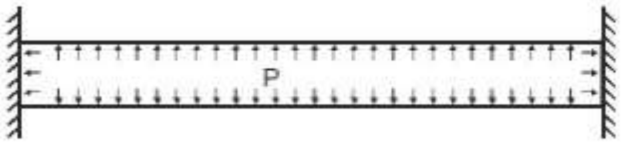
Restrained Pipe

$$N = -\alpha \Delta TEA + 2\nu \frac{\pi P(D-2t)^2}{4} \approx -\alpha \Delta TEA + \nu S_h \cdot A$$



$$S_a = \frac{N}{A} = -\alpha \Delta TE + 2\nu \frac{P(D-2t)^2}{D^2-(D-2t)^2} \approx -\alpha \Delta TE + \nu S_h$$

$$S_a = -\alpha \Delta TE + \nu S_h + \frac{M}{Z} + \frac{N}{A} \leq S_{Allow}$$

If axial force already contain pressure thrust force (Bourdon effect), then stress check can be done by the following equation:

$$S_a = \frac{M}{Z} + \frac{N}{A} \leq S_{Allow}$$

We got the same equation as for unrestrained zone!

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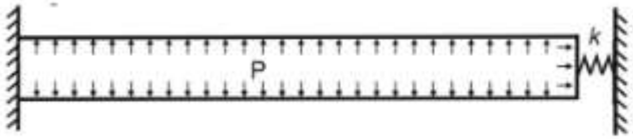
Partially Restrained Pipe



$$S_a = \frac{-\alpha \Delta T E - 2\nu \frac{P(D-2t)^2}{D^2-(D-2t)^2}}{\frac{EA}{kL}+1} + \frac{P(D-2t)^2}{D^2-(D-2t)^2} \approx \frac{-\alpha \Delta T E - (0.5-\nu)S_h}{\frac{EA}{kL}+1} + 0.5S_h$$

If axial force already contain pressure thrust force (Bourdon effect), then stress check can be done by the following equation:

$$S_a = \frac{M}{Z} + \frac{N}{A} \leq S_{Allow}$$

The same equation as for restrained and unrestrained zone!
More detains in my articles:

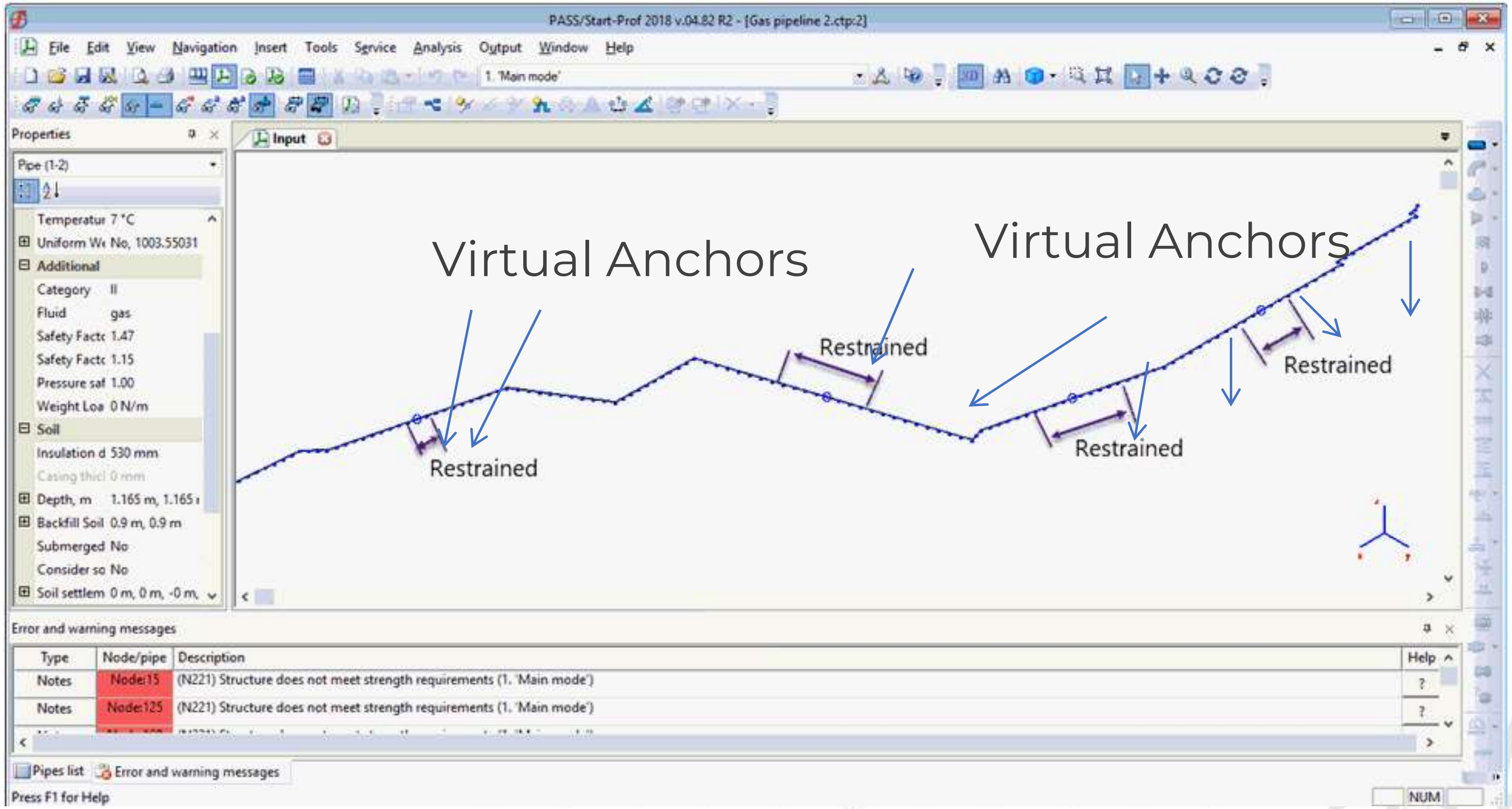
https://www.passuite.com/kbase/doc/start/WebHelp_en/index.htm#t=RestrainedPipe.htm

https://whatispiping.com/restrained-and-unrestrained1

https://whatispiping.com/restrained-and-unrestrained2

PASS/Start-Prof | Dry Soil Model

In fact, most of long pipelines has restrained and unrestrained zones and virtual anchors
We need to find the position of the each virtual anchor in the pipeline system?! For each value of temperature (operating mode)?! Manually?!



PASS

PASS/Start-Prof | Dry Soil Model

PASS/START-PROF Offers 3 Options to Solve this Problem

1) Manual Selection of Restrained/Unrestrained Zones

2) Autodetect Function. Automatically selects the type of zone for each pipe

$$\frac{F/A}{-E\alpha\Delta T + \upsilon S_H} > 0.975$$

3) Smart start check. The best solution. As START-PROF always consider the Bourdon effect, then we can use the more general equations to check stresses

ASME B31.4 code 402.6.2 Unrestrained Pipes from Sustained Loads

$$S_L = \frac{PD}{4t} \pm \frac{iM}{A} + \frac{F_a}{A} \leq 0.75S_y \quad \Rightarrow \quad S_L = \pm\frac{iM}{A} + \frac{F_a}{A} \leq 0.75S_y \; or \; 0.8S_y$$

ASME B31.4 code 402.6.1 Restrained Pipes from Operating Loads (Sustained+Expansion)

$$S_L = S_E + \upsilon S_H \pm \frac{M}{A} + \frac{F_a}{A} \leq 0.9S_y \qquad S_{eq} \leq 0.9S_y \quad \Rightarrow \quad S_L = \pm\frac{M}{A} + \frac{F_a}{A} \leq 0.9S_y \qquad S_{eq} \leq 0.9S_y$$

PASS/Start-Prof | Dry Soil Model

Start smart check equations does not contradict the original requirements of the code!
If pipeline failed the “Start Smart Check”, then it will fail the original code check too!

But this feature allows to forget about Restrained/Unrestrained Zones, Virtual Anchors.
Just Draw the pipeline and run analysis

Original ASME B31.4 Requirements

Element	Sustained, L1 SUS				Operation, L2 OPE				Expansion, L9 EXP		Test, L10	
	S_{eq}	allow	S_L	allow	S_{eq}	allow	S_L	allow	S_E	allow	S_L	allow
Onshore Pipeline												
Pipe/R	-	-	-	-	S_{eq}	$0.9S_y$	S_L	$0.9S_y$	S_E	$0.9S_y$	S_L	$0.9S_y$
Fitting/R	-	-	-	-	-	-	-	-	-	-	-	-
Pipe/U	-	-	S_L	$0.75S_y$	-	-	-	-	S_E	S_A	S_L	$0.8S_y$
Fitting/U	-	-	S_L	$0.75S_y$	-	-	-	-	S_E	S_A	S_L	$0.8S_y$
Raiser												
Pipe/W	-	-	S_L	$0.8S_y$	-	-	-	-	S_E	$0.8S_y$	S_L	$0.9S_y$
Fitting/W	-	-	S_L	$0.8S_y$	-	-	-	-	S_E	$0.8S_y$	S_L	$0.9S_y$
Offshore Pipeline (Ch. IX)												
Pipe	S_{eq}	$0.9S_y$	$\lvert S_L \rvert$	$0.8S_y$	S_{eq}	$0.9S_y$	$\lvert S_L \rvert$	$0.8S_y$	-	-	-	-
Fitting	S_{eq}	$0.9S_y$	$\lvert S_L \rvert$	$0.8S_y$	S_{eq}	$0.9S_y$	$\lvert S_L \rvert$	$0.8S_y$	-	-	-	-
Slurry Pipes (Ch. XI)												
Pipe/R	-	-	-	-	S_{eq}	$0.9S_y$	S_L	$0.9S_y$	S_E	$0.9S_y$	S_L	$0.9S_y$
Fitting/R	-	-	-	-	-	-	-	-	-	-	-	-
Pipe/U	-	-	S_L	$0.75S_y$	-	-	-	-	S_E	S_A	S_L	$0.88S_y$
Fitting/U	-	-	S_L	$0.75S_y$	-	-	-	-	S_E	S_A	S_L	$0.88S_y$

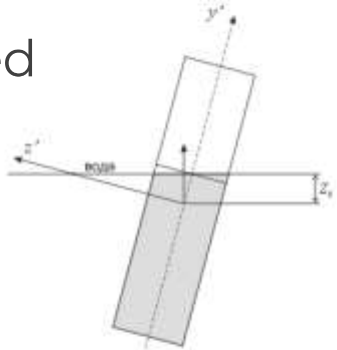
ASME B31.4 + Start Smart Check

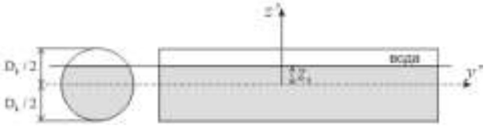
Element	Sustained, L1 SUS				Operation L2 OPE				Expansion, L9 EXP		Test, L10	
	S_{eq}	allow	S_L	allow	S_{eq}	allow	S_L	allow	S_E	allow	S_L	allow
Onshore Pipeline												
Pipe	-	-	S_L	$0.75S_y$	S_{eq}	$0.9S_y$	S_L	$0.9S_y$	S_E	$0.9S_y \Vert S_A$	S_L	$0.8S_y$
Fitting	-	-	S_L	$0.75S_y$	-	-	-	-	S_E	S_A	S_L	$0.8S_y$
Raiser												
Pipe	-	-	S_L	$0.8S_y$	S_{eq}	$0.9S_y$	S_L	$0.9S_y$	S_E	$0.8S_y$	S_L	$0.9S_y$
Fitting	-	-	S_L	$0.8S_y$	-	-	-	-	S_E	$0.8S_y$	S_L	$0.9S_y$
Offshore Pipeline (Ch. IX)												
Pipe	S_{eq}	$0.9S_y$	$\lvert S_L \rvert$	$0.8S_y$	S_{eq}	$0.9S_y$	$\lvert S_L \rvert$	$0.8S_y$	-	-	-	-
Fitting	S_{eq}	$0.9S_y$	$\lvert S_L \rvert$	$0.8S_y$	S_{eq}	$0.9S_y$	$\lvert S_L \rvert$	$0.8S_y$	-	-	-	-
Slurry Pipes (Ch. XI)												
Pipe	-	-	S_L	$0.75S_y$	S_{eq}	$0.9S_y$	S_L	$0.9S_y$	S_E	$0.9S_y$	S_L	$0.88S_y$
Fitting	-	-	S_L	$0.75S_y$	-	-	-	-	S_E	S_A	S_L	$0.88S_y$

PASS/Start-Prof | Submerged Buried Pipeline

Soil Model for Submerged Buried Pipelines:

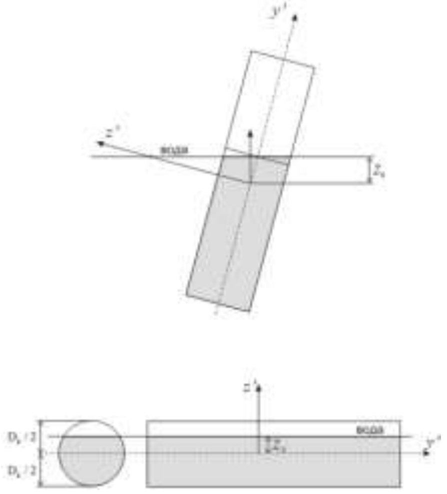
- Soil springs are placed every 5D
- The weight of pipeline, insulation and product is not removed to get the accurate results with the ballasting
- Ballasting weight objects can be added
- Water Buoyancy Considered Automatically
- Liquefied Soil Properties are taken into account automatically

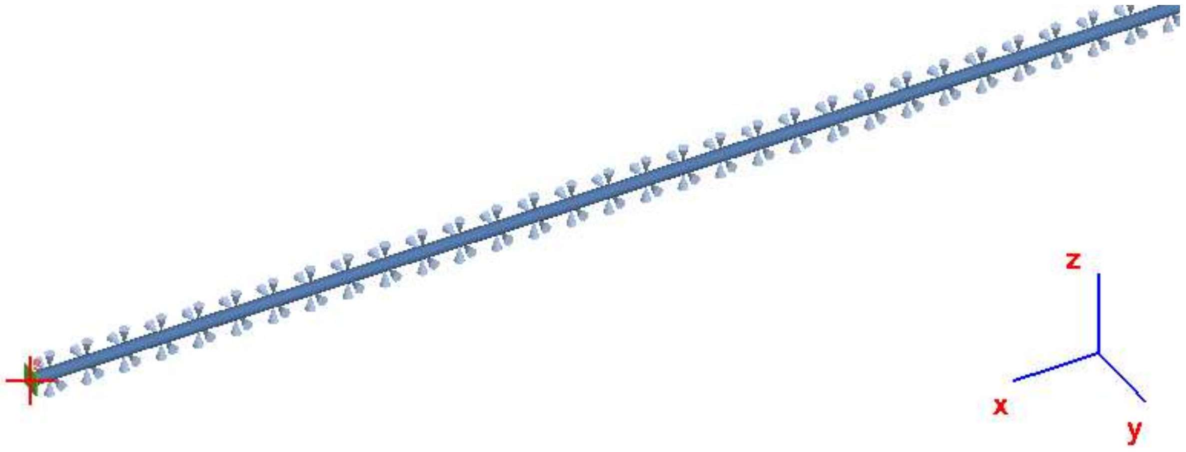


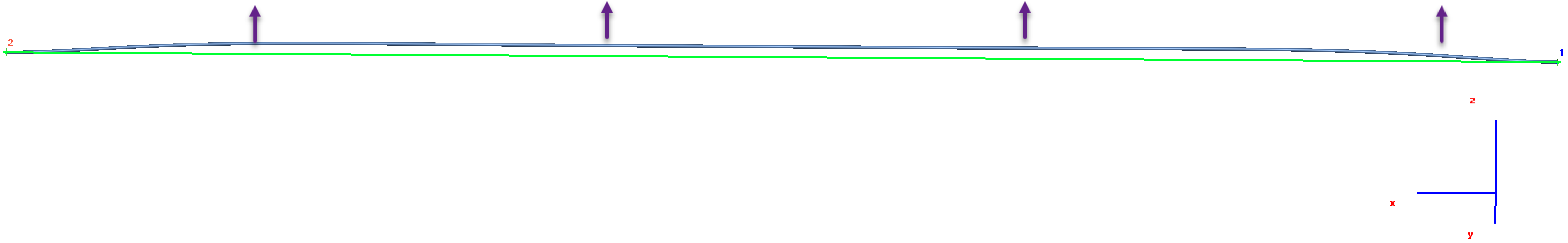


PASS/Start-Prof | Submerged Buried Pipeline

Pops Up with Water Buoyancy

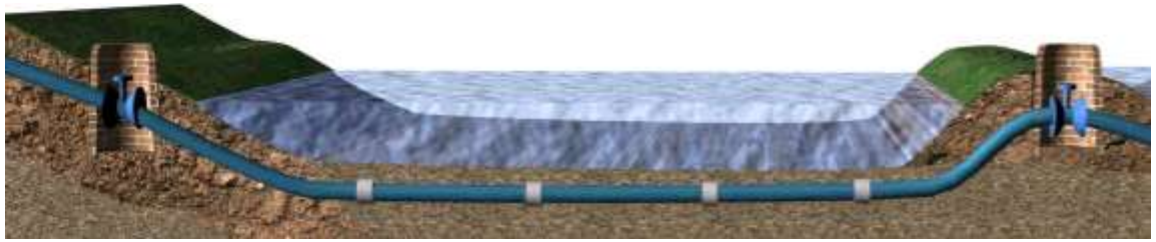


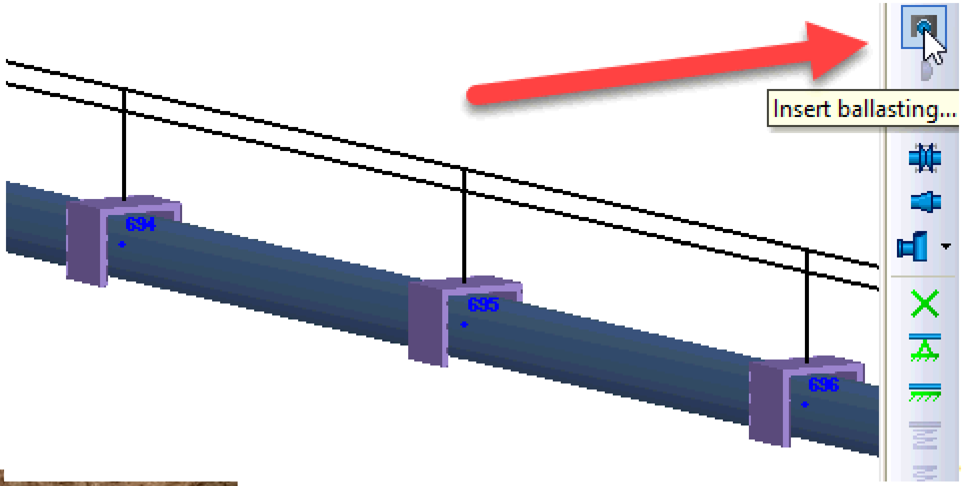




PASS/Start-Prof | Submerged Buried Pipeline

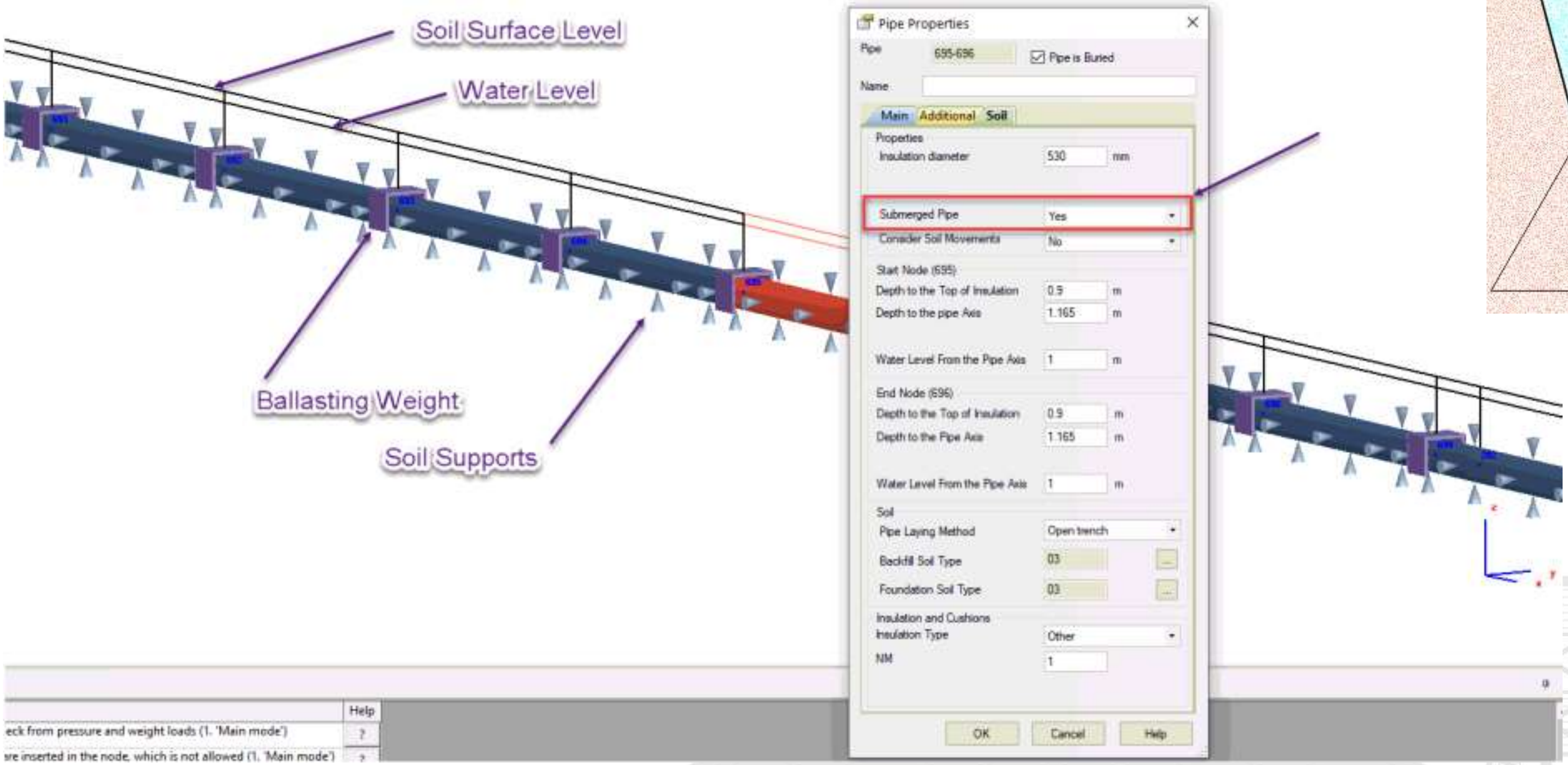
Ballasting Weight Object
Lake/river crossings

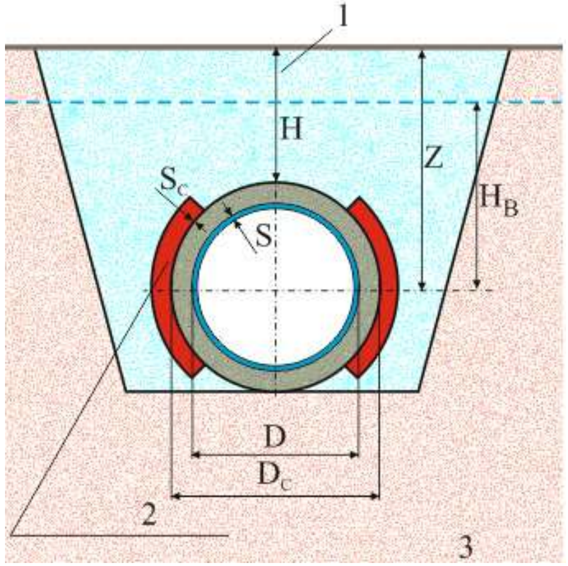




PASS/Start-Prof | Submerged Buried Pipeline

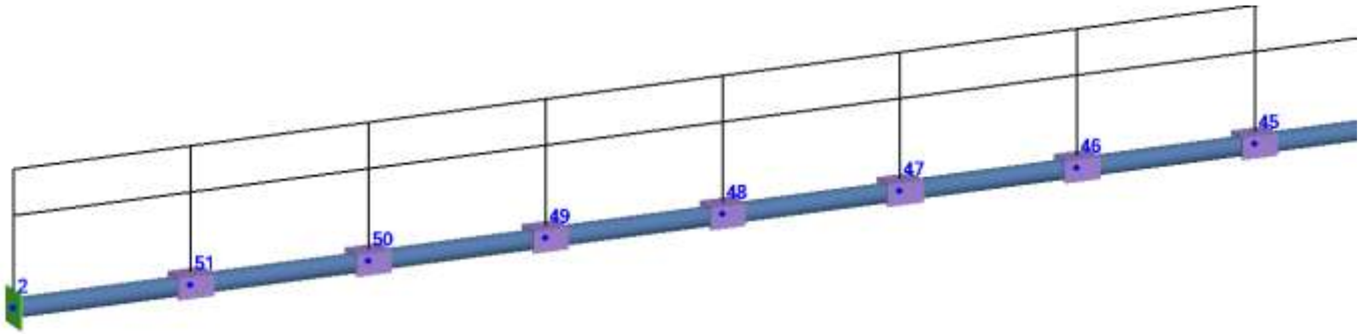
Submerged Pipeline Soil Model

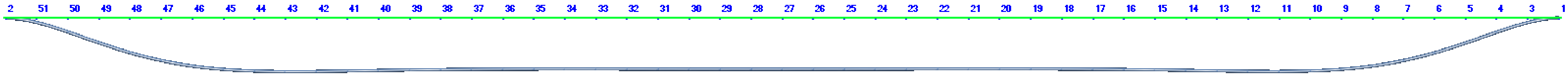




PASS/Start-Prof | Submerged Buried Pipeline

Drowning With Ballasting Weights





PASS/Start-Prof | Soil Model

PASS/START-PROF has a very powerful and detailed, but easy to use and fully automatic soil model. Software user's manual work is reduced to minimum.

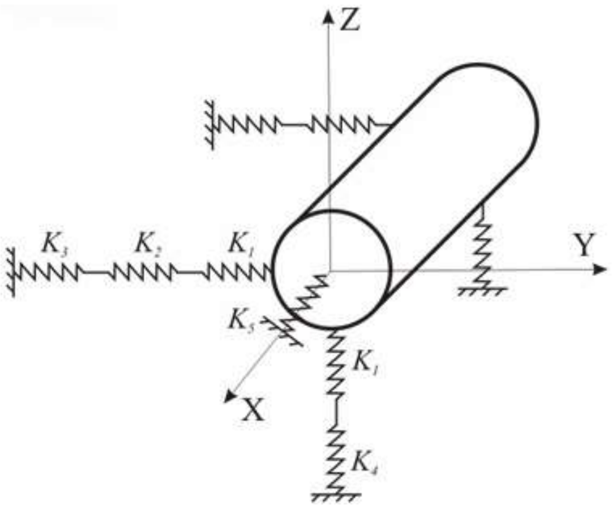
It can easily deal with the pipelines buried in the dry soil, submerged in the liquefied soil, considering the expansion cushions and insulation stiffness, ballasting weights, horizontal, vertical, inclined pipes, combined buried and above ground (not buried) piping model, seismic wave propagation analysis, landslide, soil subsidence, seismic fault crossing, consider the natural arch of collapse for horizontal directional drilling method.

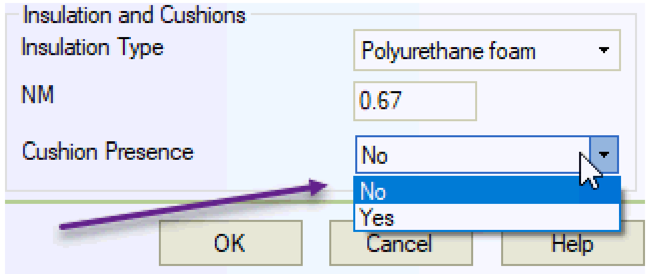
This soil model was developed at VNIIST Company (Moscow), and successfully used in 5 pipe stress analysis programs more than 35 years by lot of companies in Russia, Belarus, Ukraine, Kazakhstan, and some other countries.

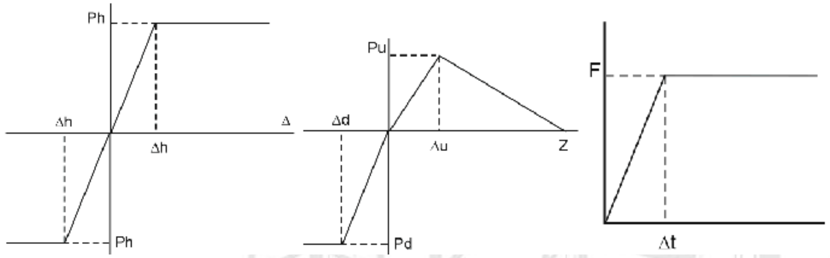
PASS/Start-Prof | Soil Model

Each soil support stiffness consist of vertical, horizontal and longitudinal nonlinear springs

- Horizontal spring consist of 3 springs K1, K2, K3.
- Vertical Spring consist of 2 (or 3) springs K1, K4 (and K2).
- Longitudinal spring K5.

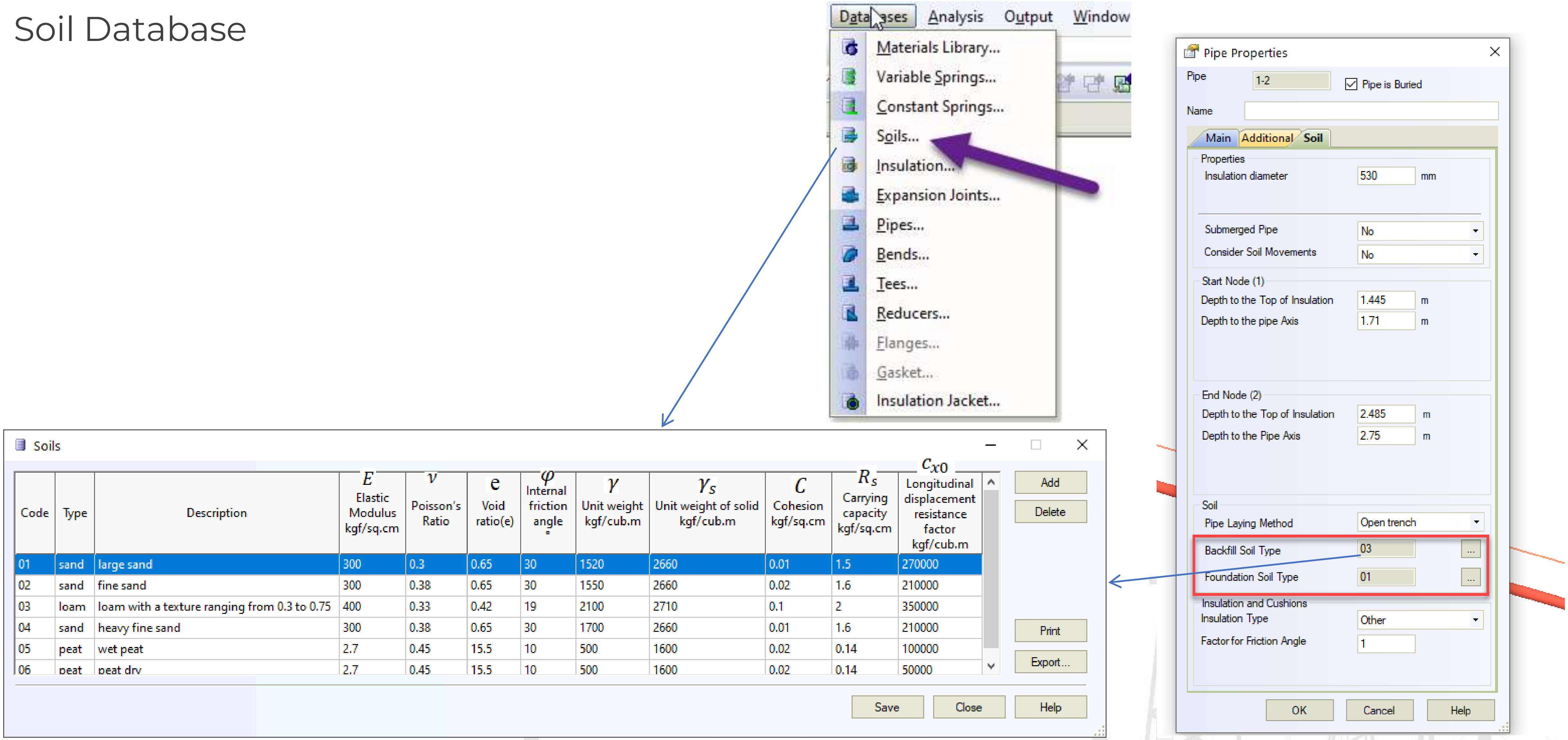






PASS/Start-Prof | New Features

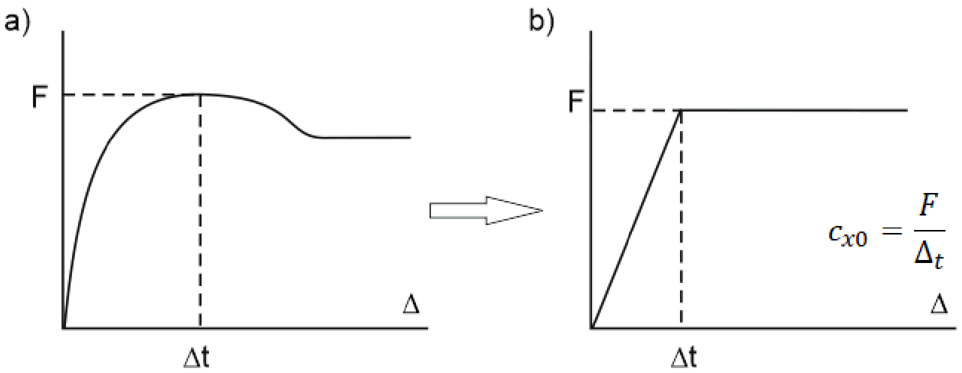
Soil Database

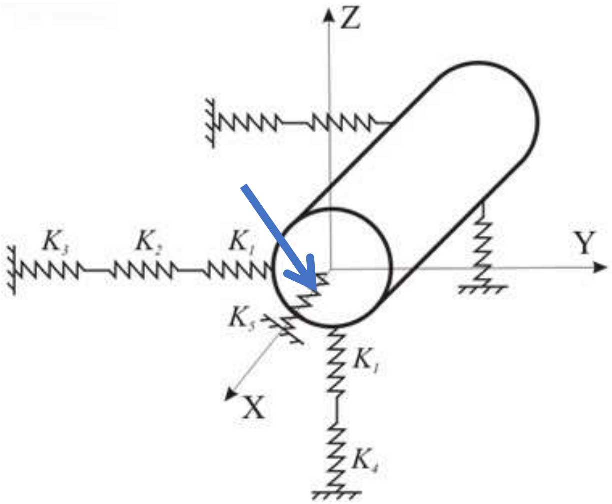


Code	Type	Description	E Elastic Modulus kgf/sq.cm	ν Poisson's Ratio	e Void ratio(e)	φ Internal friction angle °	γ Unit weight kgf/cub.m	γ_s Unit weight of solid kgf/cub.m	C Cohesion kgf/sq.cm	R_s Carrying capacity kgf/sq.cm	C_{x0} Longitudinal displacement resistance factor kgf/cub.m
01	sand	large sand	300	0.3	0.65	30	1520	2660	0.01	1.5	270000
02	sand	fine sand	300	0.38	0.65	30	1550	2660	0.02	1.6	210000
03	loam	loam with a texture ranging from 0.3 to 0.75	400	0.33	0.42	19	2100	2710	0.1	2	350000
04	sand	heavy fine sand	300	0.38	0.65	30	1700	2660	0.01	1.6	210000
05	peat	wet peat	2.7	0.45	15.5	10	500	1600	0.02	0.14	100000
06	peat	peat dry	2.7	0.45	15.5	10	500	1600	0.02	0.14	50000

PASS/Start-Prof | Soil Model

Longitudinal Bi-linear Soil Spring Model





$$F = \mu\left(2\pi D_c^2 C_h \bar{\gamma} + G\right) + 0.6\pi D_c C$$

μ – Friction factor

$$\mu = tg(\varphi \cdot n_m)$$

D_c – Insulation casing outer diameter
C – Soil Cohesion from database
φ - Soil internal friction angle from database
G – Pipe, Insulation, Product weight, minus Buoyancy
n_m - Insulation adhesion factor. For steel pipes without insulation $n_m = 1$, f
$n_m = 0.67$

$C_h = -0.056\beta^2 + 0.416\beta + 0.095$ - For sand and sandy load
$C_h = -0.046\beta^2 + 0.367\beta - 0.06$ - For clay and loam

$$\beta = \begin{cases} \frac{Z}{D_c}, & \frac{Z}{D_c} < 4 \\ 4, & \frac{Z}{D_c} \geq 4 \end{cases}$$

$\bar{\gamma}$ – Effective soil unit weight, considering the water liquefaction effect.
For horizontal pipes it is calculated using the following method:

- If the pipe is above the water level, then

$$\bar{\gamma} = \gamma$$

- If the pipe is below the water level, then

$$\bar{\gamma} = \frac{\gamma_s - \gamma_w}{1 + e}$$

For vertical and horizontal pipes the more complex equations are used, we will skip it to simplify the understanding.
γ – Dry soil unit weight from soil database
γ_s –Soil particle unit weight from soil database
γ_w – Water unit weight
e - Void Ratio

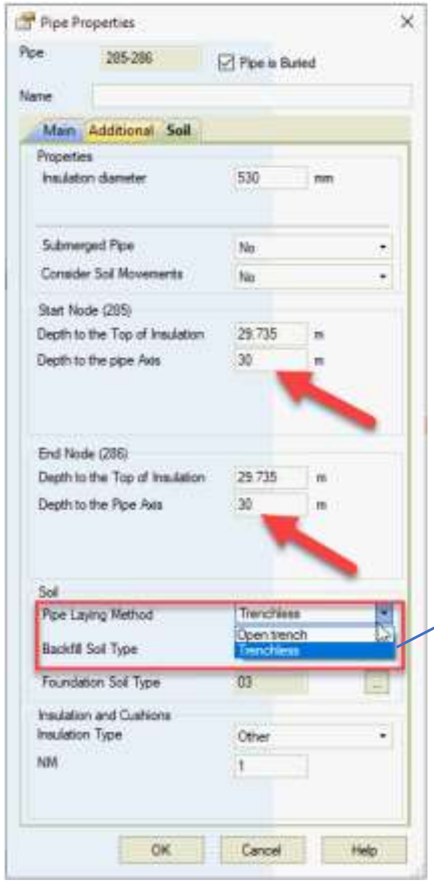
$$e = \frac{V_v}{V_s} = \frac{\gamma_s - \gamma}{\gamma} = \frac{n}{1-n}$$

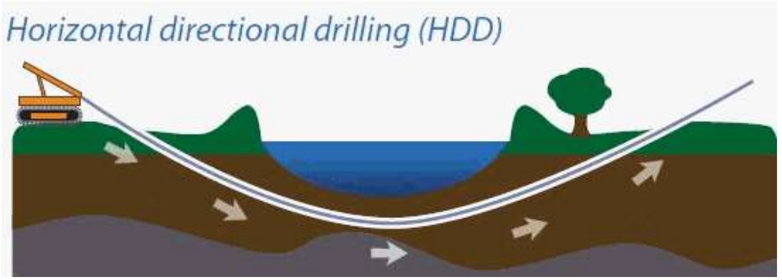
V_v - Volume of the void space
V_s - Volume of the solids
n – Porosity
All needed soil data is stored in the START-PROF soil database

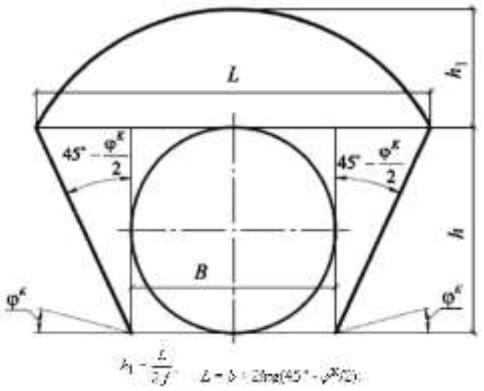
PASS
PIPING AND EQUIPMENT ANALYSIS & SIZING SUITE

PASS/Start-Prof | Soil Model

Natural Arch of Collapse Phenomena



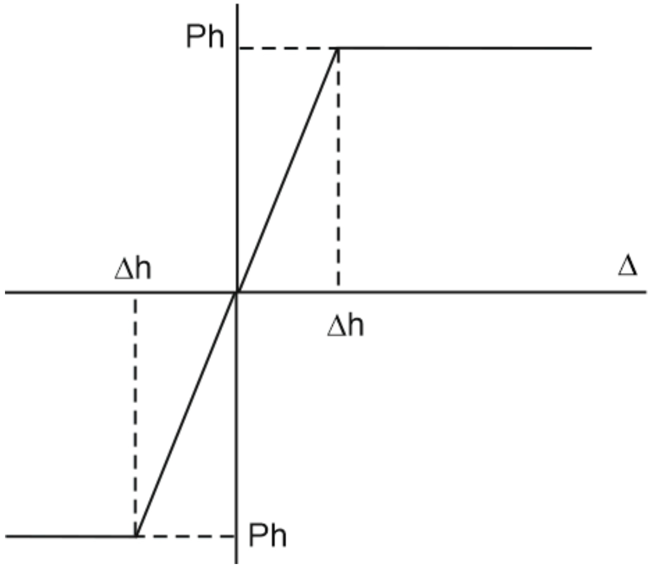


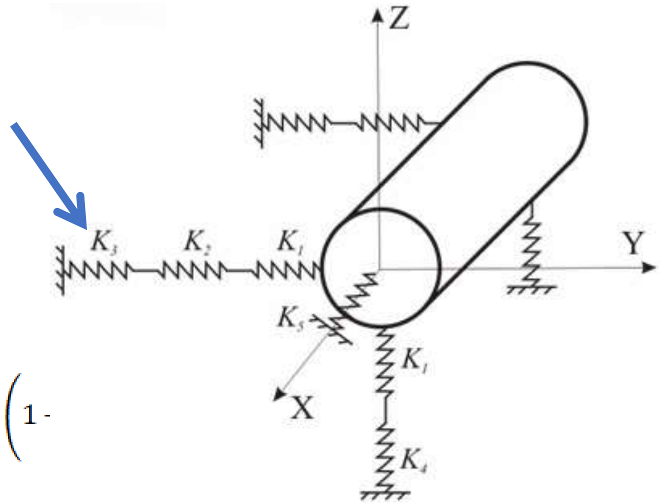


PIPING AND EQUIPMENT
ANALYSIS & SIZING SUITE

PASS/Start-Prof | Soil Model

Lateral Bi-linear Soil Spring Properties





Lateral soil stiffness is calculated using the equation

$$K_L = \frac{P_h}{\Delta_h} = \frac{0.12E\eta}{(1-\nu^2)\sqrt{D_c}}\Bigg(1 -$$

$$P_h = R_s$$

Z – Soil spring depth from the surface to the pipe axis

$$\eta = 0.547\beta^2 - \beta + 0.854$$

$$\beta = \begin{cases} \frac{a}{Z}\ if\ a/Z < 1 \\ 1\ if\ a/Z \geq 1 \end{cases}$$

$$a = \begin{cases} 150\ if\ D_c < 700mm \\ 0.25D_c\ if\ D_c \geq 700mm \end{cases}$$

E – Backfilling Soil Elastic modulus from database

ν – Backfilling Soil Poisson's factor from database

R_s – Backfilling Soil maximum lateral force from database

PASS/Start-Prof | Soil Model

Vertical Tri-linear Soil Spring Properties

Trilinear diagram is used for vertical springs
Vertical downward soil stiffness is calculated using the equation

$$K_d = \frac{P_d}{\Delta_d} = \frac{0.144E_2}{(1-\nu_2^2)\sqrt{D_c}}$$

$$P_d = R_{s2}$$

Vertical upward soil stiffness is calculated using the equation

$$K_u = \frac{P_d}{\Delta_u} = \frac{0.072E\eta_v}{(1-\nu^2)\sqrt{D_c}}\left(1-e^{\frac{-2Z}{D_c}}\right)$$

$$\eta_v = \begin{cases} 1 \; if \; Z_w \le Z \\ 0.5(2 - Z_w/Z) \; if \; 0 < Z_w < Z \\ 0.5 \; if \; Z_w > Z \end{cases}$$

$$P_d = \overline{\gamma} D_c \left(Z - \frac{\pi}{8} D_c\right) + k\left(\overline{\gamma} Z^2 \tan 0.7\varphi + \frac{0.7ZC}{\cos 0.7\varphi}\right)$$

$\overline{\gamma}$ – Effective soil unit weight, considering the water liquefaction effect.
For horizontal pipes it is calculated using the following method:

- If the pipe is above the water level, then

$$\overline{\gamma} = \gamma$$

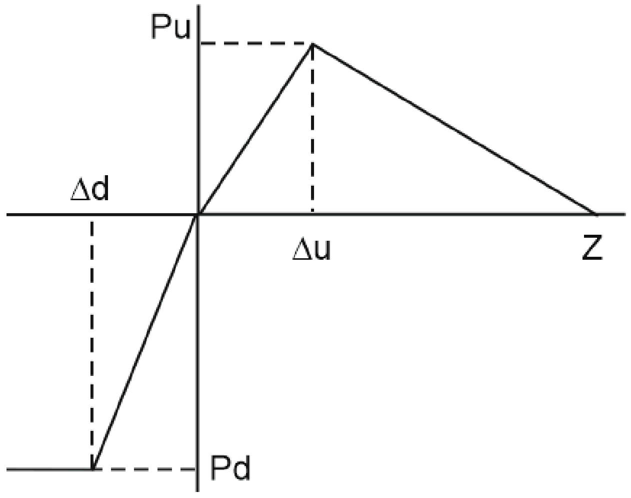
- If the pipe is below the water level, then

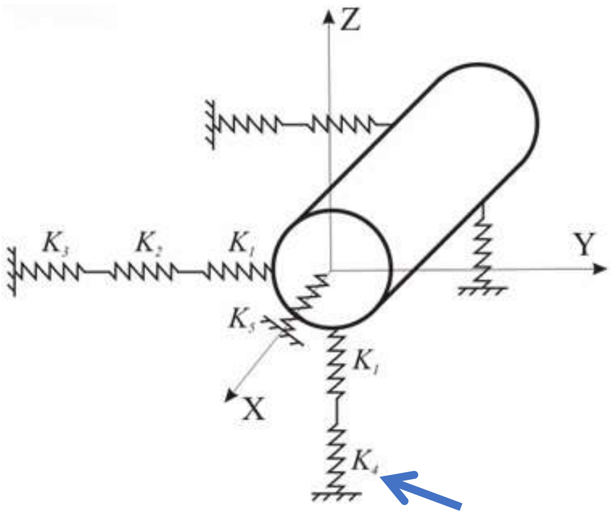
$$\overline{\gamma} = \gamma \frac{Z - \frac{\pi}{8}D_c - Z_w}{Z - \frac{\pi}{8}D_c} + \frac{\gamma_s - \gamma_w}{1+e}\frac{Z_w}{Z - \frac{\pi}{8}D_c}$$

- If the water level is within the pipe then

$$\overline{\gamma} = \gamma \frac{Z - Z_w - \frac{\pi}{4}D_c + V_w/D_c}{Z - \frac{\pi}{8}D_c} + \frac{\gamma_s - \gamma_w}{1+e}\frac{Z_w + \frac{\pi}{8}D_c - V_w/D_c}{Z - \frac{\pi}{8}D_c}$$

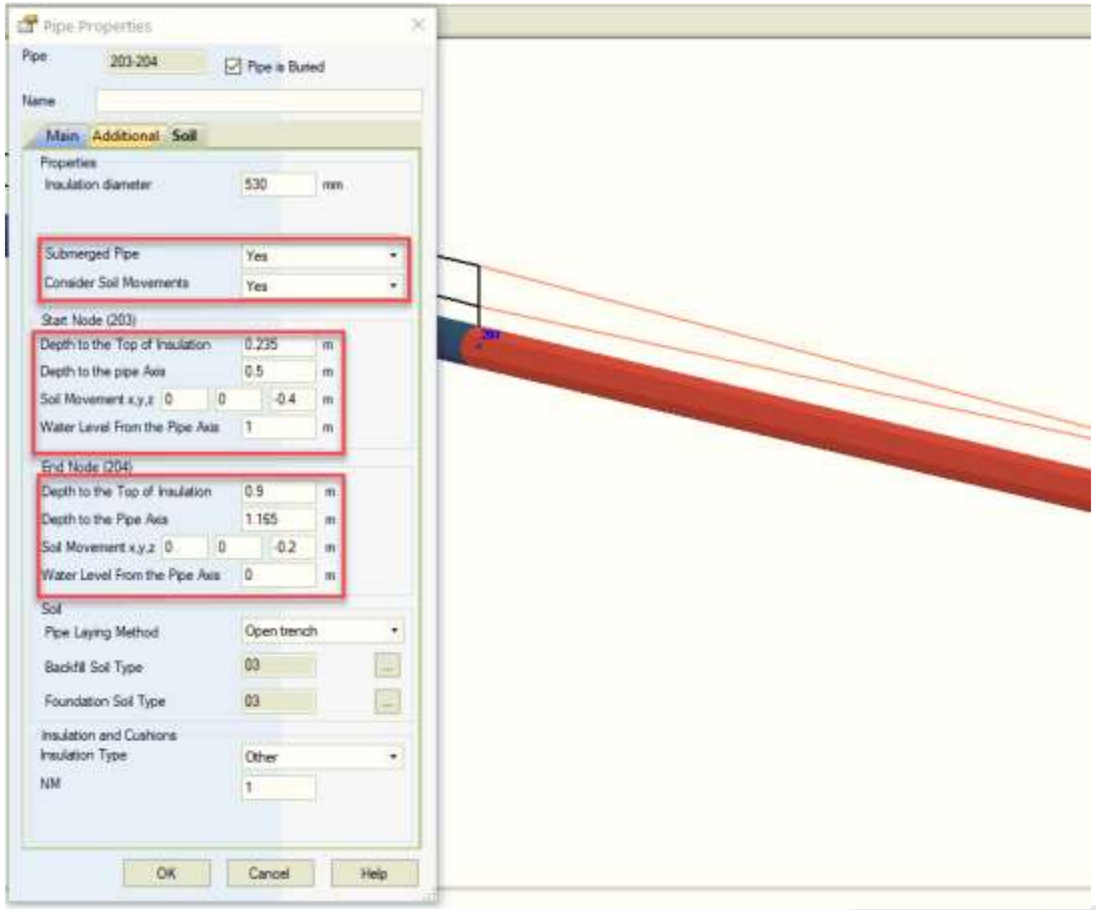
$$V_w = \frac{D_c^2}{8}(\alpha - \sin\alpha)$$

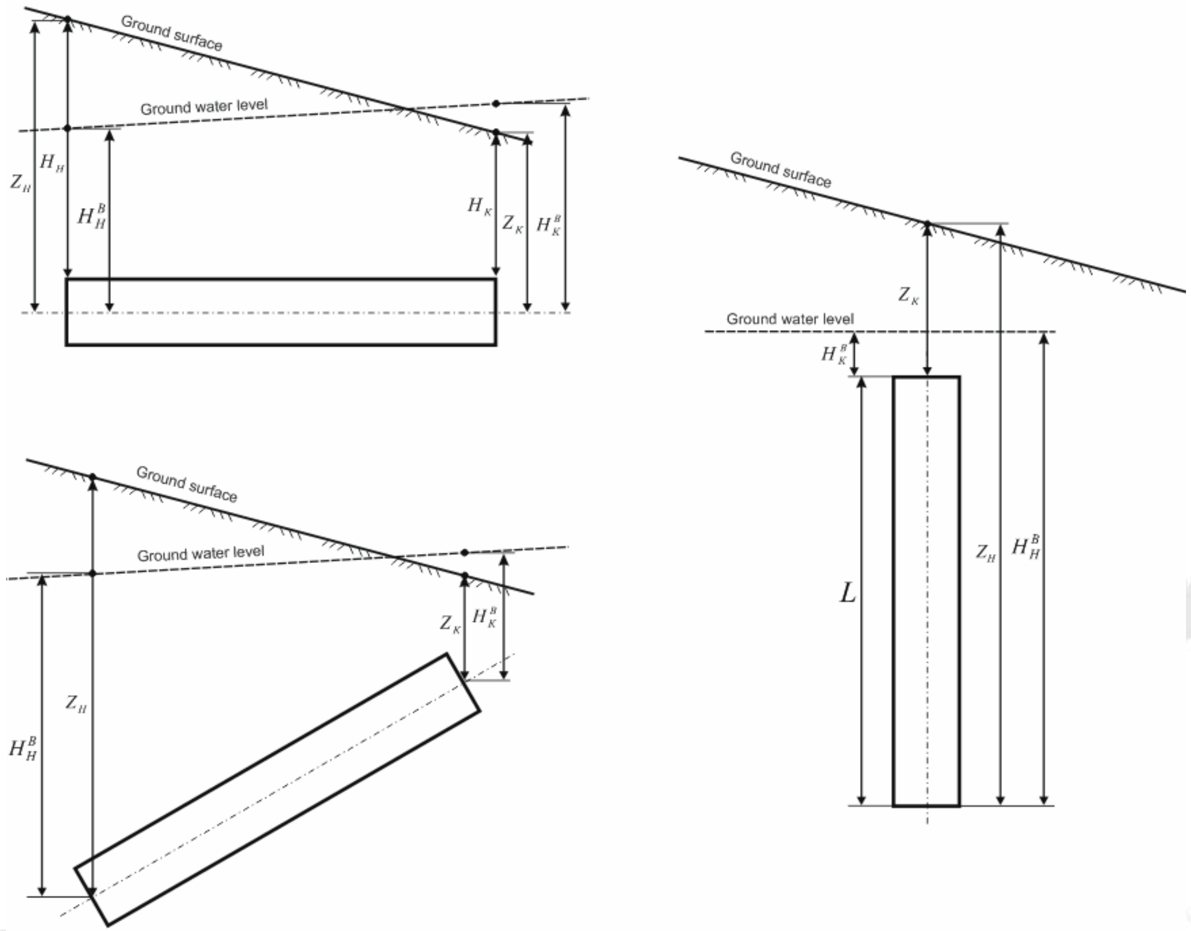




PASS/Start-Prof | Soil Model

You can define the depth from the surface at any node of the pipeline. Depth, water height and subsidence can change along the pipe length

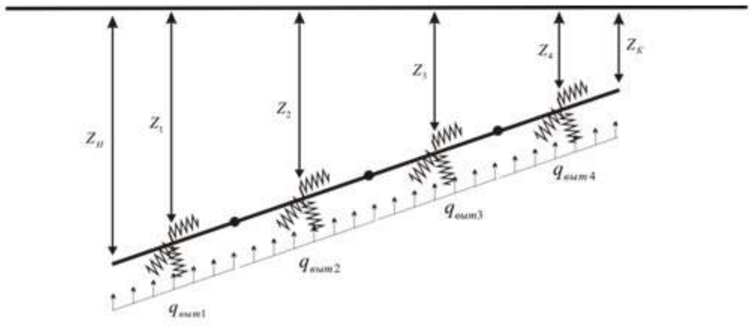


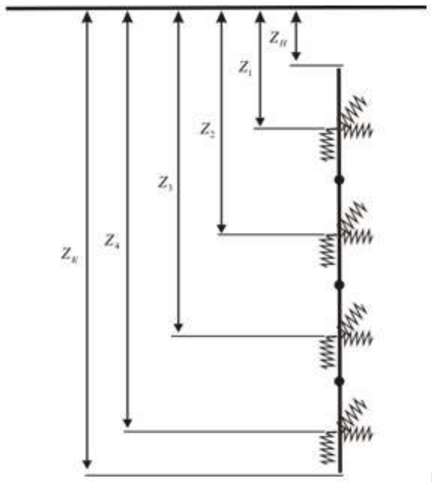


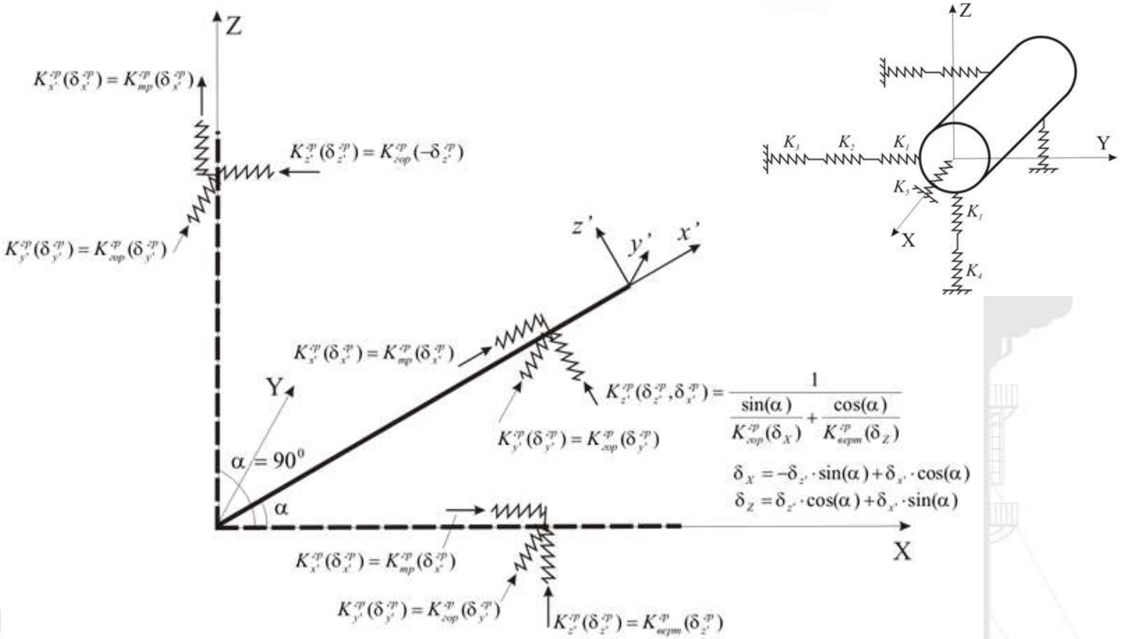
PASS/Start-Prof | Soil Model

For inclined and vertical pipes:

- The bilinear properties of each soil spring (stiffness, water buoyancy, spring displacement etc.) are calculated using individual depth of the specific spring
- Stiffness of the springs K3, K4 and K5 are also depend on the pipe angle to the horizontal plane (from 0 to 90 degrees). For vertical pipe elements the vertical stiffness K4 behavior becomes the same as behavior of horizontal spring K3



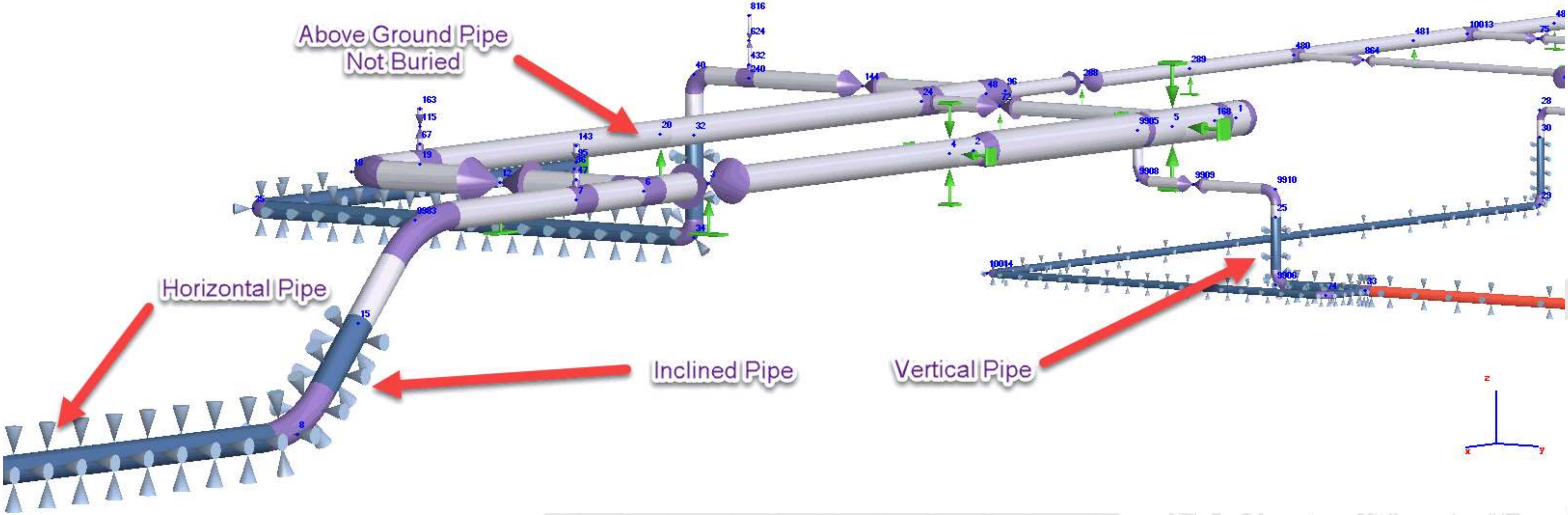




PASS/Start-Prof | Soil Model

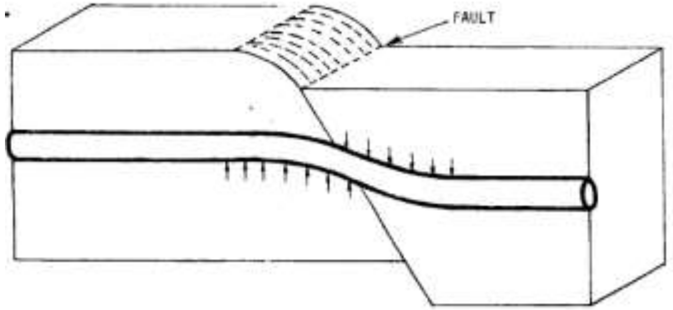
PASS/START-PROF can automatically calculate the mixed pipeline models with above ground pipes, horizontal pipes, inclined pipes, vertical pipes.

You don’t need to do something manually. Just draw the pipeline “as is” and run analysis

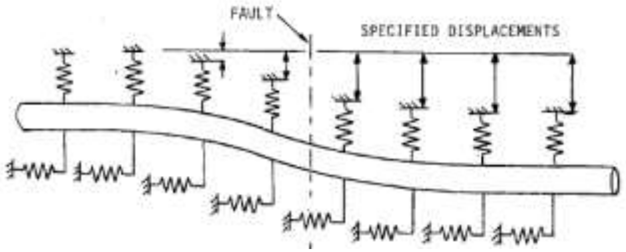


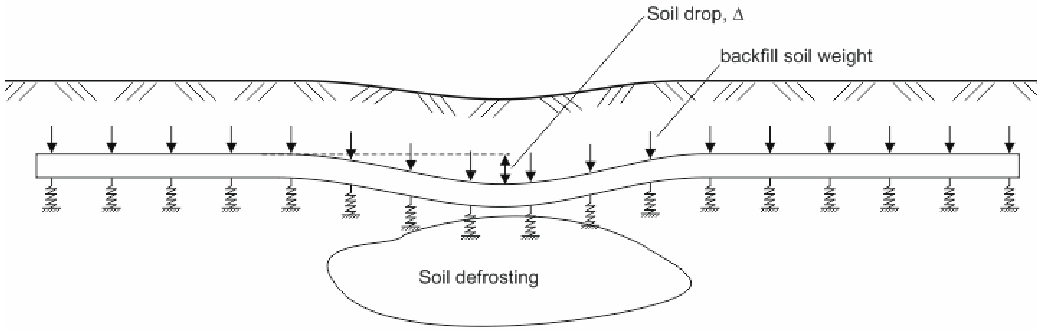
PASS/Start-Prof | Soil Model

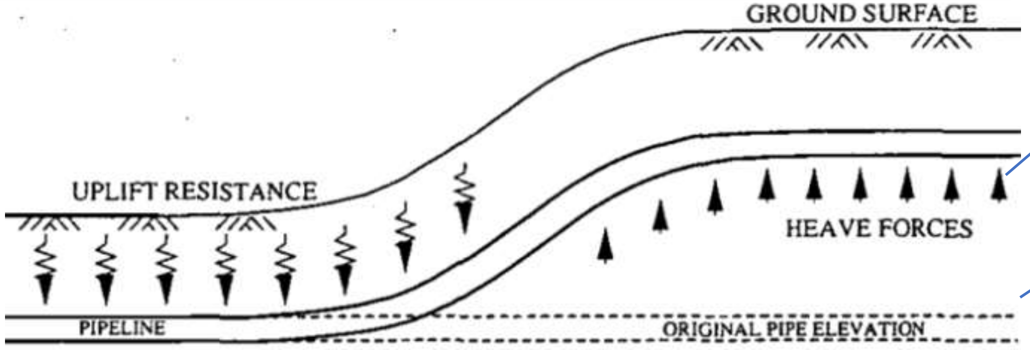
Modeling of Soil Subsidence, Frost Heaving, Landslide, Seismic Fault Crossing
It is modeled as soil movements at the both ends of the each pipe at X, Y, Z directions

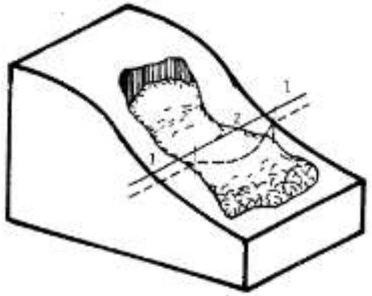


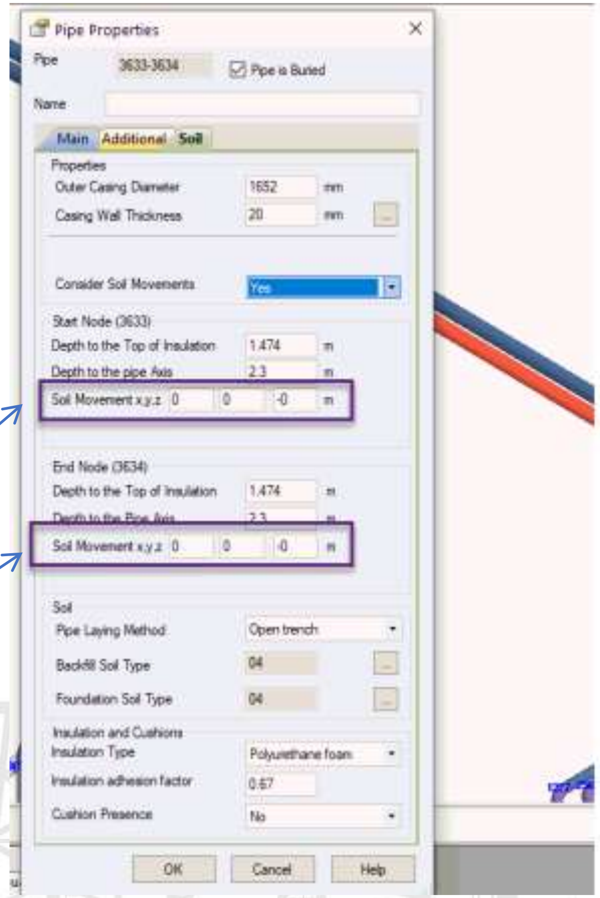
(A) ACTUAL GEOMETRY







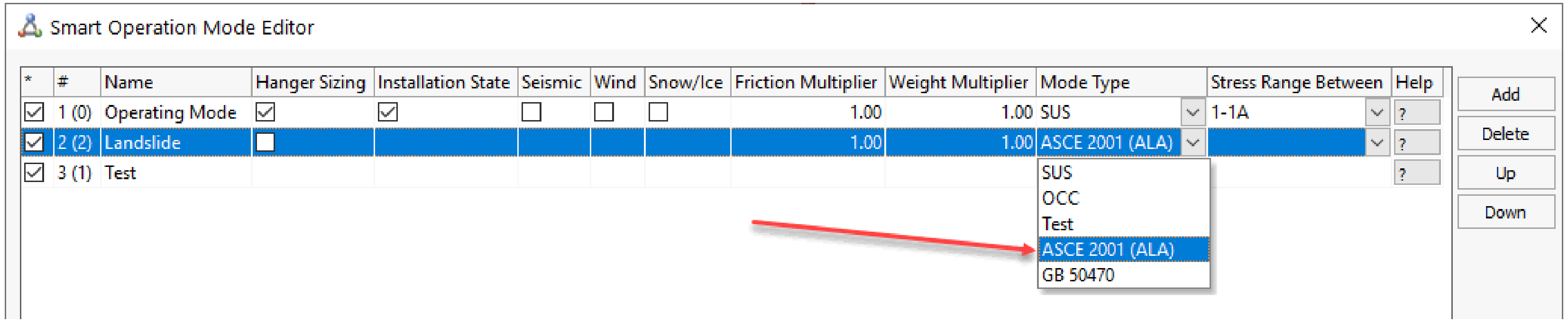


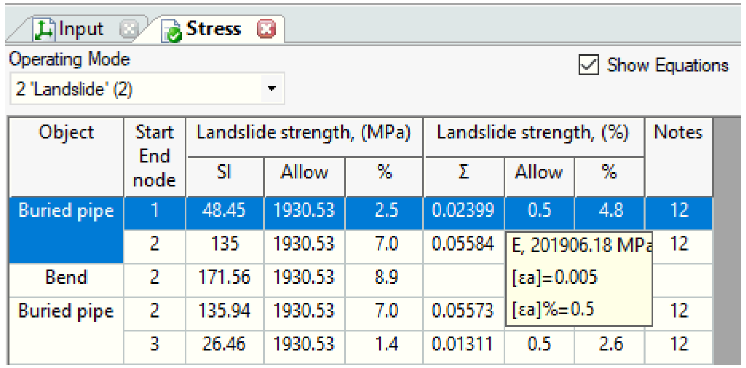


PASS
PIPING AND EQUIPMENT
ANALYSIS & SIZING SUITE

PASS/Start-Prof | Soil Model

Landslide, Soil subsidence, frost heaving, Permanent ground deformation (seismic fault crossing) strain check is made according to ASCE 2001 (ALA) and GB 50470

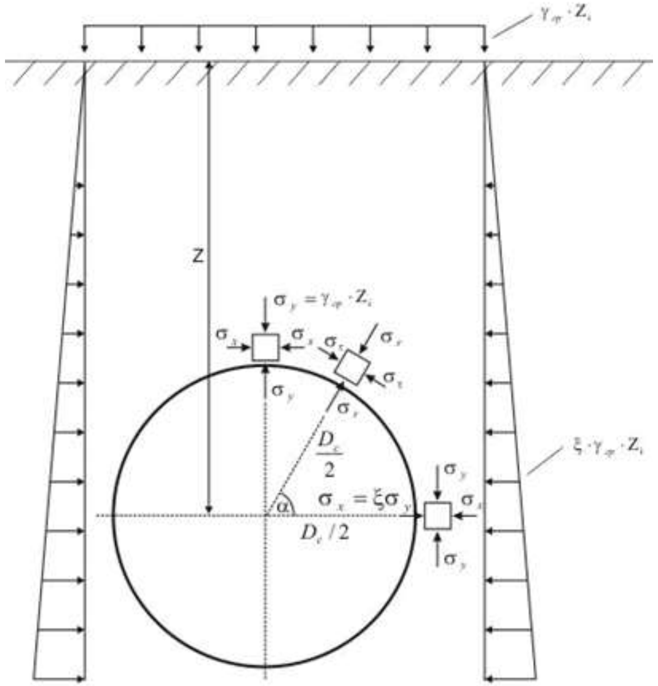




Longitudinal strain from ground movement due to earthquake, landslide, or mine subsidence, combined with thermal strain	N/A[2]	***Operable limits***[4,5] Tension strain limit 2% Compression strain limit $0.50\left(\frac{t}{D'}\right)-0.0025+3000\left(\frac{pD}{2Et}\right)^2$ $D'=\frac{D}{1-\frac{3}{D}(D-D_{min})}$ ***Pressure integrity limits***[4,5] Tension strain limit 4% Compression strain limit $1.76\frac{t}{D}$

PASS/Start-Prof | Soil Model

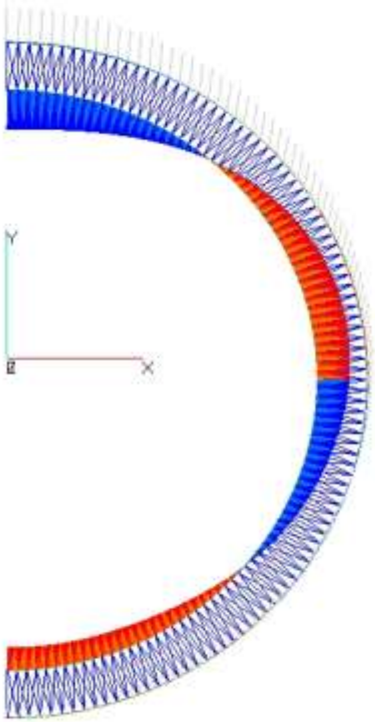
To calculate the ring bending stresses the finite element model of pipe cross-section is used. The loads from the soil weight are calculated and applied for each point of pipe cross-section at whole perimeter.

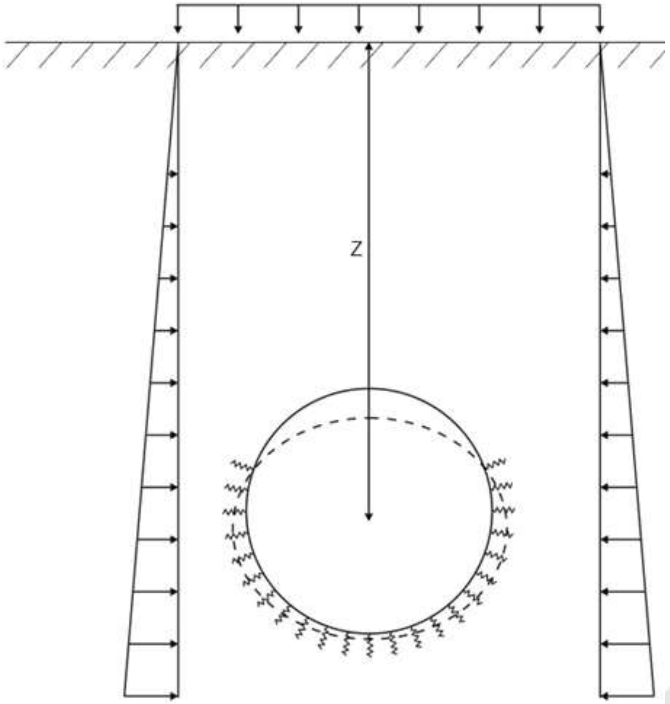


PASS/Start-Prof | Soil Model

Soil is modeled as discrete springs around pipe perimeter. The springs are switched off if tension is detected (usually at the top of the pipe). Flexible insulation also modeled if exist.

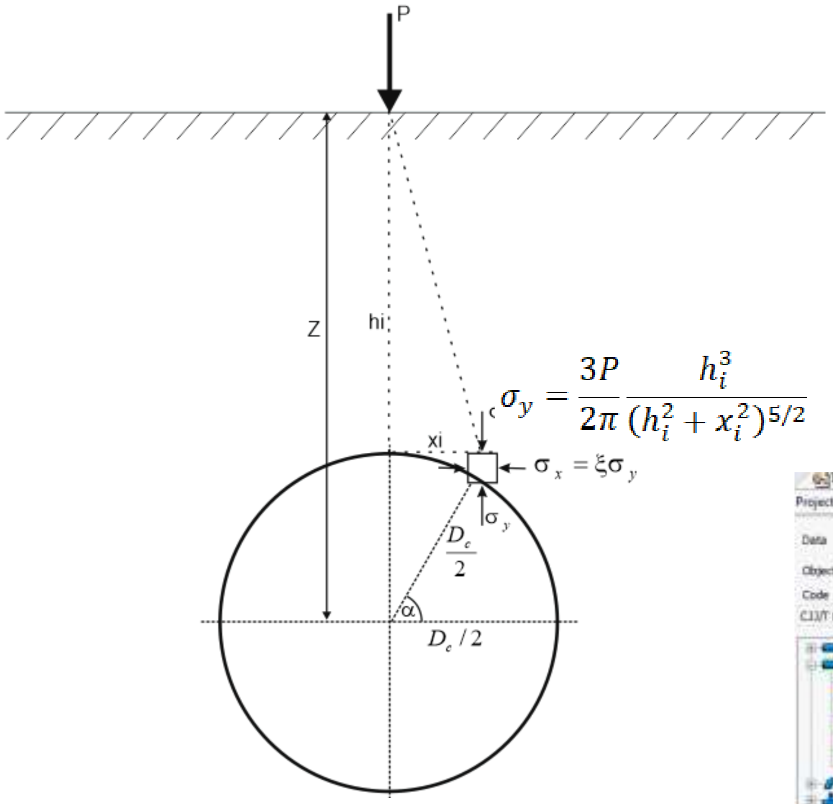
Internal pressure and product hydrostatic pressure is applied. The analysis consider geometric nonlinearity, the additional internal pressure stiffening effect is taken into account

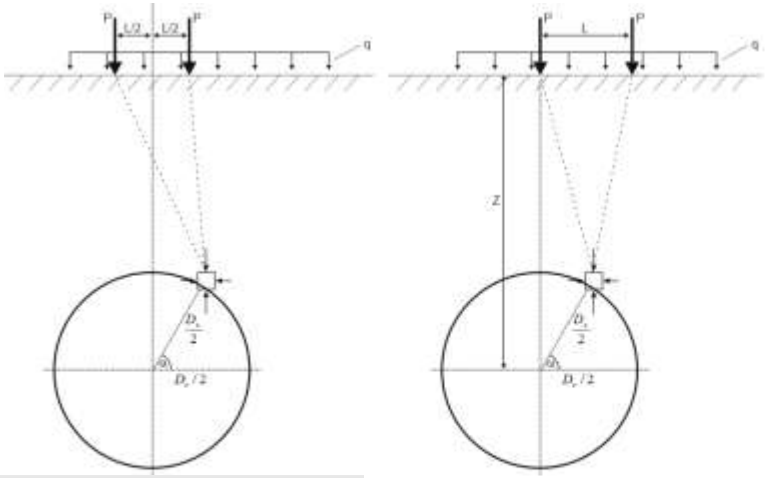


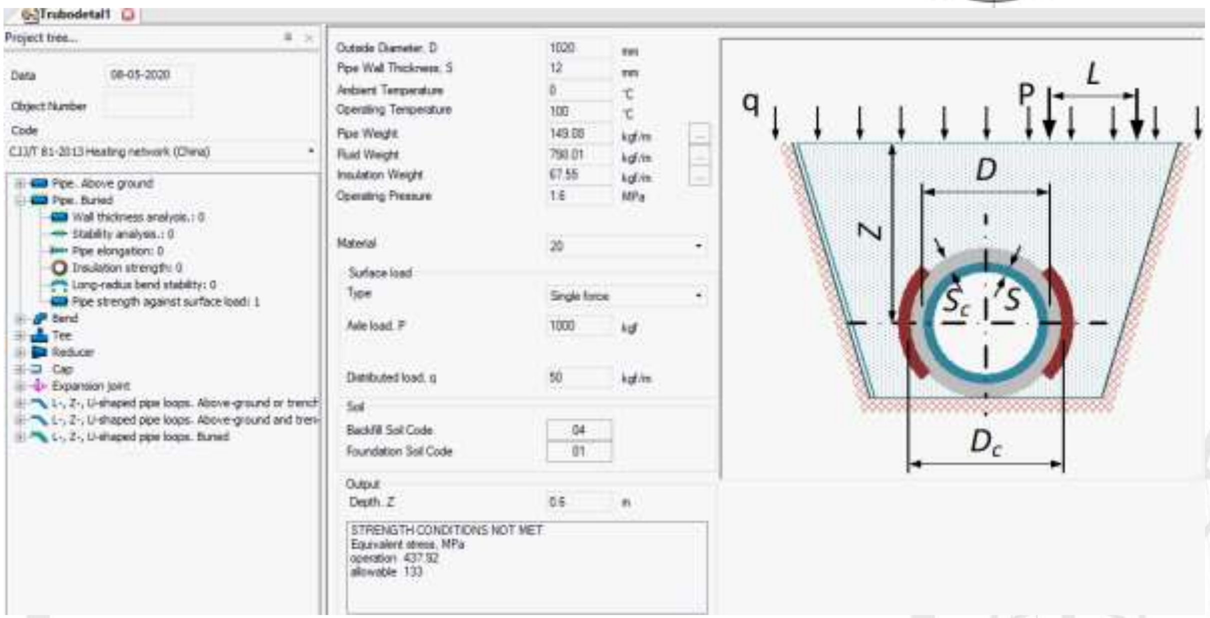


PASS/Start-Prof | Soil Model

Pipe and Insulation Strength Against the Surface Heavy Truck Loading





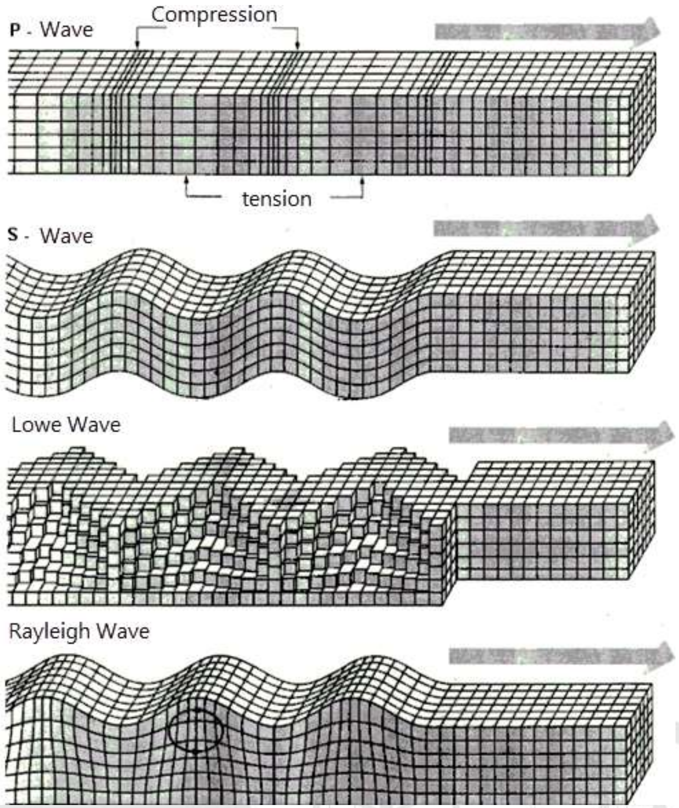


PASS PIPING AND EQUIPMENT ANALYSIS & SIZING SUITE

PASS/Start-Prof | Seismic Wave Propagation

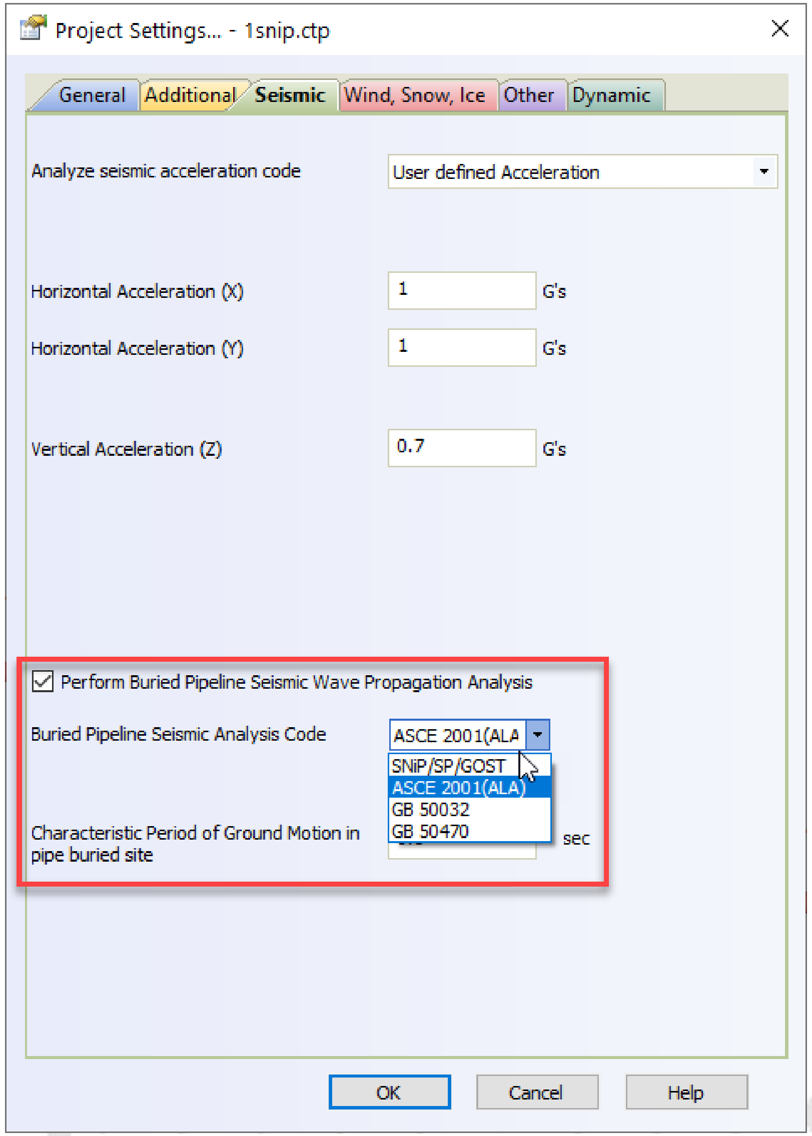
Seismic wave propagation analysis for underground pipelines. START-PROF calculate stress and strain in buried pipeline caused by seismic wave propagation and check the stress and strain limits according to:

- ASCE 2001 Guidelines for the Design of Buried Steel Pipe (American Lifelines Alliance). Improved by START-PROF authors, added shear wave effect
- GB 50032 (China)
- GB 50470 (China)
- SNiP 2.05.06-85 (Russia)
- SP 36.13330.2012 (Russia)
- GOST R 55989-2014 (Russia)
- GOST R 55990-2014 (Russia)
- SP 284.1325800.2016 (Russia)
- SP 33.13330.2012 (Russia)



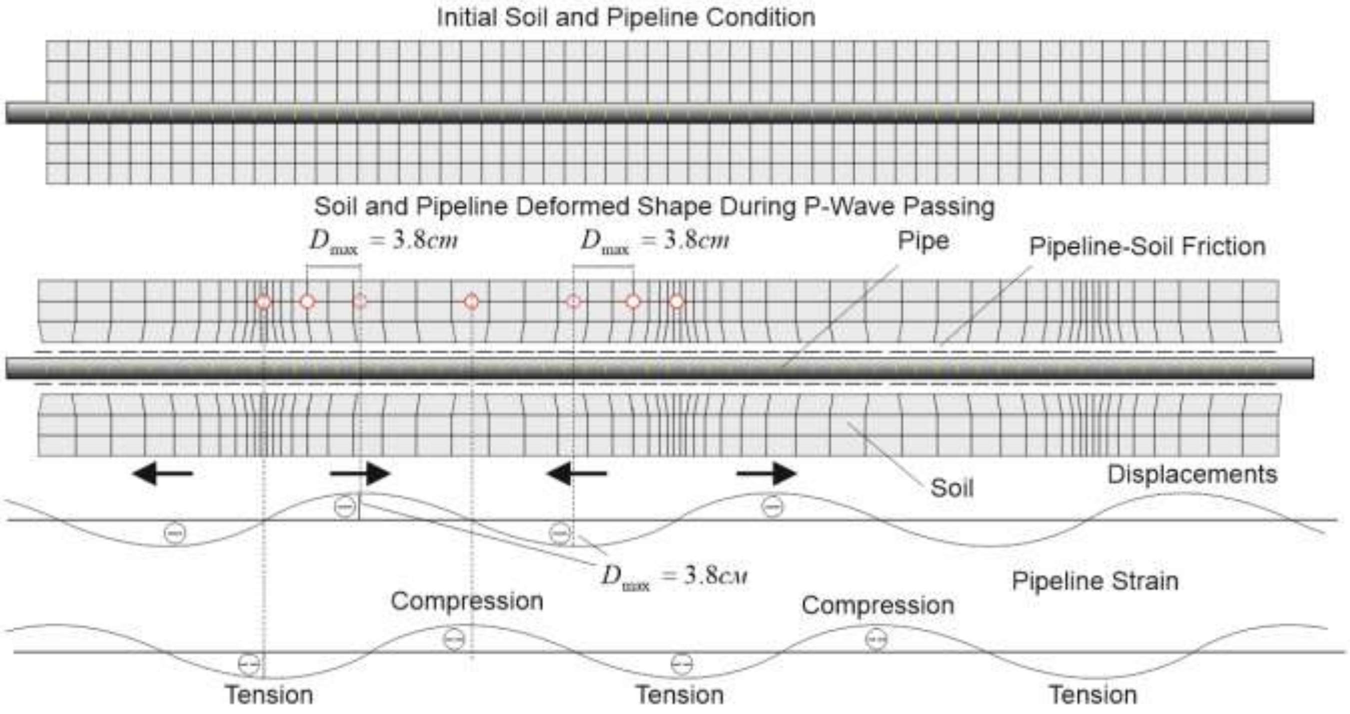
PIPING AND EQUIPMENT ANALYSIS & SIZING SUITE

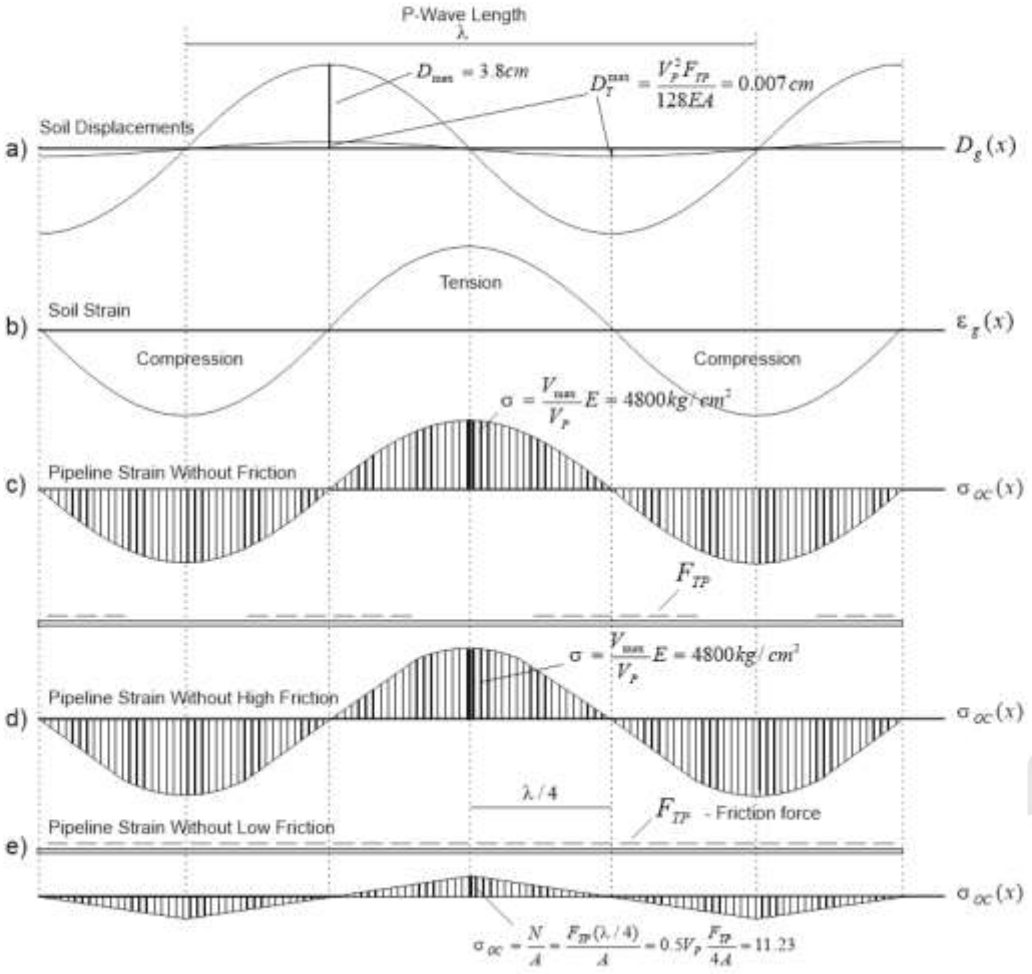
PASS/Start-Prof | Seismic Wave Propagation



PIPING AND EQUIPMENT ANALYSIS & SIZING SUITE

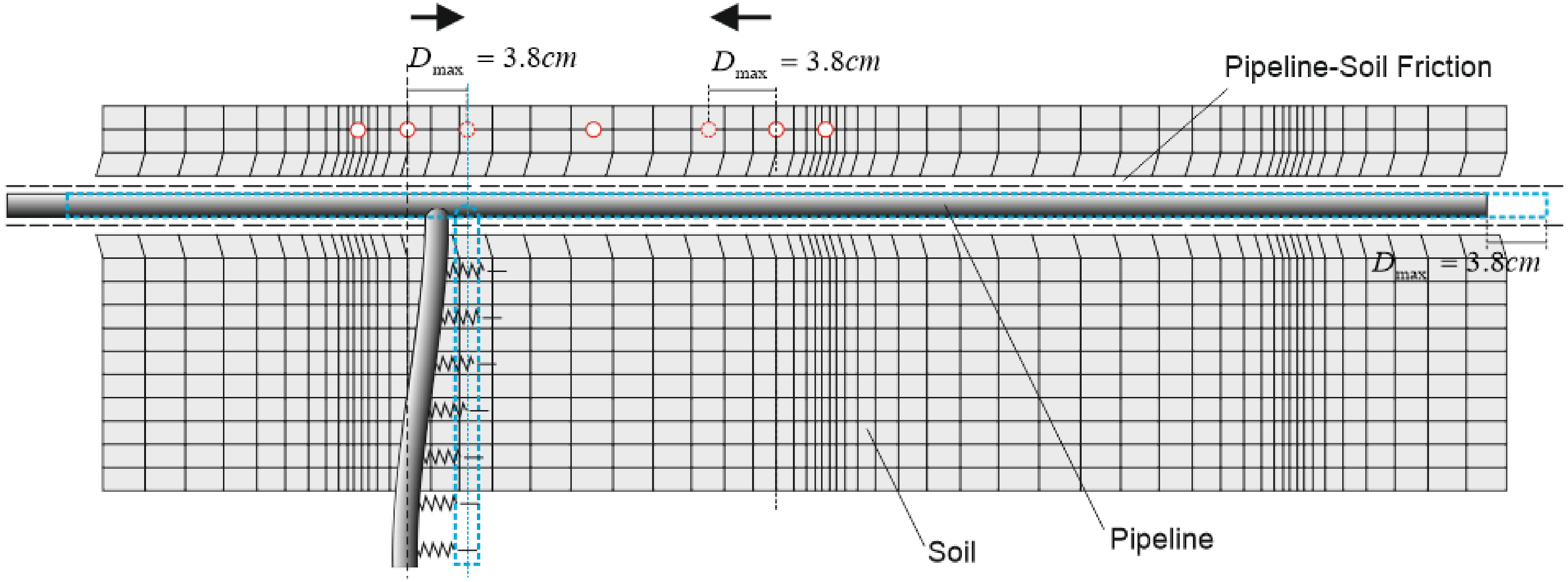
PASS/Start-Prof | Seismic Wave Propagation





PASS/Start-Prof | Seismic Wave Propagation

Every pipe branch, turn or anchor cause great axial and bending stresses



PASS/Start-Prof | Seismic Wave Propagation

Axial seismic strain due to wave propagation is calculated using equation:

$$\varepsilon = \pm max\left(min(\varepsilon_a, \varepsilon_{fr}); \frac{D}{2}\rho_{max}\right)\cos\omega$$

Actually, pipe curvature can cause only the bending moments, but we convert it into equivalent axial strain to simplify the stress analysis procedure in START-PROF software.

ω – Incline angle of the pipe. 0 for horizontal pipe, 90 for vertical pipe

D – Pipe diameter, m

ε_a – Maximum axial strain from P-, S-, R-waves

$$\varepsilon_a = max\left(\frac{V_g}{C_P}; \frac{V_g}{2C_S}; \frac{V_g}{C_R}\right)$$

Maximum strain from P-wave friction forces is

$$\frac{T_u\lambda}{4EA}$$

λ –Wave length, m

$$\lambda = 0.5C_P$$

So maximum strain caused by friction from P-, S-, R-waves is

$$\varepsilon_{fr} = max\left(0.5C_P\frac{T_u}{4EA}; 0.5C_S\frac{T_u}{4EA}; 0.5C_R\frac{T_u}{4EA}\right)$$

ρ_{max} – Maximum curvature from P-, S-, R-waves

$$\rho_{max} = max\left(\frac{0.385A_g}{(C_P)^2}; \frac{A_g}{(C_S)^2}; \frac{A_g}{(C_R)^2}\right)$$

V_g – Peak ground velocity, m/s. Specified by user in pipe properties

A_g – Peak ground acceleration, m/s2. Specified by user in pipe properties

A – Pipe cross-section area, m2

T_u – Peak friction force, t/m

$$T_u = \tan(n_m \cdot \varphi)\left[\gamma_a Z\pi D_c\left(\frac{1+K_0}{2}\cos^2\alpha - K_0\sin^2\alpha\right)\right] + \pi D_c\omega c$$

$$\omega = 0.608 - 0.123c - \frac{0.274}{c^2+1} + \frac{0.695}{c^3+1}$$

c – Soil cohesion

C_P – Apparent P-wave propagation velocity, m/s. Specified by user in START-PROF pipe properties. Default value 2 km/s

C_S – Apparent S-wave propagation velocity, m/s. Specified by user in START-PROF pipe properties. Default value 1 km/s

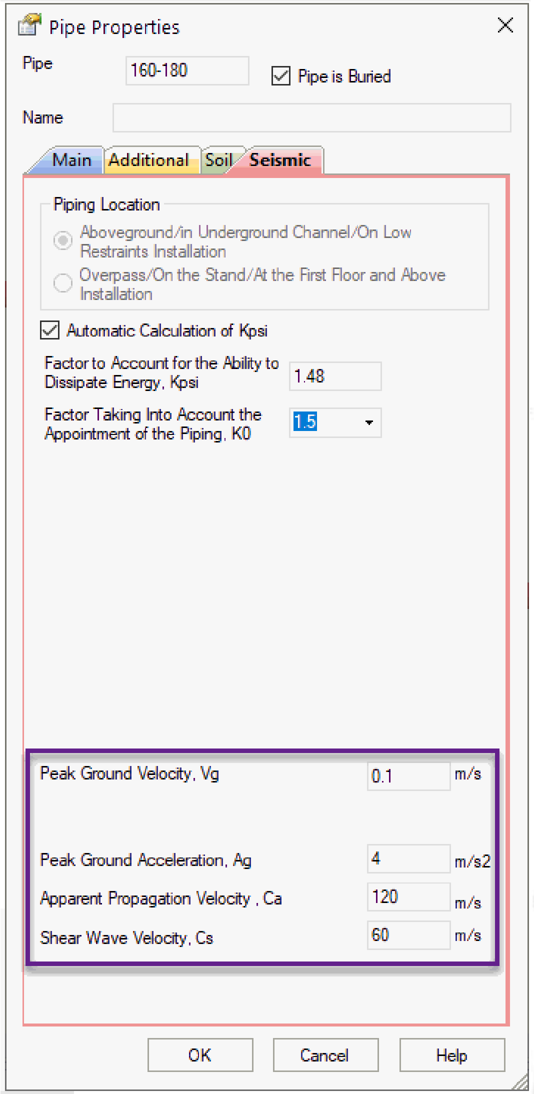
C_R – Apparent R-wave propagation velocity, m/s

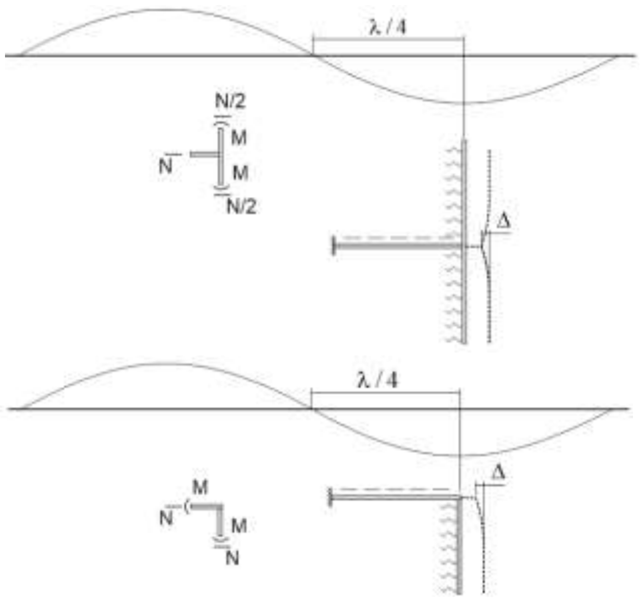
Rayleigh wave velocity is equal to $C_R = kC_S$, where k is obtained from the equation

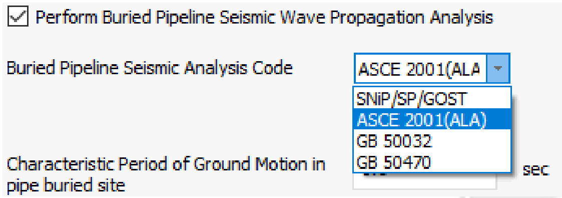
$$\frac{1}{8}k^6 - k^4 + \frac{2-\nu}{1-\nu}k^2 - \frac{1}{1-\nu} = 0.$$

Depending on Poisson's ratio values the k values are within $0.92 < k < 0.95$ We approximately assume that $k = 0.92$

$$C_R \approx 0.92C_S$$







PASS/Start-Prof | Seismic Wave Propagation

Added strain check according to ASCE 2001 Guidelines for the Design of Buried Steel Pipe (American Lifelines Alliance), SNiP, SP, GOST, GB Codes

Input | Stress

Operating Mode: 1.1 'Soil Seismic Wave Propaga

☑ Show Equations ☐ Stress Range from Operation to Cold ☐ Add Axial Force and Torsion Stress ?

Object	Start End node	Buried piping Seismic Check, (MPa)			Buried piping Seismic Check, (%)			Notes
		SI	Allow	%	Σ	Allow	%	
Buried pipe	9	515.60	965.27	53.4	0.2009	0.2939	68.4	
	3	515.58	965.27	53.4	0.2009	0.2939	68.4	
Buried pipe	8	510.81	965.27	52.9	0.1985			
	9	515.60	965.27	53.4	0.2009			
Buried pipe	7	490.91	965.27	50.9	0.1884			
	8	510.81	965.27	52.9	0.1985	0.2939	67.5	

E, 201051.12 MPa
[εa]=0.75(0.5t/D-0.0025+3000(PD/(2Et))²), 0.002939
[εa]%, 0.2939

Tension strain limit 5%

Compression strain limit

$$0.75\left[0.50\left(\frac{t}{D'}\right)-0.0025+3000\left(\frac{pD}{2Et}\right)^2\right]$$

$$D'=\frac{D}{1-\frac{3}{D}(D-D_{\min})}$$

Input | Stress

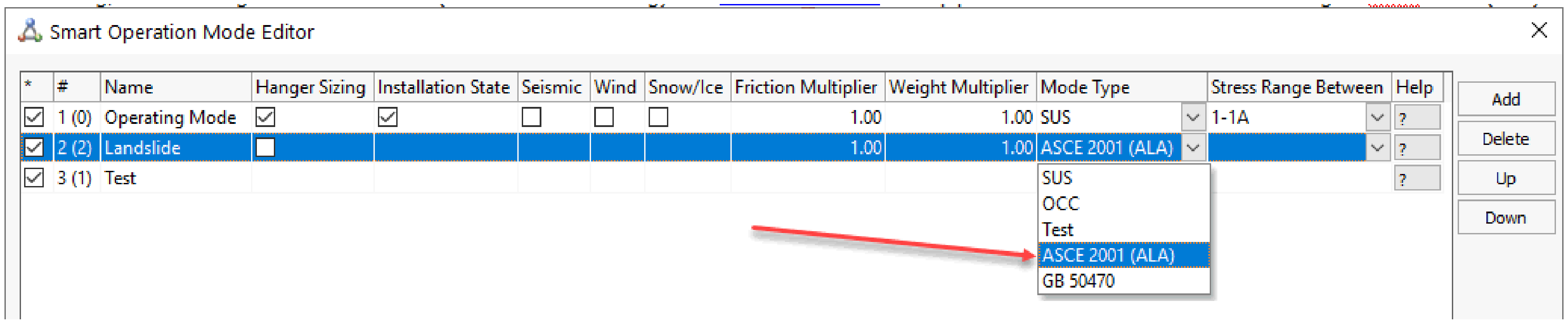
Operating Mode: Maximum

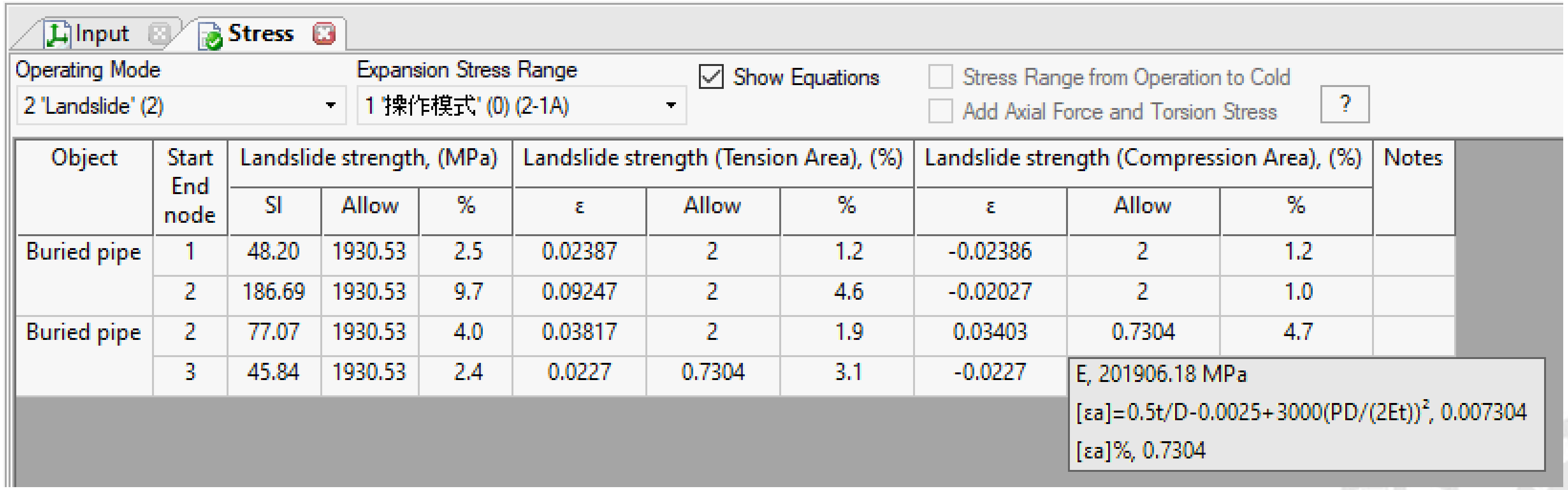
☑ Show Equations ☐ Stress Range from Operation to Cold ☐ Add Axial Force and Torsion Stress ?

Object	Start End node	Hoop Stress, (MPa)			Primary Loads Stress in Hot State, (MPa)						Primary&Secondary Loads Stress in Hot State, (MPa)						Expansion Stress Range, (MPa)			Buried piping Seismic Check, (MPa)			Buried piping Seismic Check, (%)			Notes
		Sh	F*E*Sy	%	Seq	F*Sy	%	Sl	F*Sy	%	Seq	F*Sy	%	Sl	F*Sy	%	Se	Sa	%	Sl	Allow	%	Σ	Allow	%	
Buried pipe	9	85	173.75	48.9				24.62	180.99	13.6	154	217.18	70.9	69	217.18	31.8	93.61	217.18	43.1	515.60	965.27	53.4	0.2009	0.2939	68.4	
	3	85	173.75	48.9				24.62	180.99	13.6	154	217.18	70.9	69	217.18	31.8	93.61	217.18	43.1	515.58	965.27	53.4	0.2009	0.2939	68.4	
Buried pipe	8	85	173.75	48.9				24.69	180.99	13.6	153.55	217.18	70.7	68.55	217.18	31.6	93.23	217.18	42.9	510.81	965.27	52.9	0.1985	0.2939	67.5	
	9	85	173.75	48.9				24.62	180.99	13.6	154	217.18	70.9	69	217.18	31.8	93.61	217.18	43.1	515.60	965.27	53.4	0.2009	0.2939	68.4	
Buried pipe	7	85	173.75	48.9				24.98	180.99	13.8	151.70	217.18	69.9	66.70	217.18	30.7	91.60	217.18	42.2	490.91	965.27	50.9	0.1884	0.2939	64.1	
	8	85	173.75	48.9				24.69	180.99	13.6	153.55	217.18	70.7	68.55	217.18	31.6	93.23	217.18	42.9	510.81	965.27	52.9	0.1985	0.2939	67.5	
Long Radius Pipe Bend	2	85	173.75	48.9				35.27	180.99	19.5	204.13	217.18	94.0	119.13	217.18	54.9	84.97	217.18	39.1	732.51	965.27	75.9	0.1589	0.2939	54.1	
Buried pipe	2	85	173.75	48.9				30.03	180.99	16.6	169.99	217.18	78.3	84.99	217.18	39.1	84.91	217.18	39.1	568.23	965.27	58.9	0.1588	0.2939	54.0	
	7	85	173.75	48.9				24.98	180.99	13.8	151.70	217.18	69.9	66.70	217.18	30.7	91.60	217.18	42.2	490.91	965.27	50.9	0.1884	0.2939	64.1	

PASS/Start-Prof | Seismic Wave Propagation

The pipeline strain check is made according to ASCE 2001 (ALA) and GB 50470





Object	Start End node	Landslide strength, (MPa)			Landslide strength (Tension Area), (%)			Landslide strength (Compression Area), (%)			Notes
		SI	Allow	%	ε	Allow	%	ε	Allow	%	
Buried pipe	1	48.20	1930.53	2.5	0.02387	2	1.2	-0.02386	2	1.2	
	2	186.69	1930.53	9.7	0.09247	2	4.6	-0.02027	2	1.0	
Buried pipe	2	77.07	1930.53	4.0	0.03817	2	1.9	0.03403	0.7304	4.7	
	3	45.84	1930.53	2.4	0.0227	0.7304	3.1	-0.0227			

PASS PIPING AND EQUIPMENT ANALYSIS & SIZING SUITE

PASS/Start-Prof | Features

Automatic local pipe wall buckling check per

- ASME B31.8-2018
- EN 13941-2019 7.2.4.2
- GOST 32388

- For $(D_o - t_n)/(2t_n) \leq 28.7$

$$S_{st} = 0.0016E$$

- For $(D_o - t_n)/(2t_n) > 28.7$

$$S_{st} = (0.0458 \cdot 2t_n/(D_o - t_n) + 0.00003)E$$

$$\left(0.4\frac{t}{D} - 0.002 + 2400\left(\frac{P\cdot D}{2t\cdot E}\right)^2\right)E \text{ at } \frac{PD}{2tS} < 0.4$$

$$\left(0.4\frac{t}{D} - 0.002 + 2400\left(\frac{0.4S}{E}\right)^2\right)E \text{ at } \frac{PD}{2tS} \geq 0.4$$

Input | Stress | Stability

Operating Mode: 1 '操作模式' (0) ?

Object	Start End node	C1 Local Buckling in Hot Condition, (MPa)		C1 Local Buckling in Cold Condition, (MPa)		C1 Local Buckling in Test Condition, (MPa)		Notes
		calcu-lated	allow-able	calcu-lated	allow-able	calcu-lated	allow-able	
Buried pipe	1	36.09	33.88	38.39	33.88	0.01	33.88	1,2
	2	12.95	33.88	34.84	33.88	0	33.88	2
Bend	2							
Buried pipe	2	21.44	33.88	34.63	33.88	0	33.88	2
	3	35.93	33.88	38.89	33.88	0.01	33.88	1,2

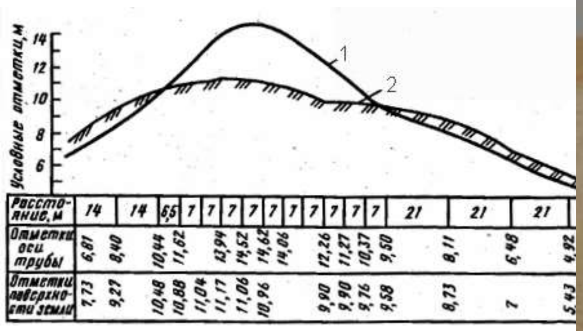
Input | Stability

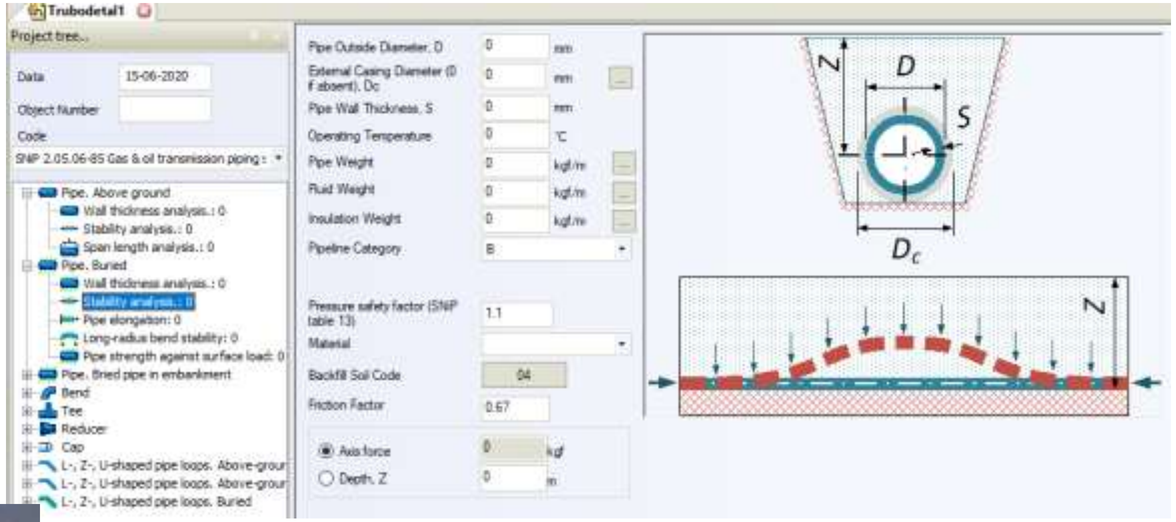
Operating Mode: 1 'СТАРТ1' (0) ?

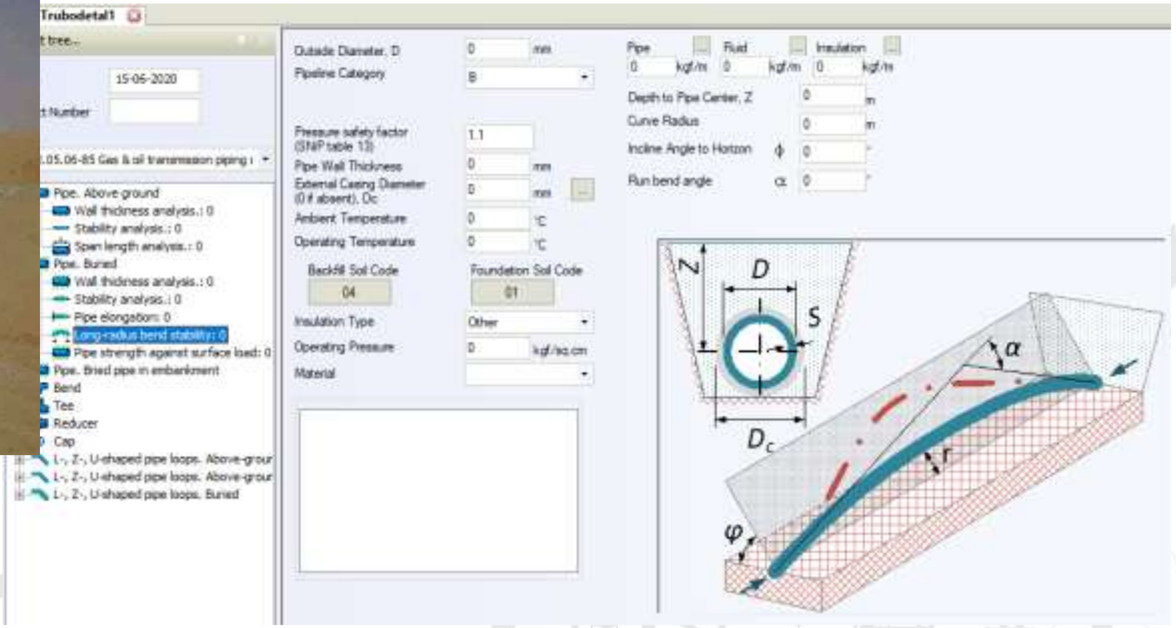
Object	Start End node	Axial Stress From All Loads in Hot condition, (kgf/sq.cm)		Axial Stress From all loads in Cold condition, (kgf/sq.cm)		Axial Stress From All Loads in Test Mode, (kgf/sq.cm)		Notes
		calcu-lated	allow-able	calcu-lated	allow-able	calcu-lated	allow-able	
Above ground pipe	7,Bend			492.22	18345.53	588.61	18322.60	
Above ground pipe	33	2963.95	17774.76	2963.95	18345.53	1771.67	18322.60	
	32,Offshore	219.58	17774.76	219.59	18345.53	219.47	18322.60	
Above ground pipe	35	4055.33	17774.76	4055.34	18345.53	2412.27	18322.60	
	34,Offshore Raiser	273.36	17774.76	273.37	18345.53	273.20	18322.60	

PASS/Start-Prof | Features

Upheaval buckling analysis in START-Elements





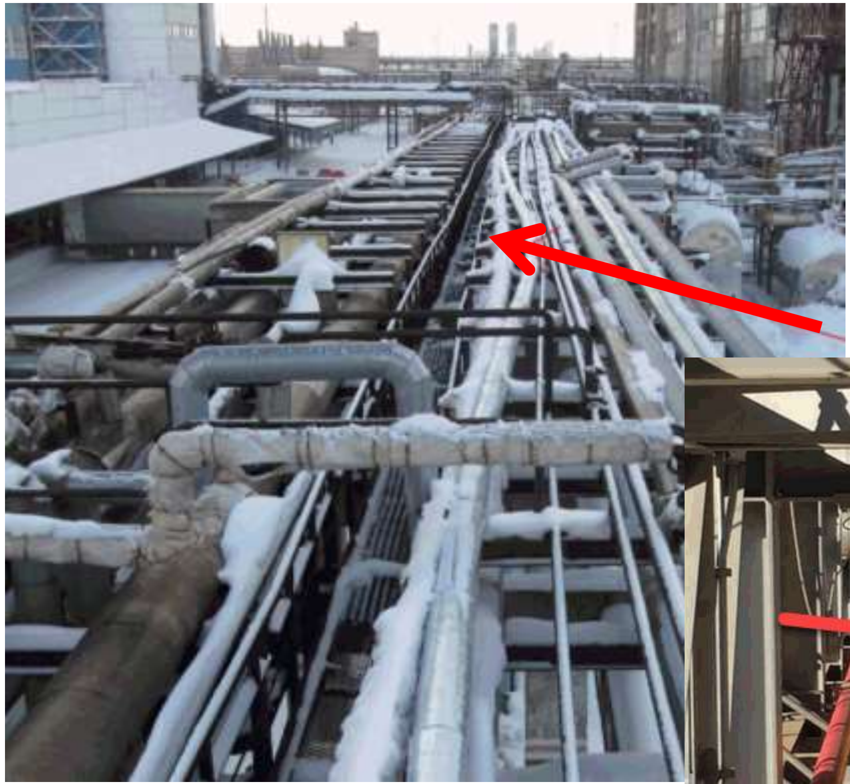


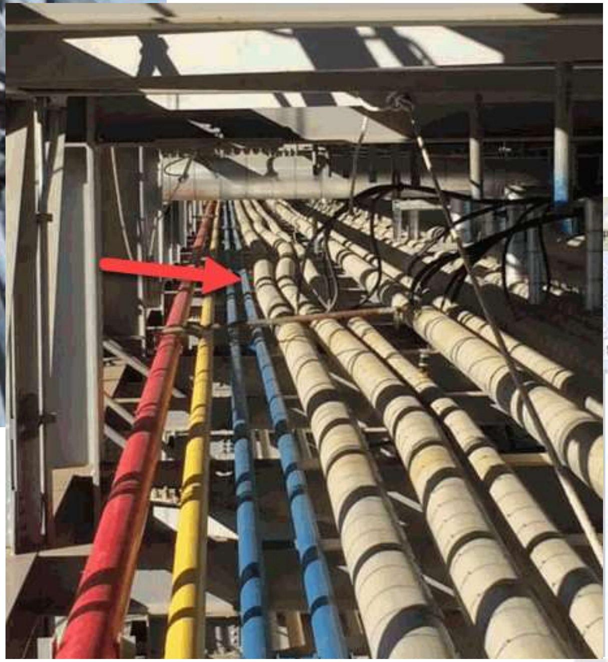
PASS

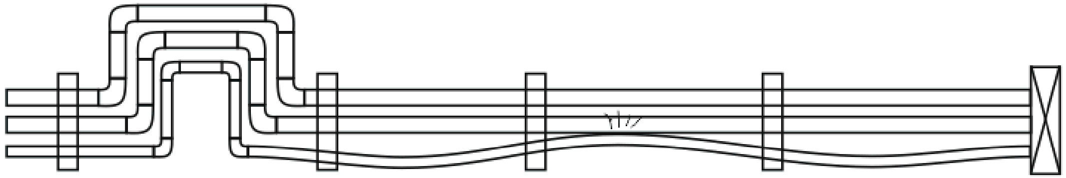
PIPING AND EQUIPMENT
ANALYSIS & SIZING SUITE

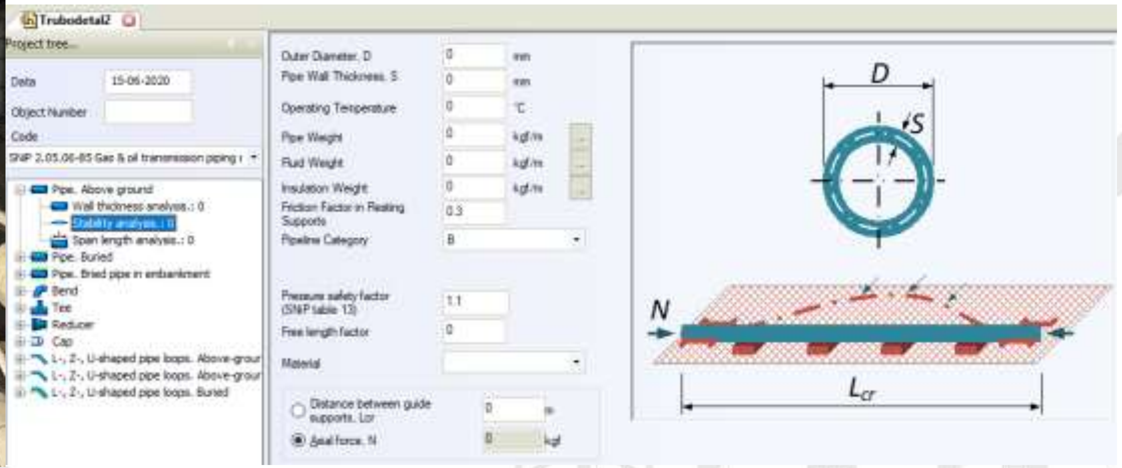
PASS/Start-Prof | Features

Lateral buckling analysis of above ground pipeline in START-Elements









PIPING AND EQUIPMENT
ANALYSIS & SIZING SUITE

PASS/Start-Prof | Piping Model Creation

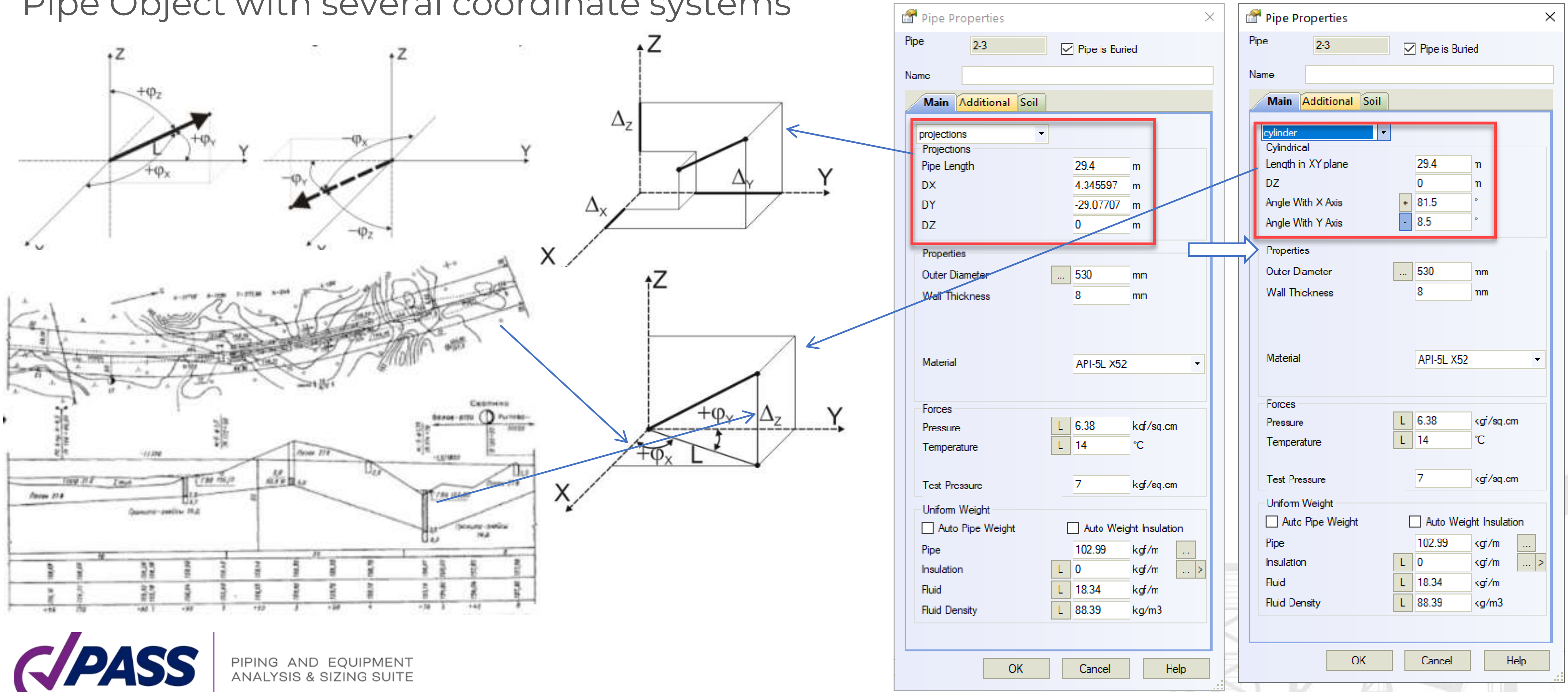
In PASS/START-PROF the piping model creation is simple and straightforward.
Even a beginner will understand what to do.
Create the Piping and Equipment Model by Combining the Objects
Like LEGO

- Fast Model Creation
- Fast and Easy Existing Model Modification
- You can Add, Delete, Modify, Copy, Rotate, Mirror, Split Objects
- Work With Object Groups

PASS
PIPING AND EQUIPMENT
ANALYSIS & SIZING SUITE

PASS/Start-Prof | Piping Model Creation

Pipe Object with several coordinate systems



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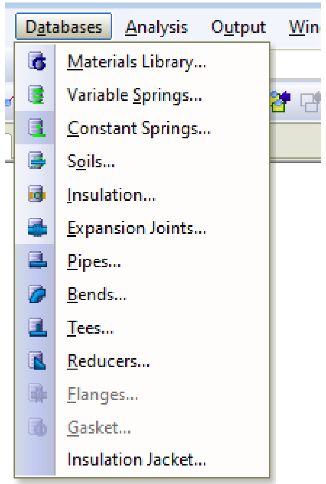
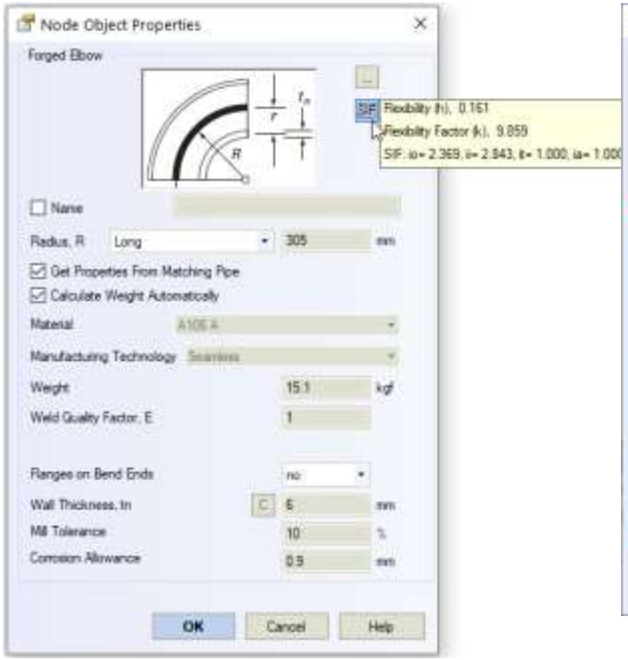
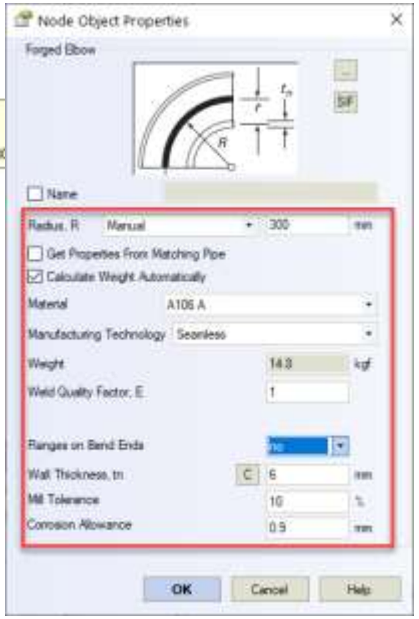
PIPING AND EQUIPMENT
ANALYSIS & SIZING SUITE

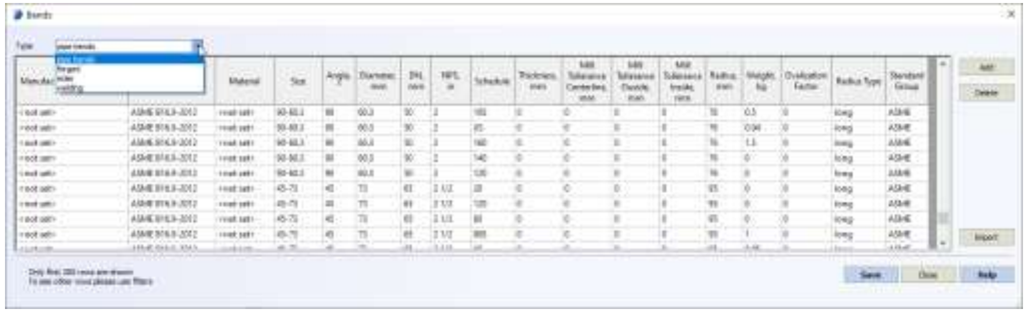
PASS/Start-Prof | Piping Model Creation

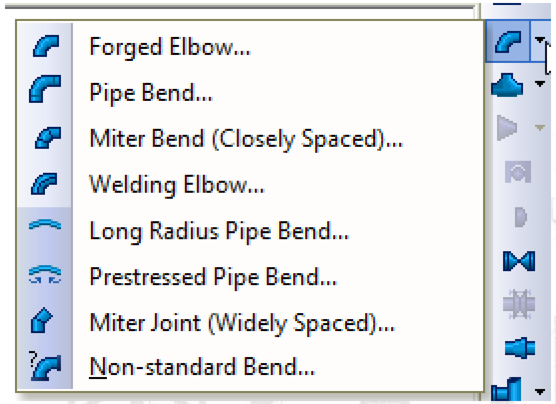
Bend Object





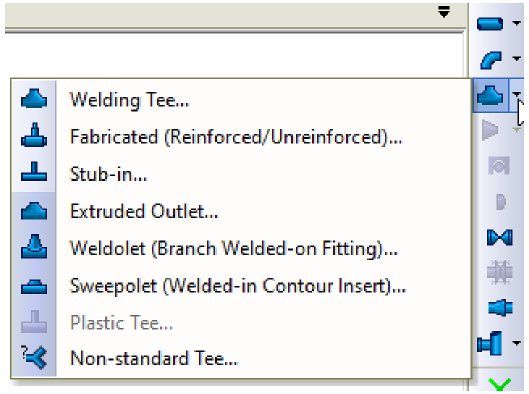




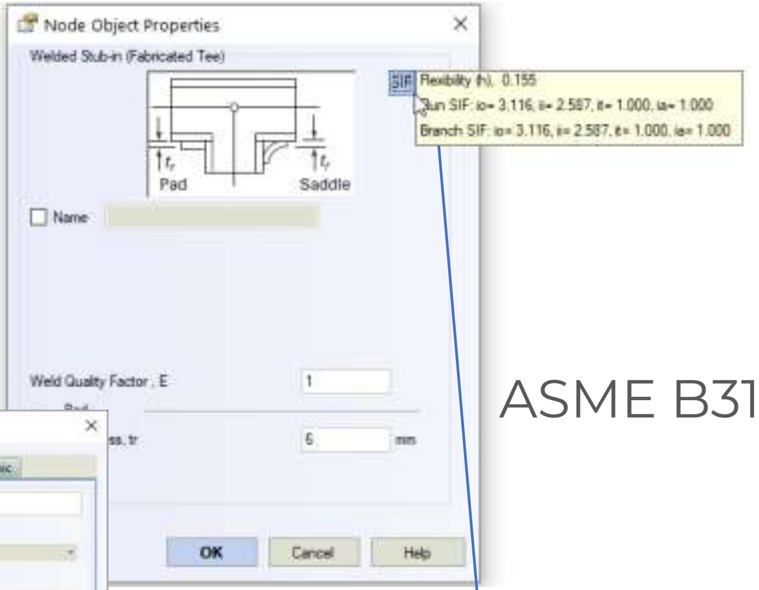


PASS
PIPING AND EQUIPMENT
ANALYSIS & SIZING SUITE

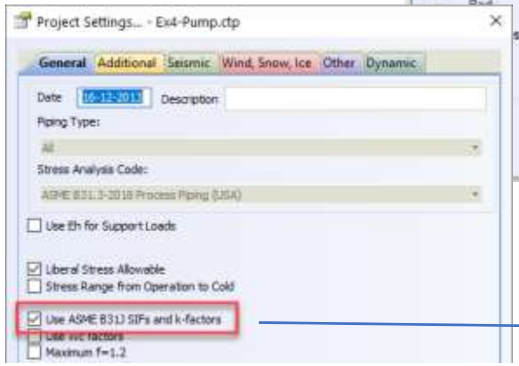
PASS/Start-Prof | Piping Model Creation

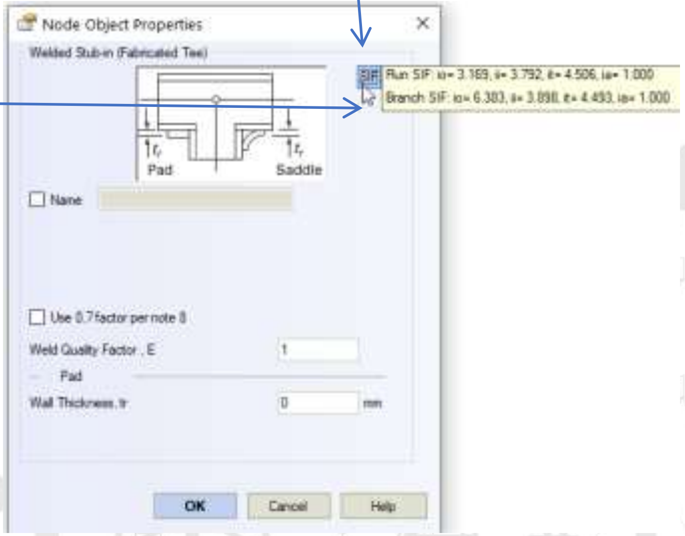


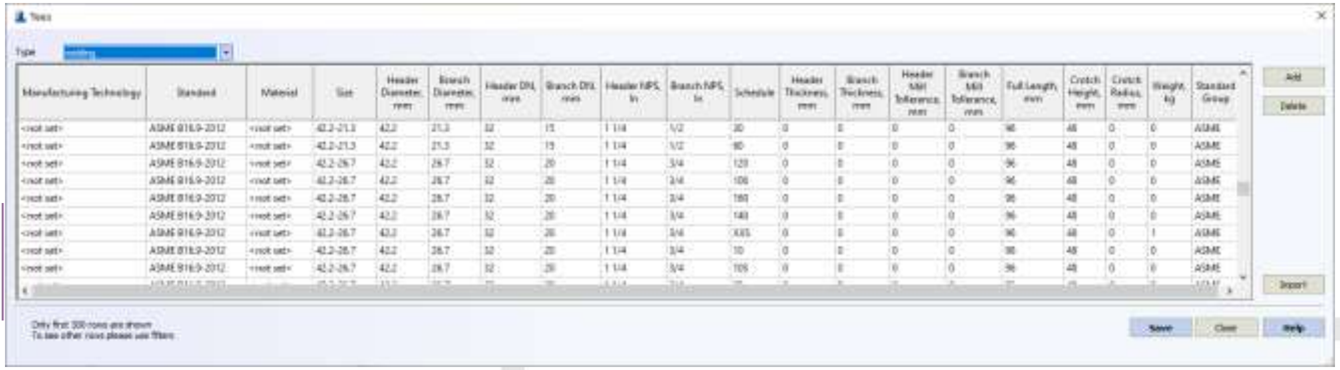
Tee Object



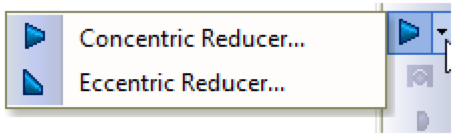
ASME B31J



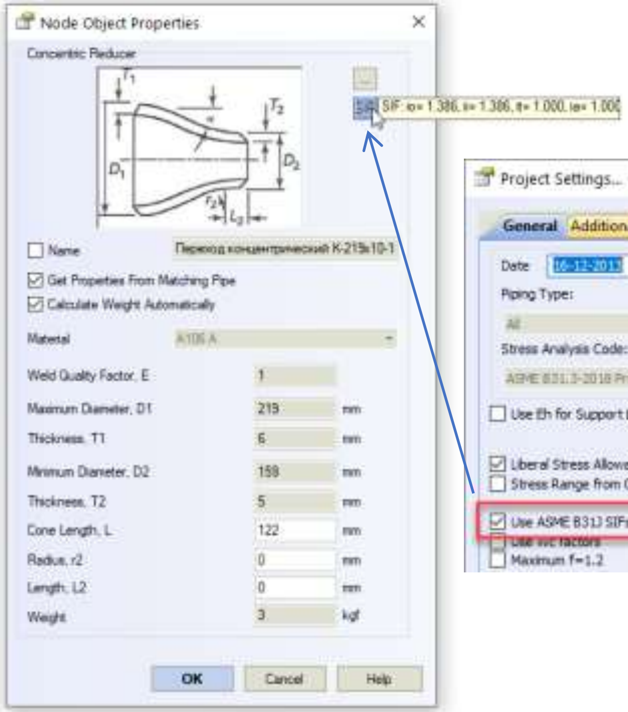




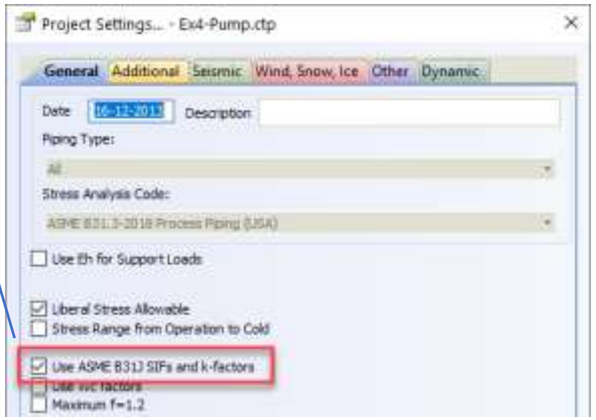
PASS/Start-Prof | Piping Model Creation

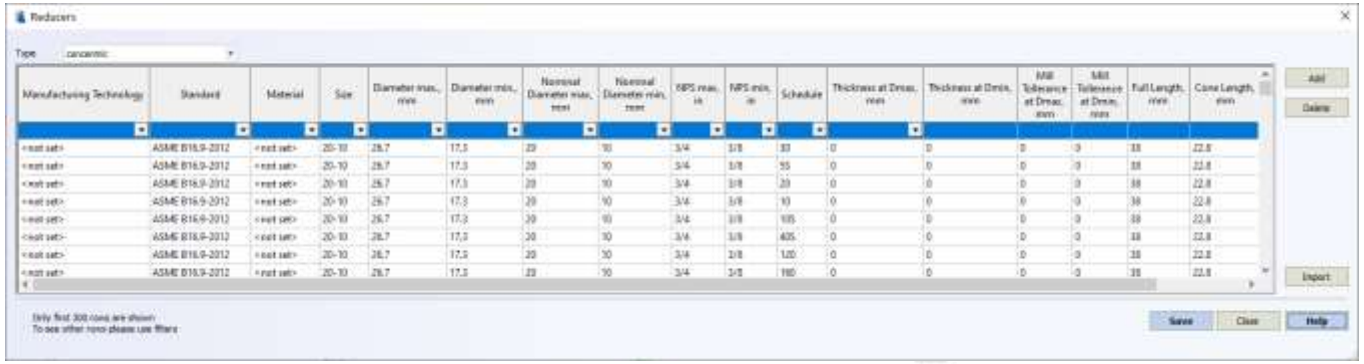


Reducer Object



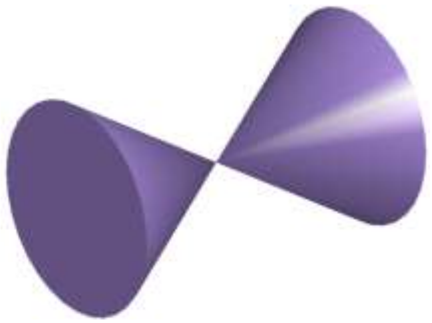
ASME B31J

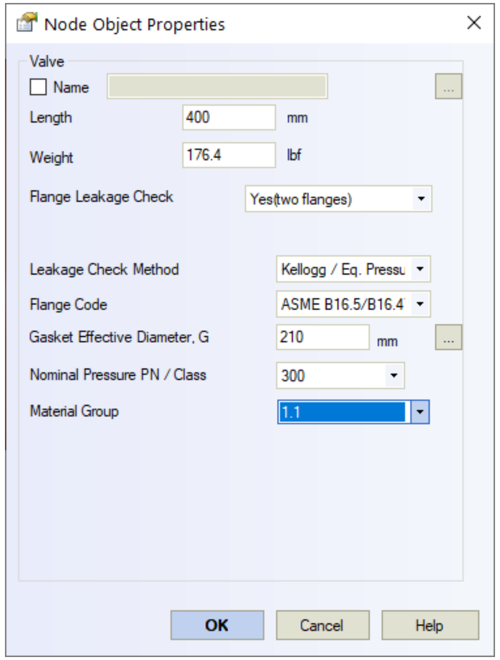




PASS/Start-Prof | Piping Model Creation

Valve Object

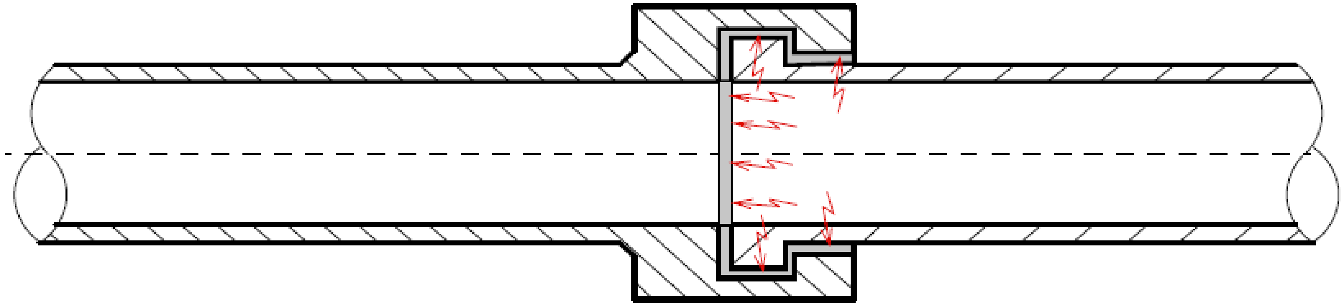


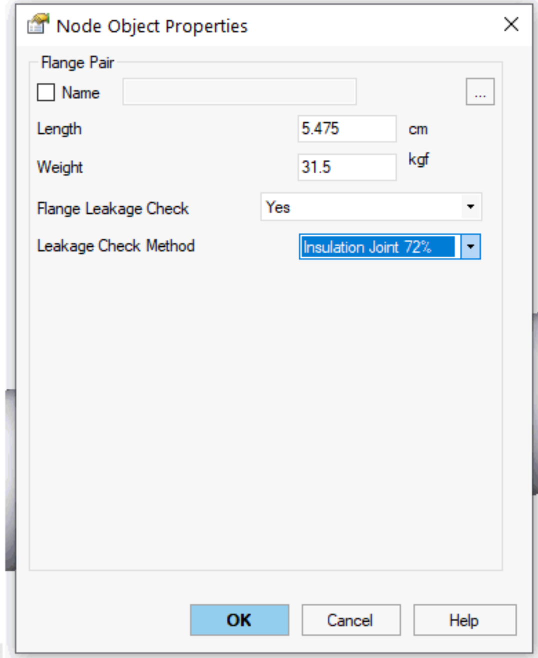


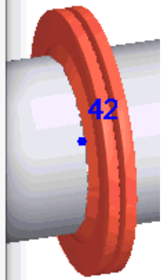
Automatic Flange Leakage Check

PASS/Start-Prof | Piping Model Creation

Insulation Joint (Electrical Insulation Kit) Object. The axial stress and stress from torsion moment is checked automatically



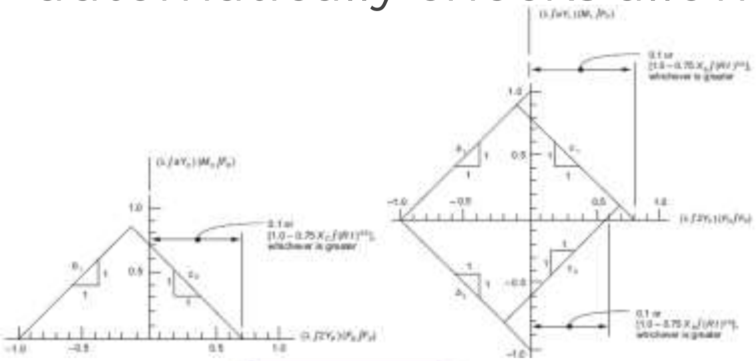


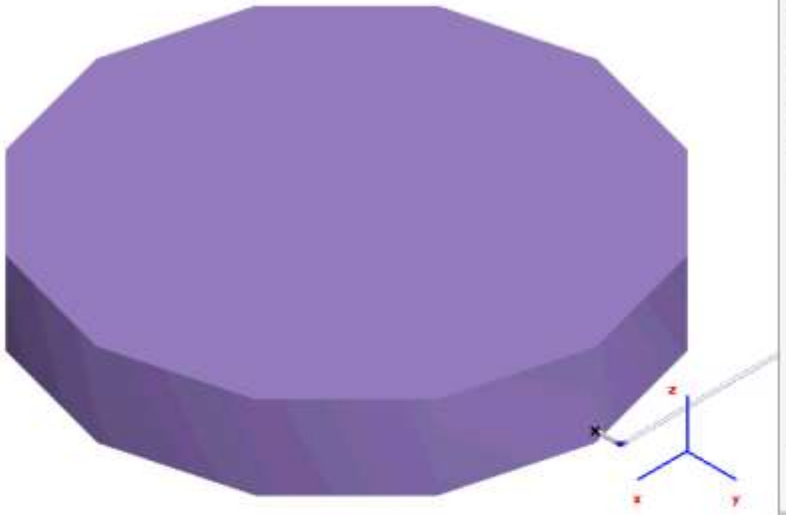


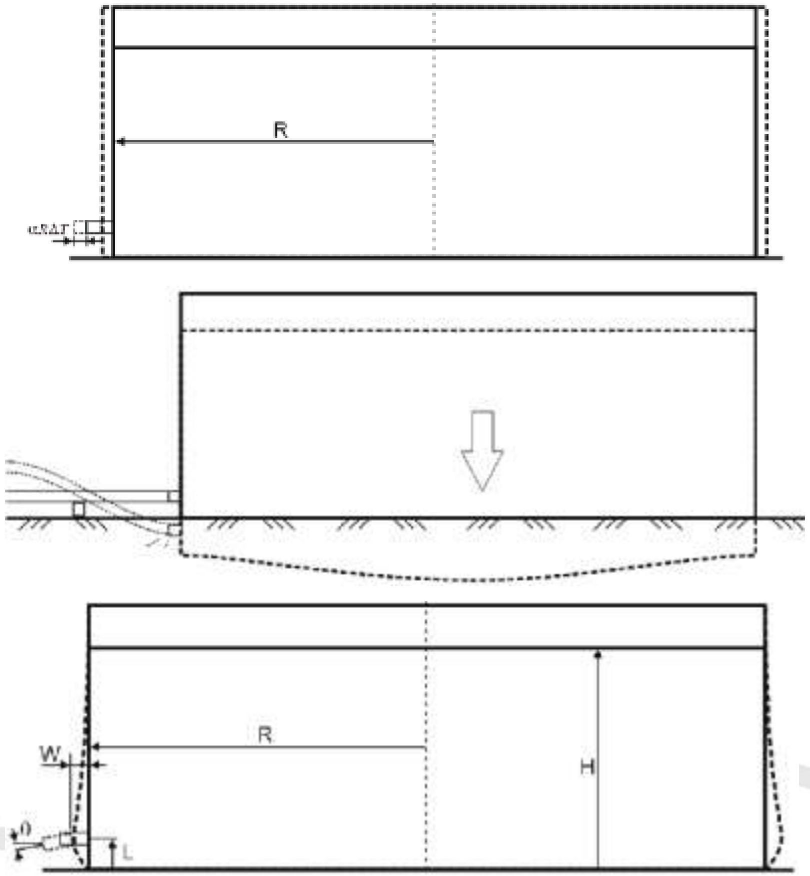
PIPING AND EQUIPMENT
ANALYSIS & SIZING SUITE

PASS/Start-Prof | Piping Model Creation

Object "Tank Nozzle API 650", allows to automatically model the storage tank nozzles. Automatically model flexibilities using API 650, thermal movements of the nozzle, movements and rotation due to tank bulging effect using API 650, tank settlement, automatically checks allowable loads using API 650 and STO-SA 03-002-2009

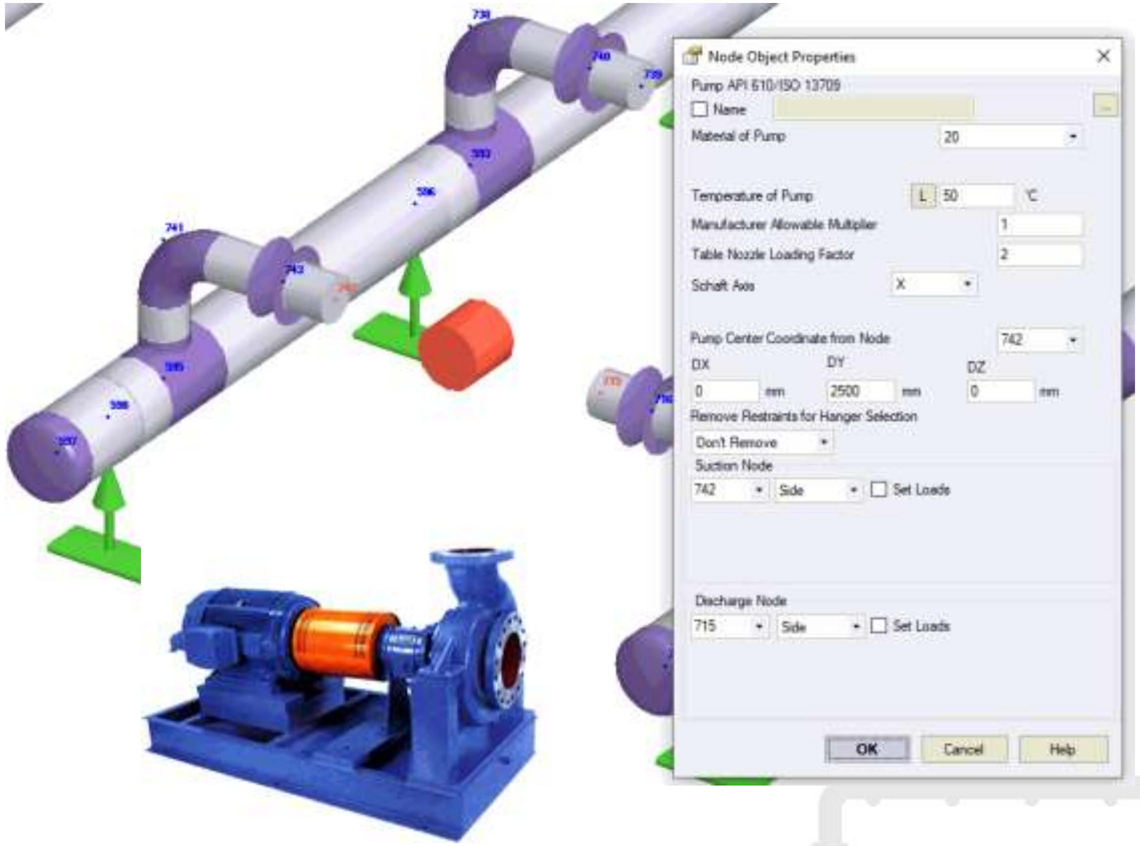






PASS/Start-Prof | Piping Model Creation

- Object "Pump API 610/ISO 13709", allows to automatically model the pumps, consider thermal movements of the nozzles, checks allowable loads using API 610 and ISO 13709
- Object "Pump ISO 9905“, "Pump ISO 5199“
- etc.



a) The individual component forces and moments acting on each pump nozzle flange shall not exceed the range specified in Table 5 (T4) by a factor of more than 2.

b) The resultant applied force (F_{RSA}, F_{RDA}) and the resultant applied moment (M_{RSA}, M_{RDA}) acting on each pump-nozzle flange shall satisfy the appropriate interaction equations as given in Equations (F.1) and (F.2):

$$[F_{RSA}/(1.5 \times F_{RST4})] + [M_{RSA}/(1.5 \times M_{RST4})] \le 2 \qquad (F.1)$$

$$[F_{RDA}/(1.5 \times F_{RDT4})] + [M_{RDA}/(1.5 \times M_{RDT4})] \le 2 \qquad (F.2)$$

c) The applied component forces and moments acting on each pump nozzle flange shall be translated to the centre of the pump. The magnitude of the resultant applied force, F_{RCA}, the resultant applied moment, M_{RCA}, and the applied moment shall be limited by Equations (F.3) to (F.5). (The sign convention shown in Figures 21 through 25 and the right-hand rule should be used in evaluating these equations.)

$$F_{RCA} < 1.5(F_{RST4} + F_{RDT4}) \qquad (F.3)$$

$$|M_{YCA}| < 2.0(M_{YST4} + M_{YDT4}) \qquad (F.4)$$

$$M_{RCA} < 1.5(M_{RST4} + M_{RDT4}) \qquad (F.5)$$

where

$$F_{RCA} = [(F_{XCA})^2 + (F_{YCA})^2 + (F_{ZCA})^2]^{0.5}$$

where

$$F_{XCA} = F_{XSA} + F_{XDA}$$

$$F_{YCA} = F_{YSA} + F_{YDA}$$

$$F_{ZCA} = F_{ZSA} + F_{ZDA}$$

$$M_{RCA} = [(M_{XCA})^2 + (M_{YCA})^2 + (M_{ZCA})^2]^{0.5}$$

where

$$M_{XCA} = M_{XSA} + M_{XDA} - [(F_{YSA})(zS) + (F_{YDA})(zD) - (F_{ZSA})(yS) - (F_{ZDA})(yD)]/1\,000$$

$$M_{YCA} = M_{YSA} + M_{YDA} + [(F_{XSA})(zS) + (F_{XDA})(zD) - (F_{ZSA})(xS) - (F_{ZDA})(xD)]/1\,000$$

$$M_{ZCA} = M_{ZSA} + M_{ZDA} - [(F_{XSA})(yS) + (F_{XDA})(yD) - (F_{YSA})(xS) - (F_{YDA})(xD)]/1\,000$$

Input | Equipment

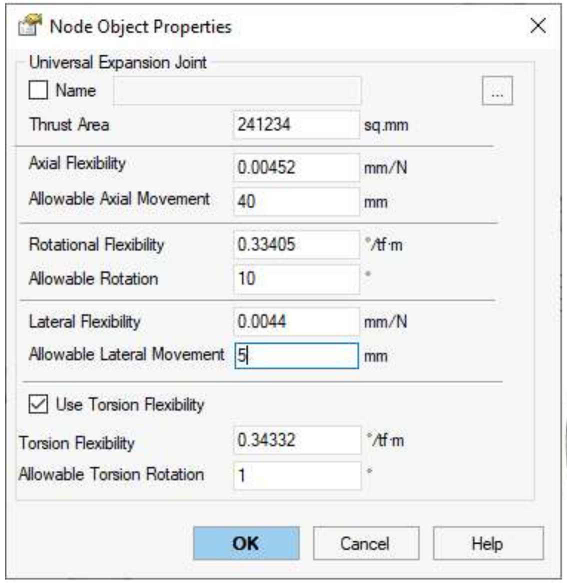
Operating Mode: 1 'main mode' (0) — Load Case: Operating W+P+T — Show Equations — ?

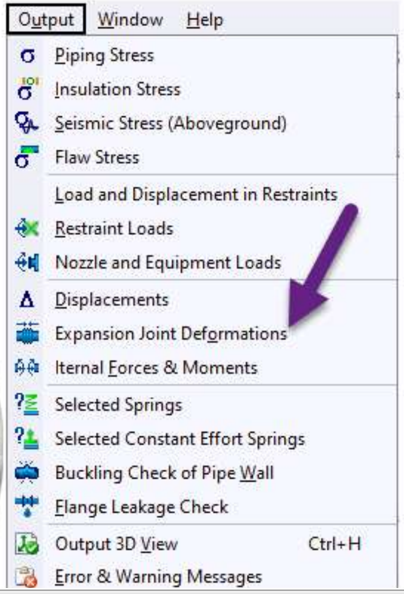
Object	Start End node	Type	DN, mm	Frad, N	Fcir, N	Flong N	FR, N	Mrad, N-m	Mcir, N-m	Mlong, N-m	MR, N-m	Sum	Notes
Pump API 610/ISO 13709	Node (1)	Suction, Side	200	-7333	5887	-29592	31050	-2626.53	18306.88	4598.20	19057.39	2.84	!
				9780	6220	7560	6920	3520	5160	7060	4710		
	Node (3)	Discharge, Side	200	1440505	-173	0	1440505	0		28.89	28.89	69.39	!
				9780	6220	7560	6920	3520	5160	7060	4710		
		Summary Loads		1433173	5714	-29592	1433490	-2626.53	33102.90	7657.21	34078.35		!
							20760	[My_sum]=2([MradT1] + [MradT2])=2*(1760+1760)=7040 N-m					

PASS/Start-Prof | Piping Model Creation

Added new object Untied Expansion Joint and database of Untied Expansion Joints, allows to specify the axial, rotational, shear and torsion flexibility and automatically checks the individual and combined allowable deformations. No need to manually model it using nonstandard expansion joint any more

model it using nonstandard expansion joint any more





$$\frac{|\lambda_p|}{[\lambda_p]} + \frac{|\lambda_\theta|}{[\lambda_\theta]} + \frac{|\lambda_\Delta|}{[\lambda_\Delta]} \le 1.$$

Input | Def exp

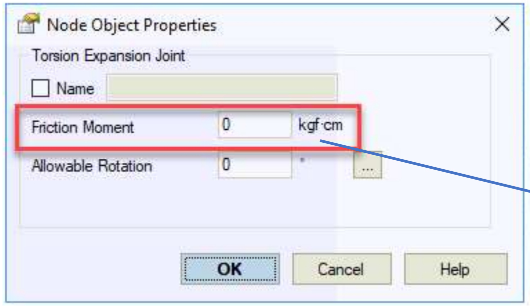
Operating Mode: 1 操作模式' (0) | Load Case: Operating W+P+T | Axis: Local axis (Design/Allowable) | ?

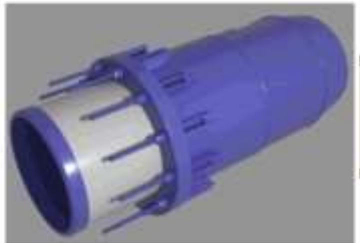
Node Number	Type	Local axis	Axial, (mm)	Allowable, (mm)	Shear, (mm)	Allowable, (mm)	Angular, (°)	Allowable, (°)	Torsion, (°)	Allowable, (°)	Summary	Notes
12	Untied Expansion Joint	Pipe 3 - 12	2.41	50	1.22	15	9.59131	10	-2.05119	No	1.09	1
13	Torsion Expansion Joint	Pipe 5 - 13	0	No	0	No	0	No	13.9229	51.5662	0.27	
15	Torsion Expansion Joint	Pipe 7 - 15	0	No	0	No	0	No	10.1299	51.5662	0.20	
21	Torsion Expansion Joint	Pipe 19 - 21	0	No	0	No	0	No	-4.36021	51.5662	0.08	

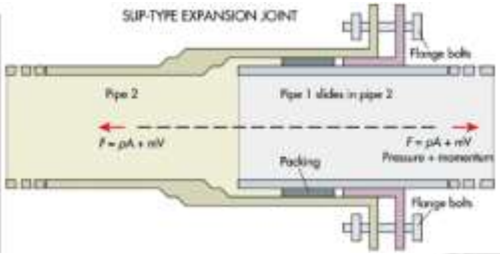
PIPING AND EQUIPMENT
ANALYSIS & SIZING SUITE

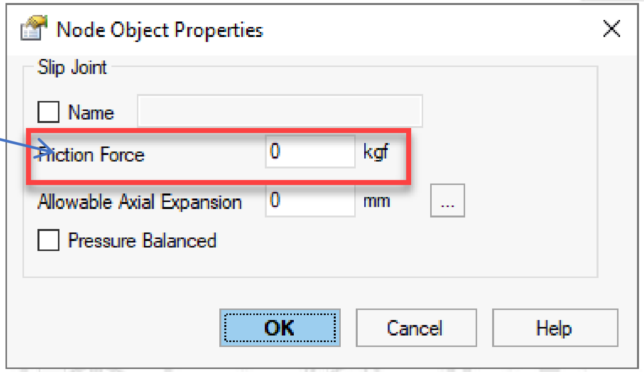
PASS/Start-Prof | Piping Model Creation

Added new object Torsion Expansion Joint and database of torsion expansion joints, automatically model torsion friction (friction moment) and checks allowable rotation angle



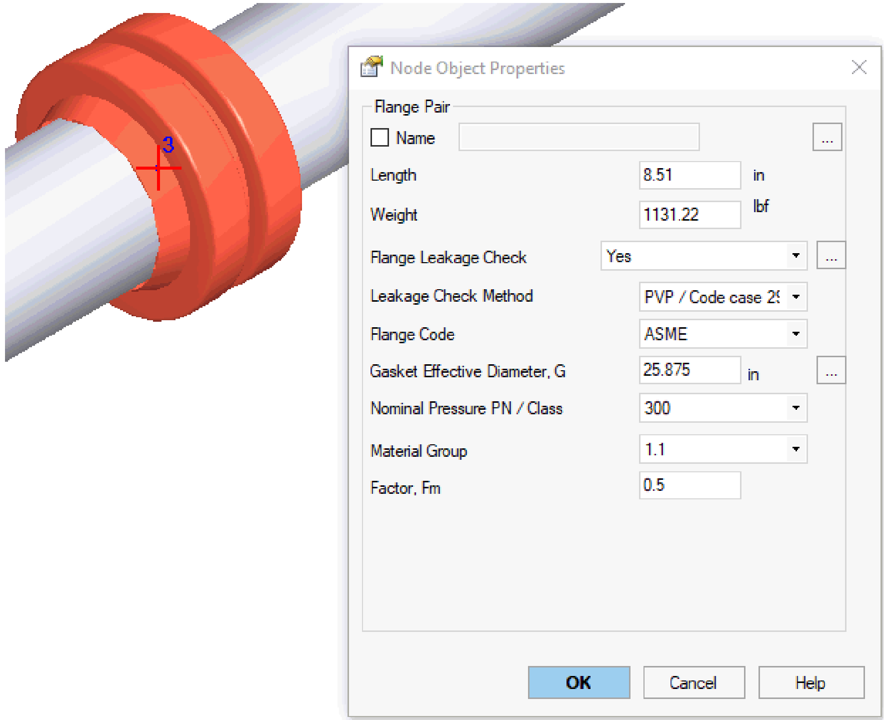






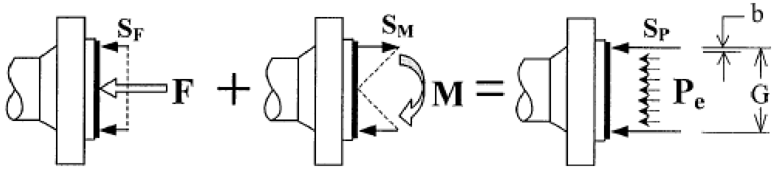
PASS/Start-Prof | Piping Model Creation

Flange Object



Automatic Flange Leakage Check:

- Equivalent pressure / Kellogg Method
- Code Case 2901 / PVP2013-97814 Method
- DNV Method
- NC 3658.3 Method



Input | Flange leakage

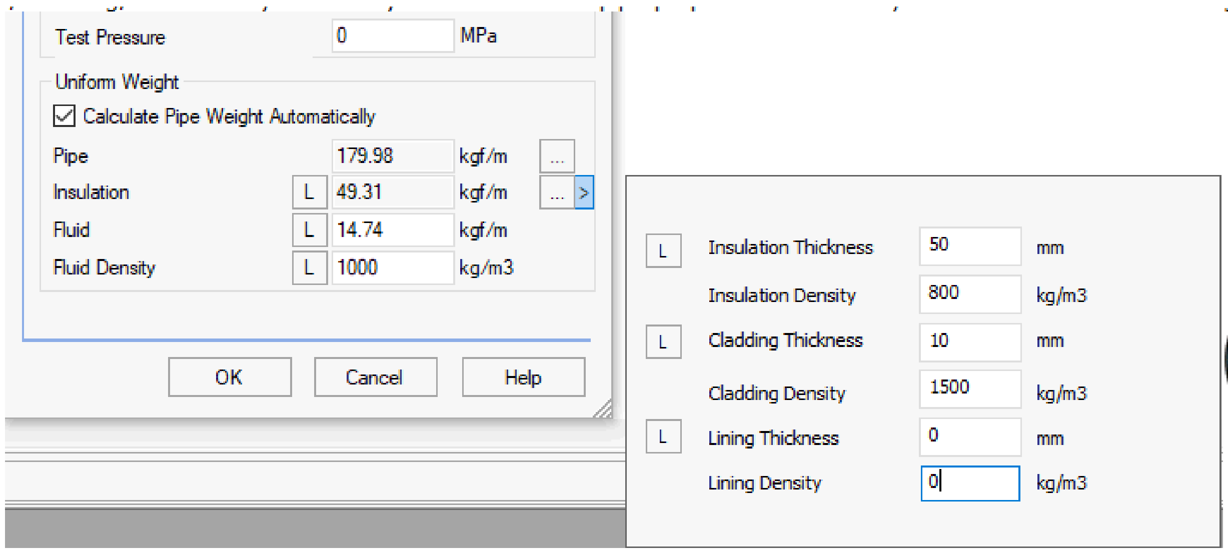
Operating Mode: 1 'Operation mode' (0)

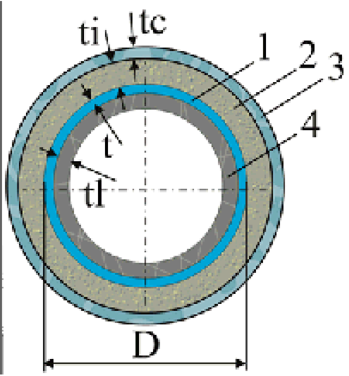
Submode: Operation (all loads)

Node Number	Object	Flange on the side of node	Pipe outside diameter, (mm)	Temperature, (°C)	Axial Force, (kgf)	Bending Moment, (kgf·m)	Parameters	Condition, (MPa)			Notes
								calcu-lated	allow-able	%	
3	Flange Pair	-	219.08	400	-1000	1499.98	1.60 MPa	4.29 MPa	17.36 MPa	24.70	

PASS/Start-Prof | Piping Model Creation

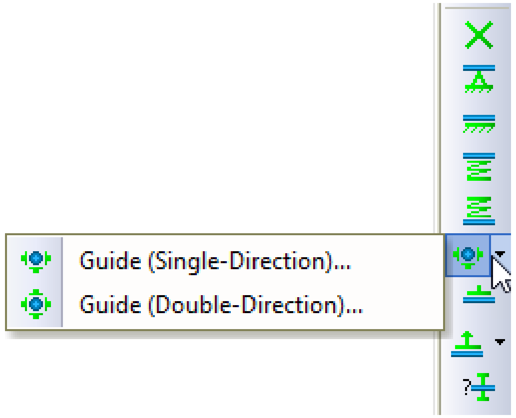
Added ability to specify insulation, cladding, and liner layers density and thickness in pipe properties. The ability to choose an insulation weight from the database still exist





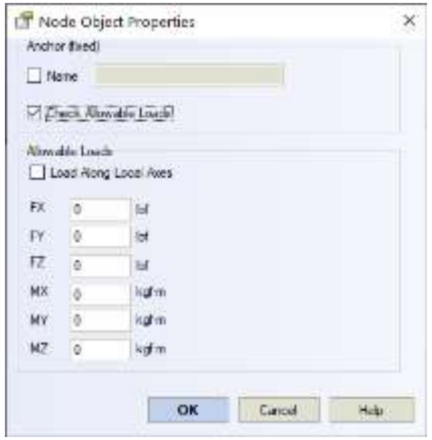
PIPING AND EQUIPMENT
ANALYSIS & SIZING SUITE

PASS/Start-Prof | Piping Model Creation

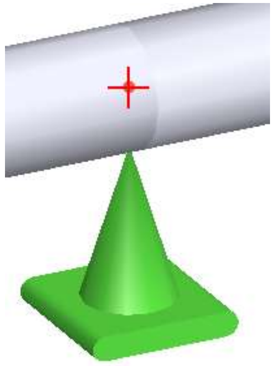


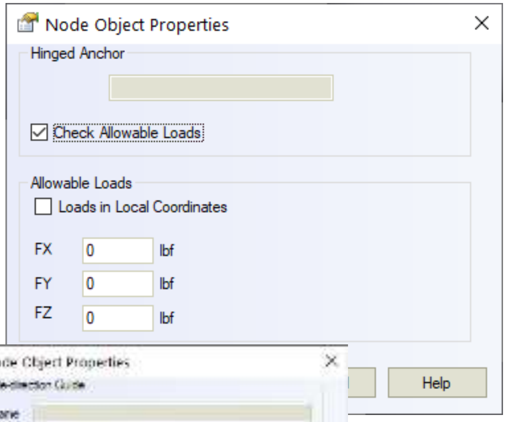
- Automatic Variable Spring Selection
- Automatic Constant Spring Selection

Anchor

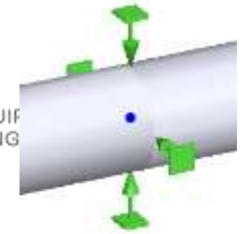


Hinged Anchor

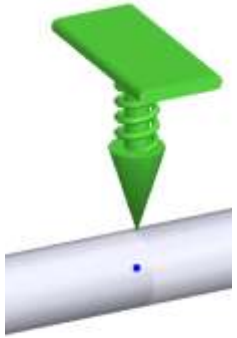


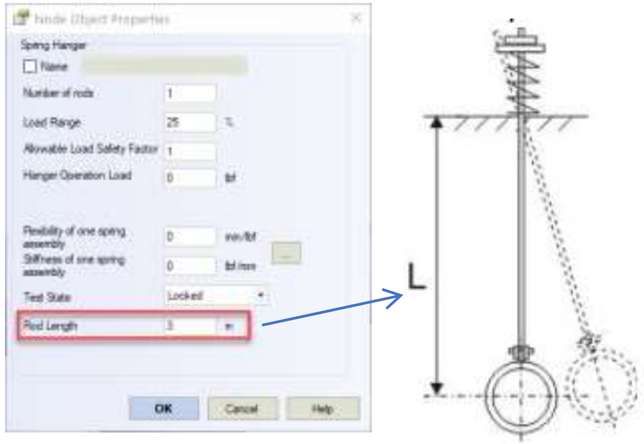


Guide Support

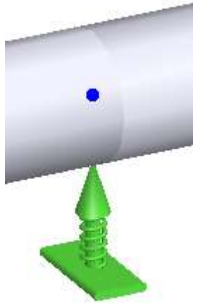


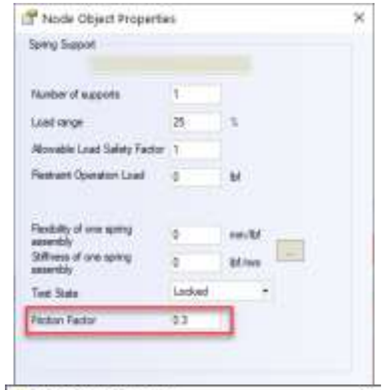
Spring Hanger



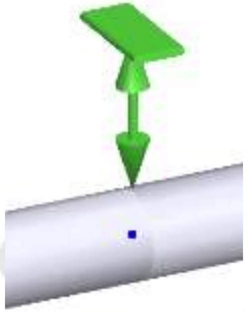


Spring Support





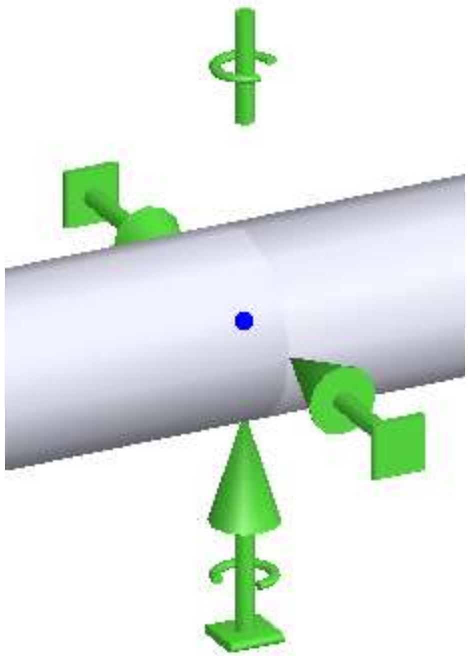
Constant Hanger

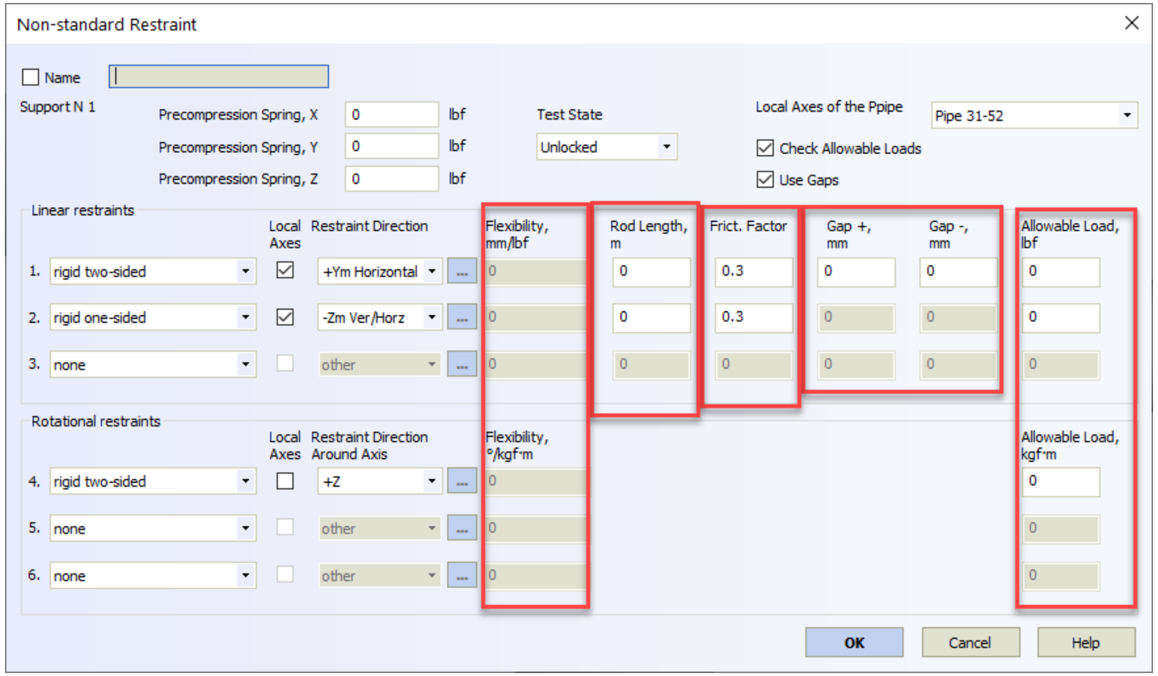


PIPING AND EQUIP
ANALYSIS & SIZING

PASS/Start-Prof | Piping Model Creation

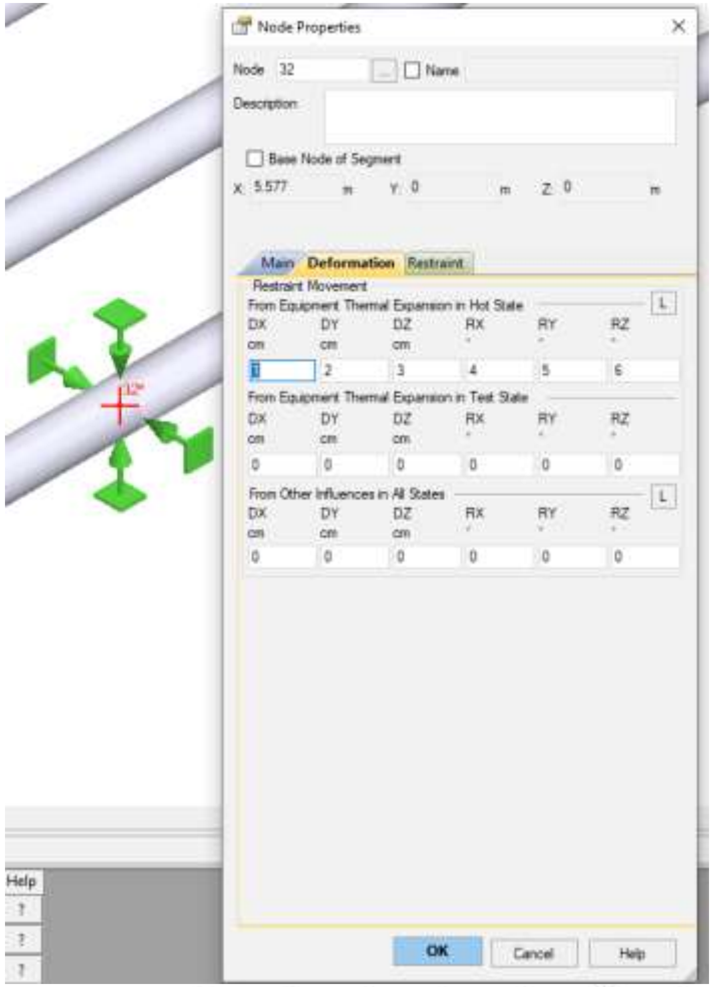
Custom Non-Standard Restraint Object

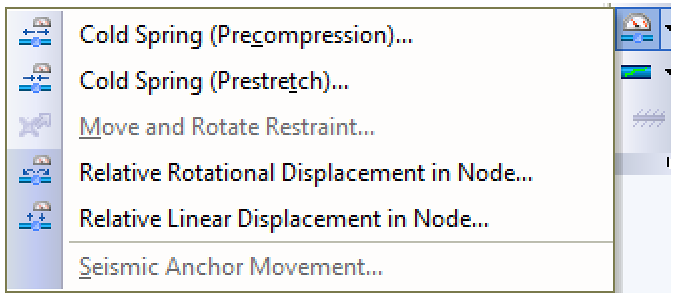




PASS/Start-Prof | Piping Model Creation

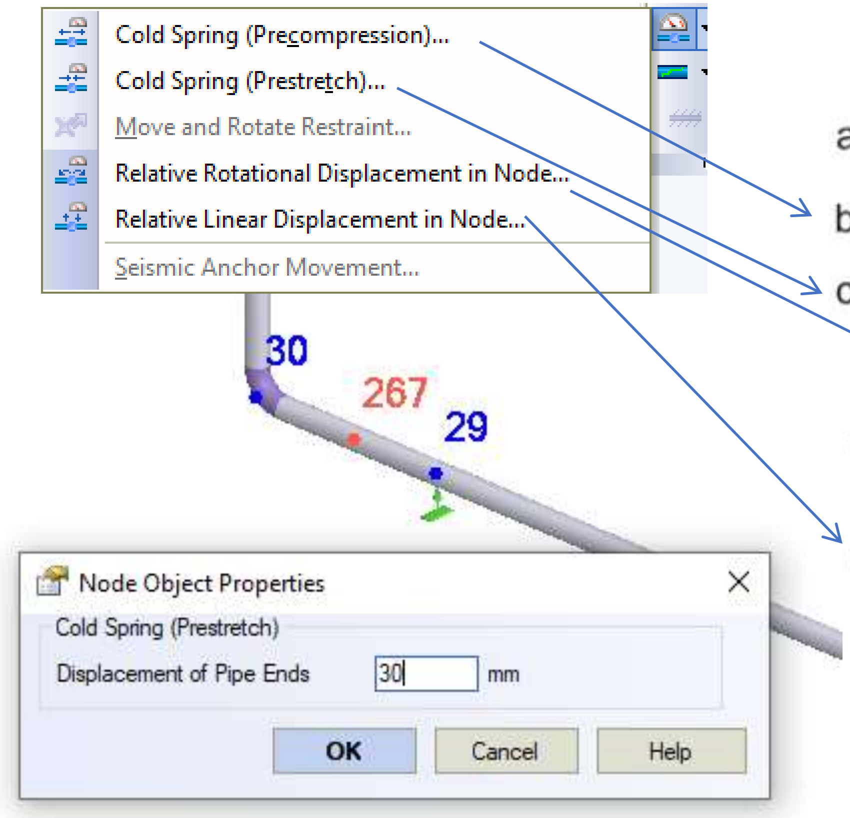
To specify support movement, just add displacement object to the support object

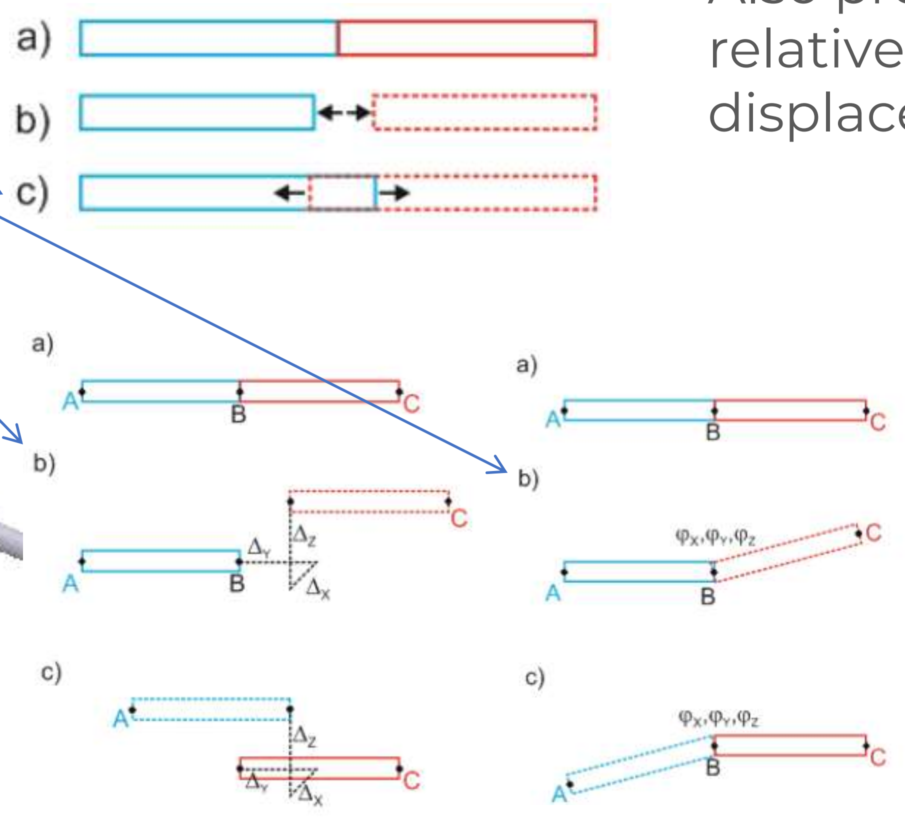




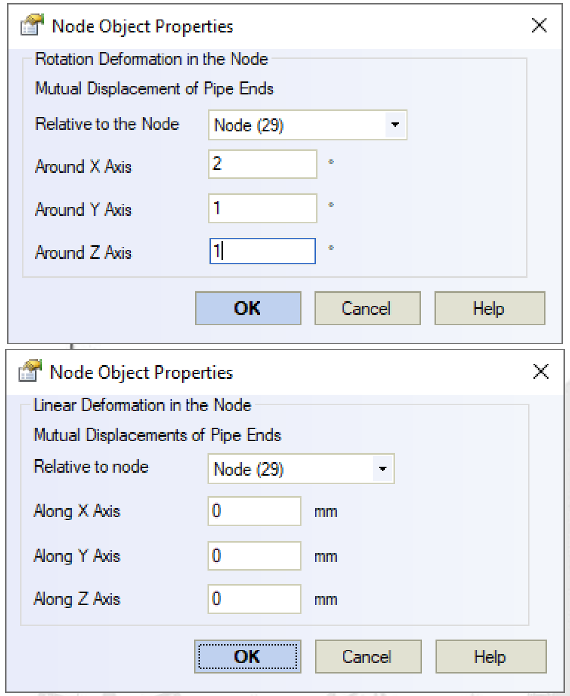
PASS/Start-Prof | Piping Model Creation

To specify the cold spring (cold pull, pre-stretch), just add the cold spring object in the node





Also pre-compression, and relative rotational or linear displacements of the pipe ends

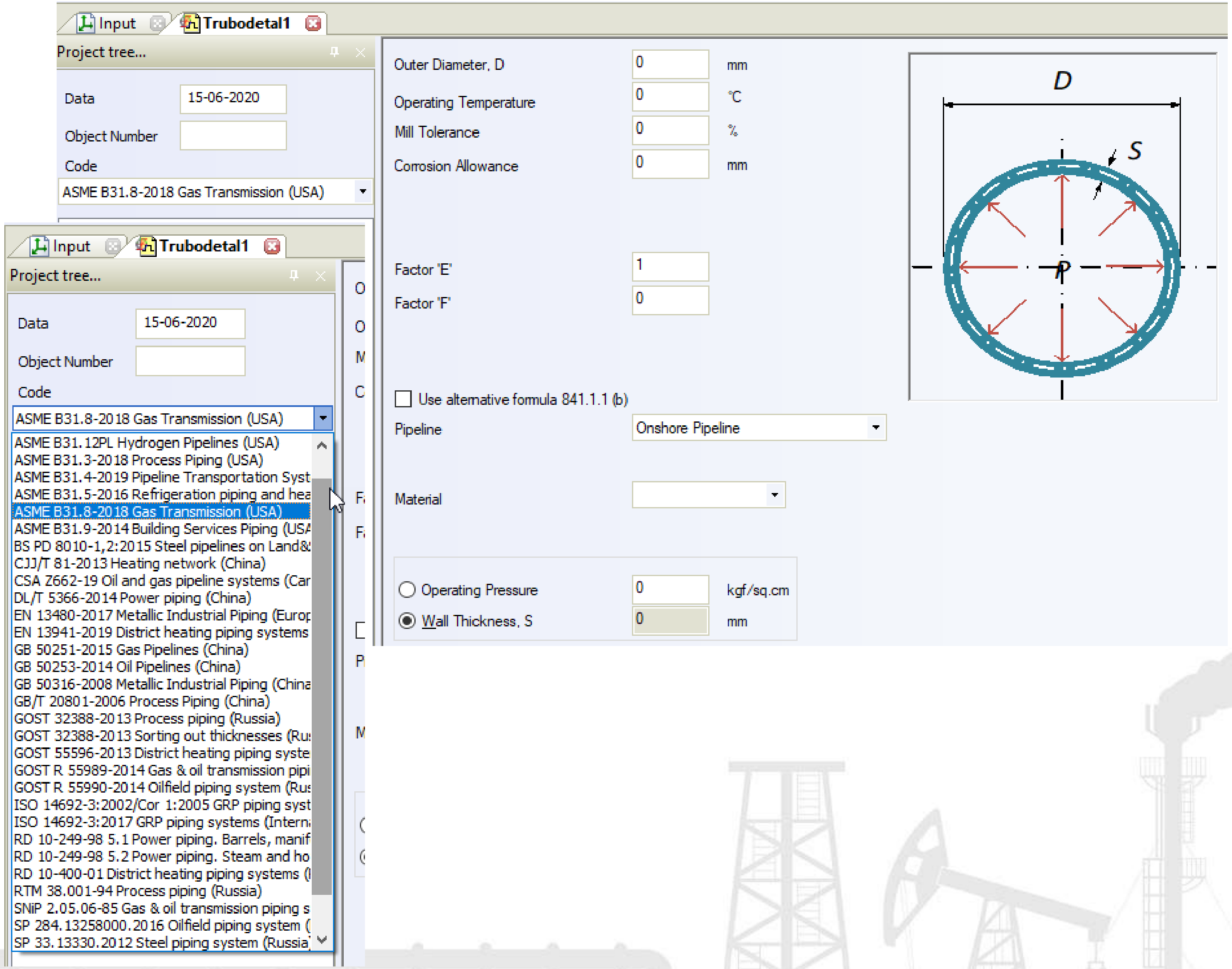


PASS

PIPING AND EQUIPMENT
ANALYSIS & SIZING SUITE

PASS/Start-Prof | START-Elements

Pipe wall thickness calculator and bend wall thickness calculator for all codes.

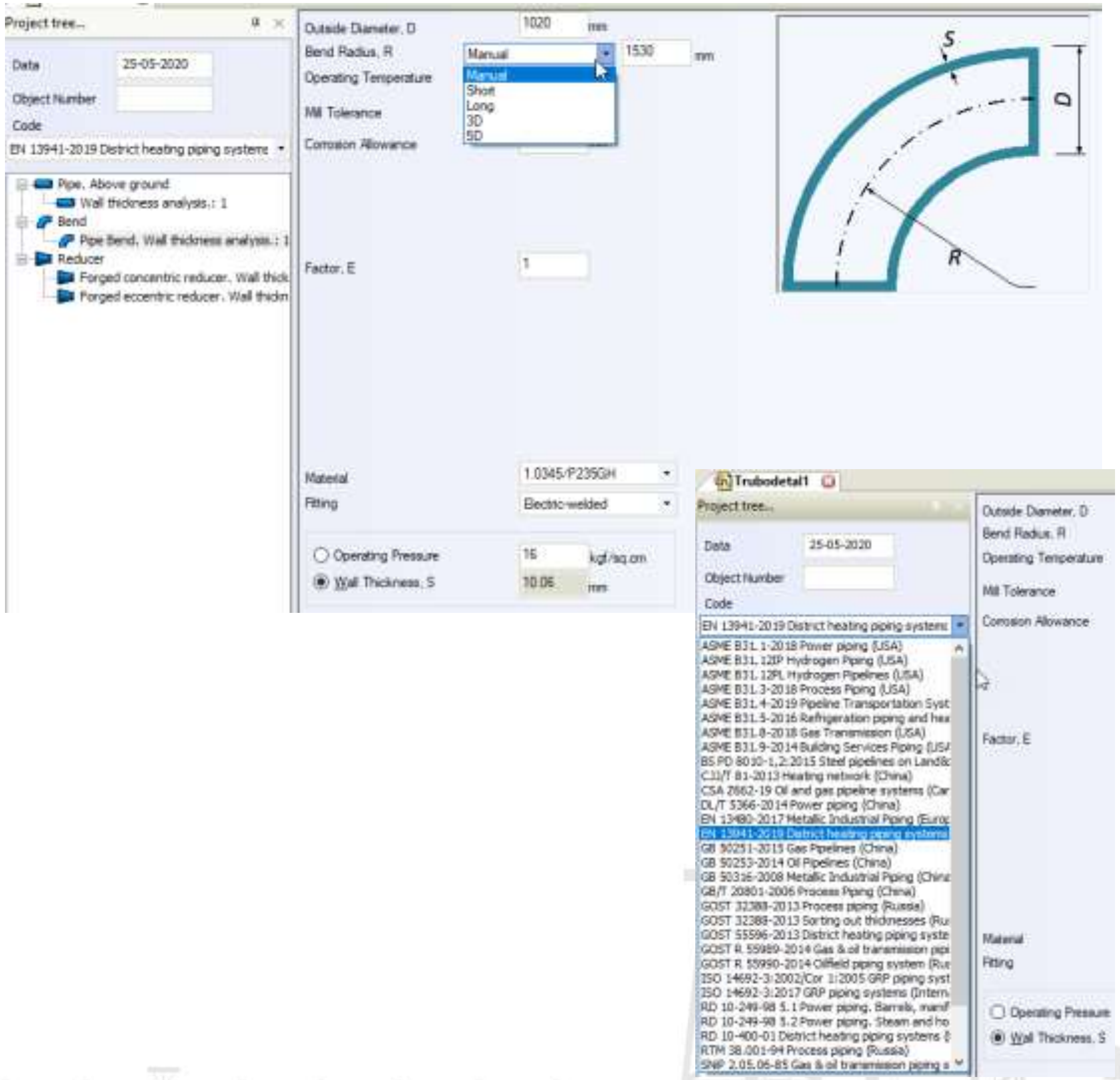


PIPING AND EQUIPMENT
ANALYSIS & SIZING SUITE

PASS/Start-Prof | START-Elements

Pipe wall thickness calculator and bend wall thickness calculator for all piping codes.

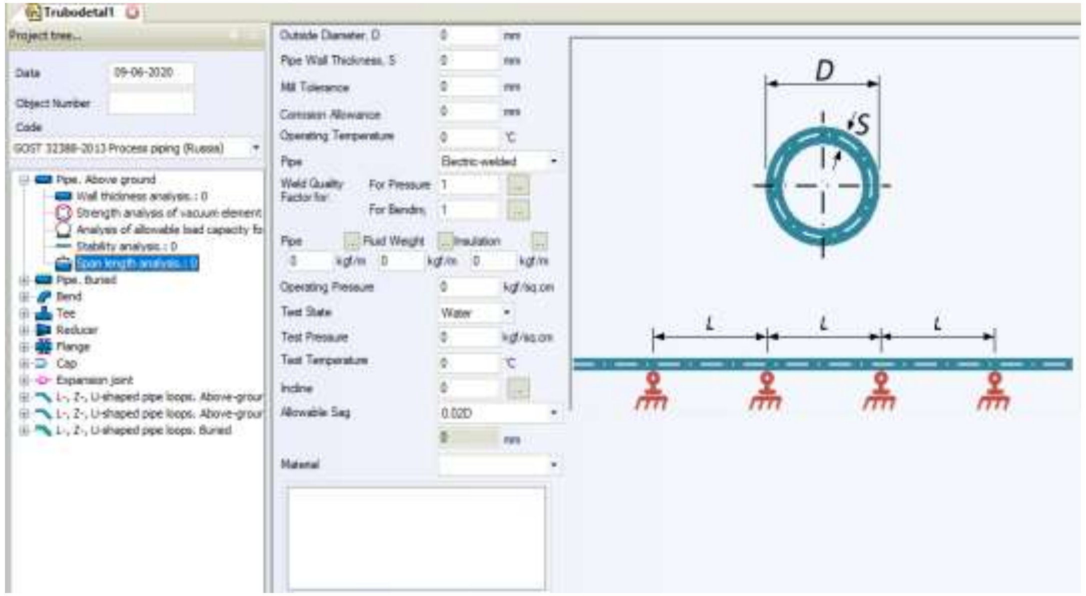
All pipe and fitting wall thicknesses are automatically checked before every run of the pipe stress analysis according to the selected code.

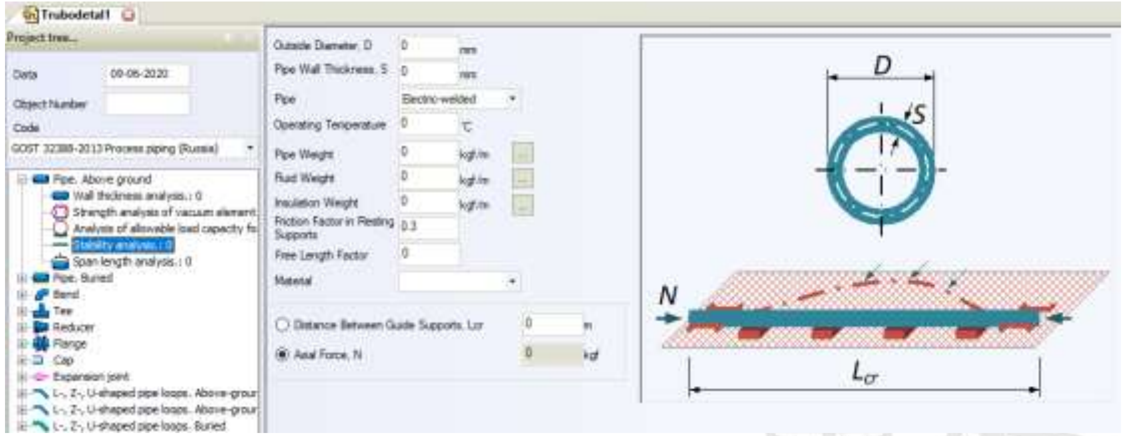


PASS/Start-Prof | START-Elements

Pipe Span Length Analysis

Longitudinal Stability Analysis



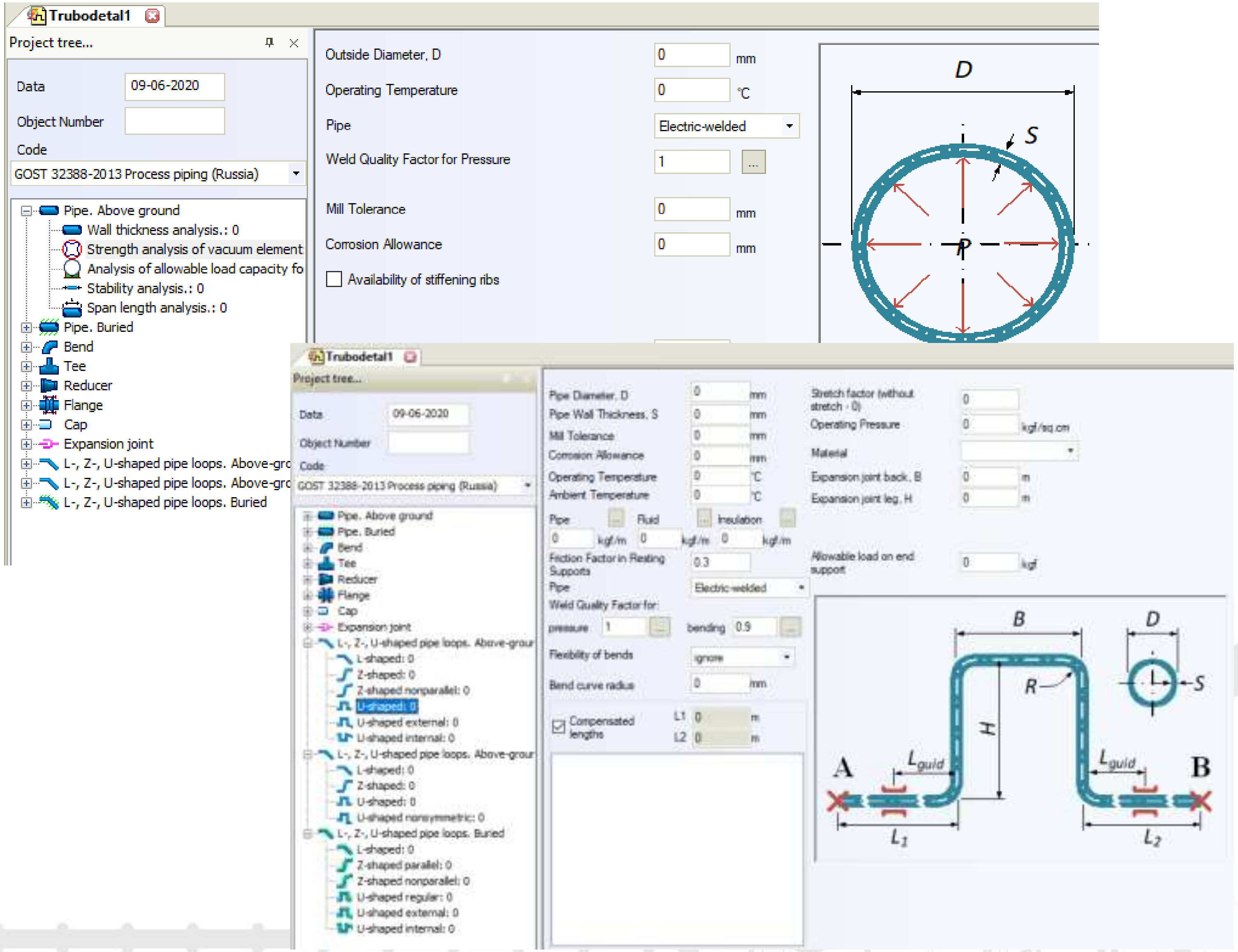


PIPING AND EQUIPMENT
ANALYSIS & SIZING SUITE

PASS/Start-Prof | START-Elements

Calculate Wall Thickness Under Vacuum and External Loading

Simple Expansion Loop Analysis

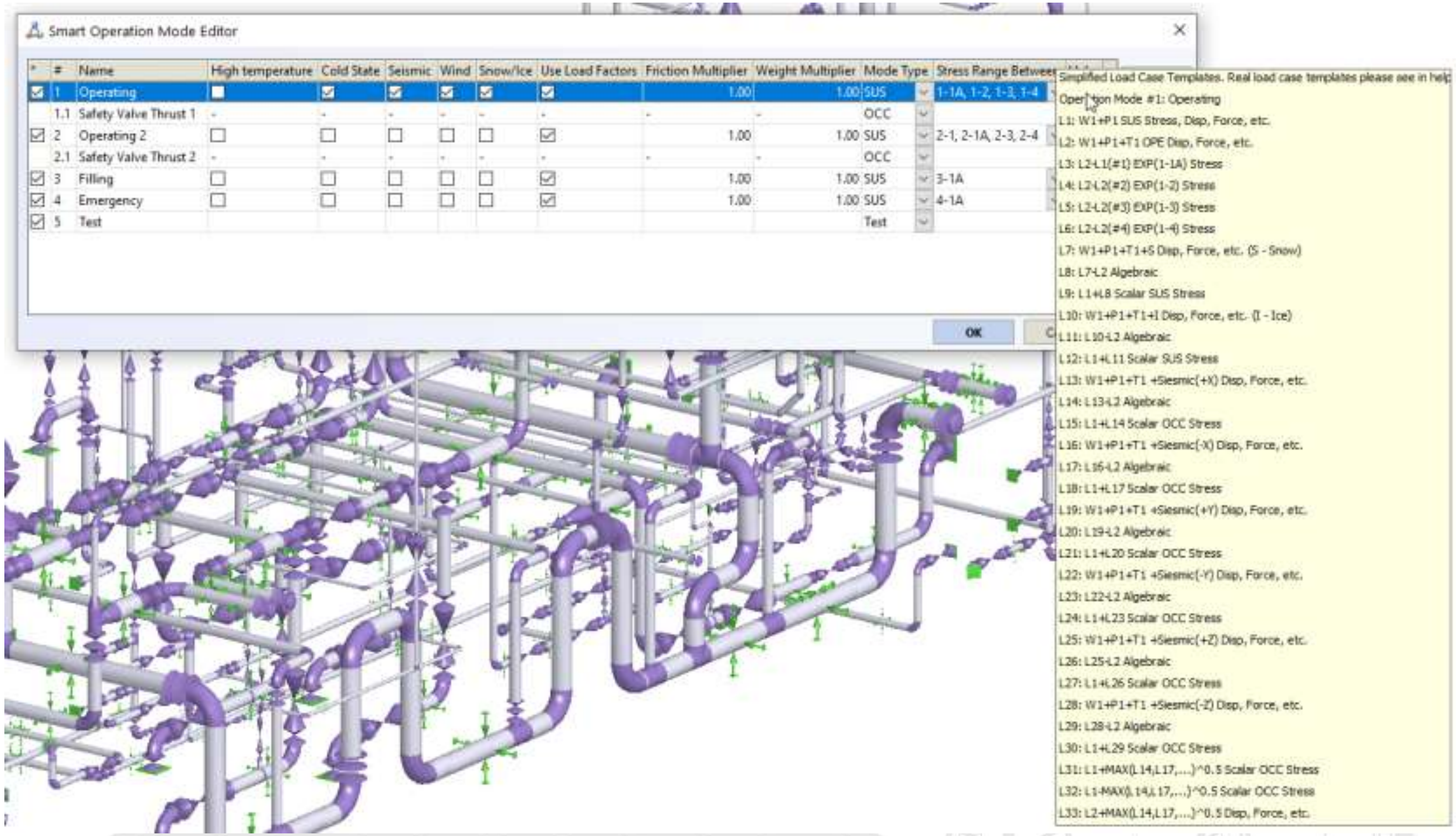


PIPING AND EQUIPMENT
ANALYSIS & SIZING SUITE

PASS/Start-Prof | Features

- No need to create the load cases manually
- Save a lot of time and protect from mistakes
- Operation Mode Editor will do this job for you
- Easy to understand and change
- No limit on pressure, temperature number

67 complex load cases are automatically generated based on simple five START-PROF operating modes

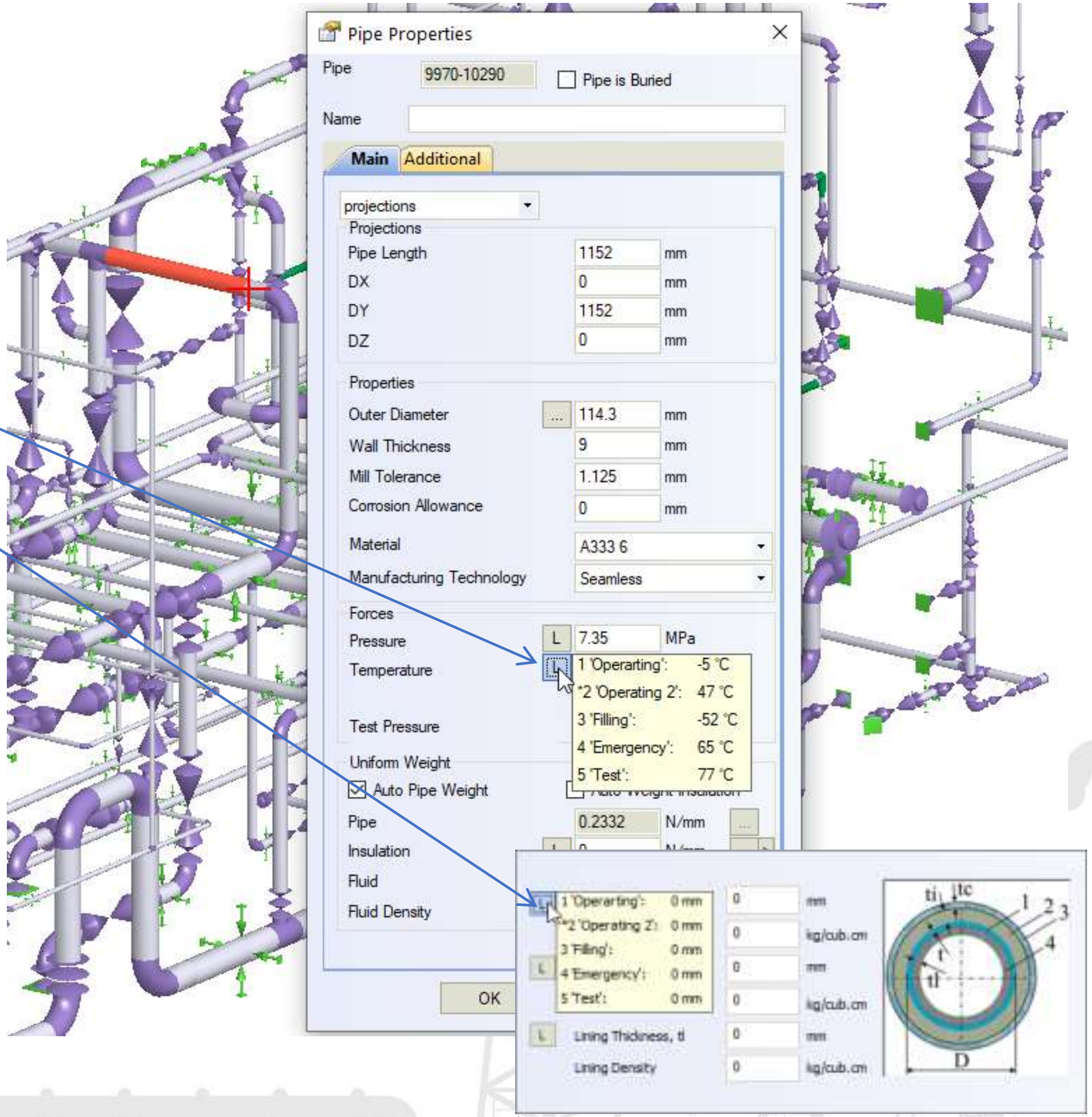


PASS
PIPING AND EQUIPMENT
ANALYSIS & SIZING SUITE

PASS/Start-Prof | Features

Different operating modes can have different:

- Temperatures 1-∞
- Pressures 1-∞
- Fluid weight 1-∞
- Restraint displacements 1-∞
- Forces and moments, uniform loads 1-∞
- Insulation layers and density, weight 1-∞
- No limit on pressure, temperature, etc. number
- No limit on operation mode number
- Load cases created automatically
- Interactive reports are compiled automatically for all operating modes

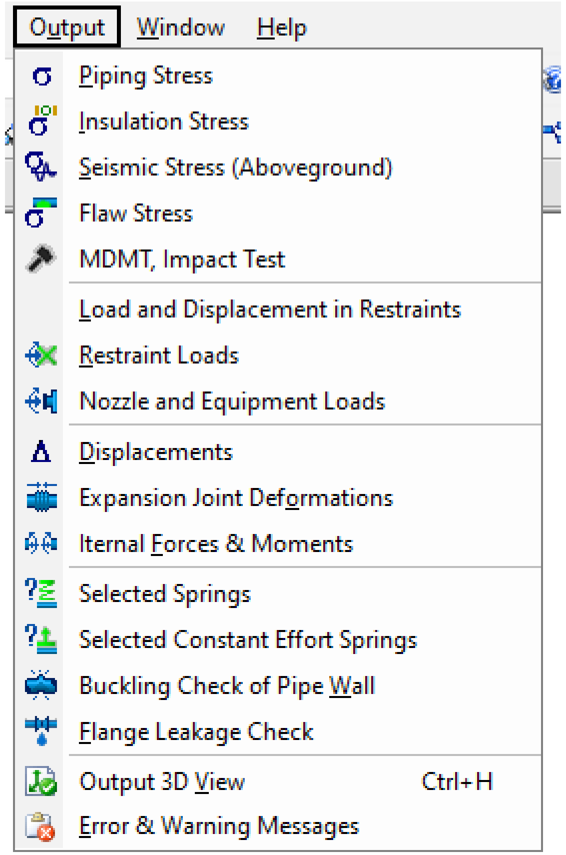


PASS

PIPING AND EQUIPMENT ANALYSIS & SIZING SUITE

PASS/Start-Prof | Reports

Full scope of the needed interactive reports after analysis



- Reports are interactive. For example, you can add or remove stresses from axial force on-the-fly, change global/local coordinates, add or remove creep stress etc.
- Reports can be copied to MS Excel
- Reports can be exported into MS Word
- Free Viewer is Available
  You can send your piping model to customer, who can open it using viewer and review piping model and all analysis results

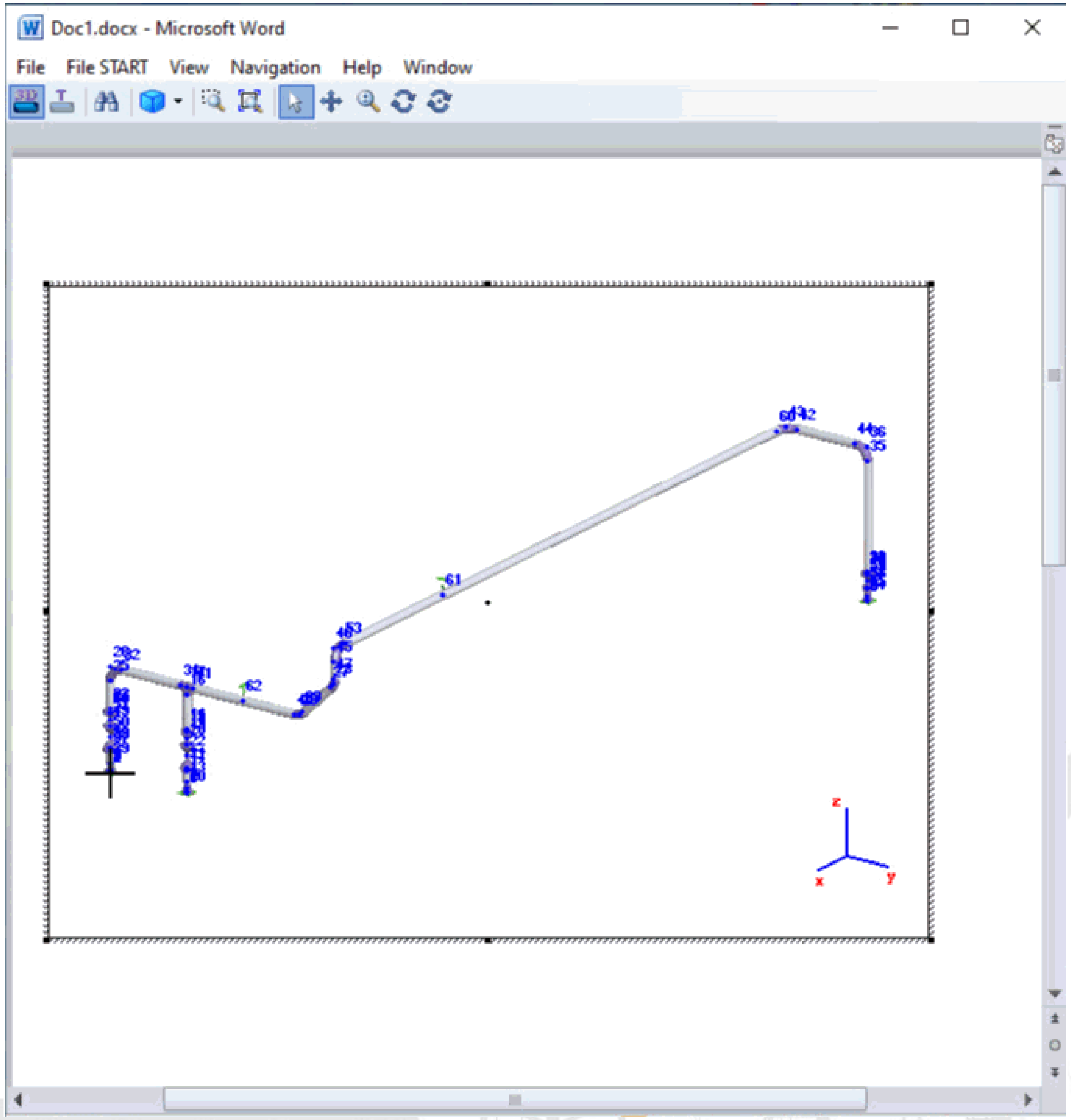
PASS/Start-Prof | Features

Function ‘Copy Whole Model’.

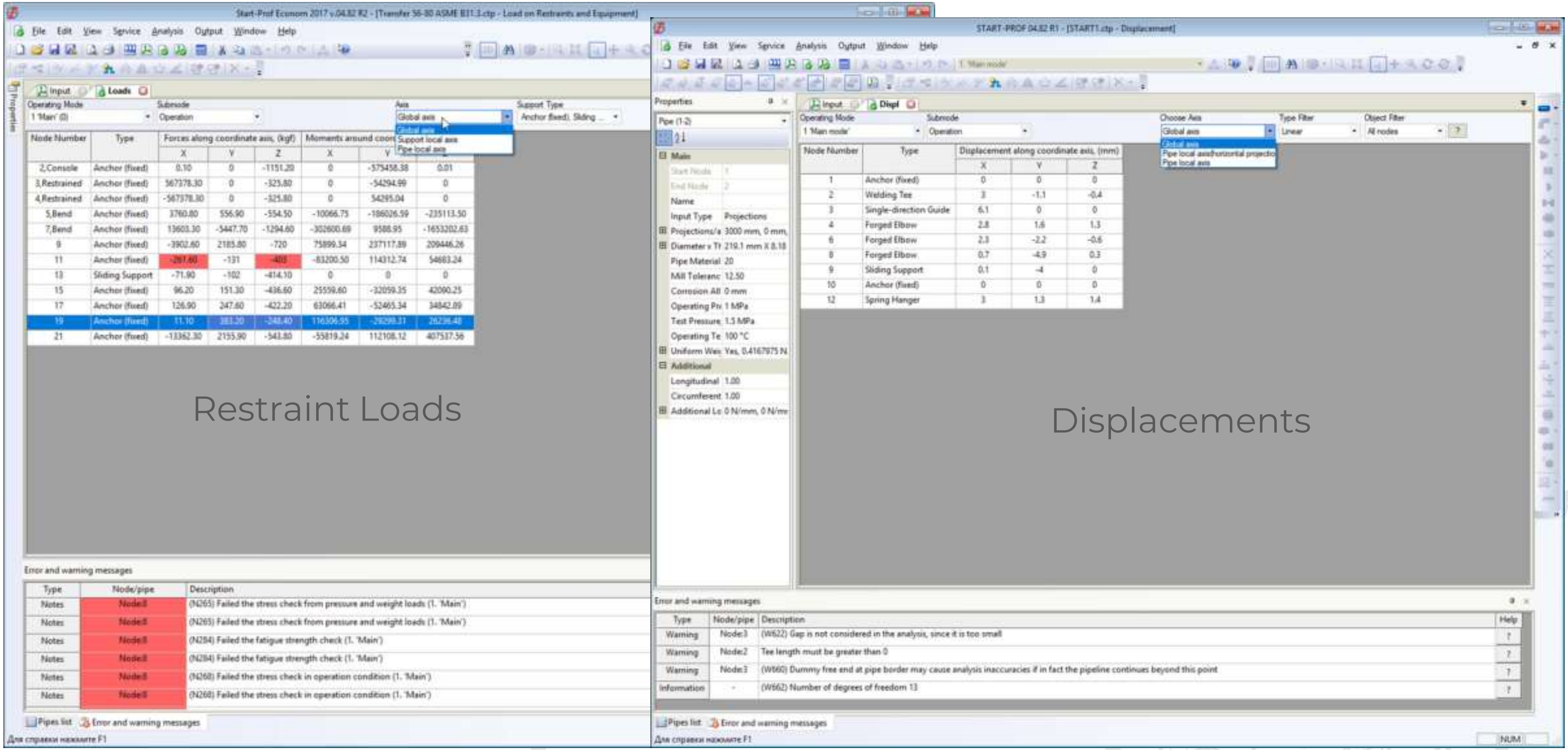
Allows to copy whole piping model as an object into clipboard. After that you can insert this interactive model into any other software like MS WORD, EXCEL etc.

You can rotate, pan zoom the model right inside MS Word

You can add interactive into report in MS Word and send to your customer for review

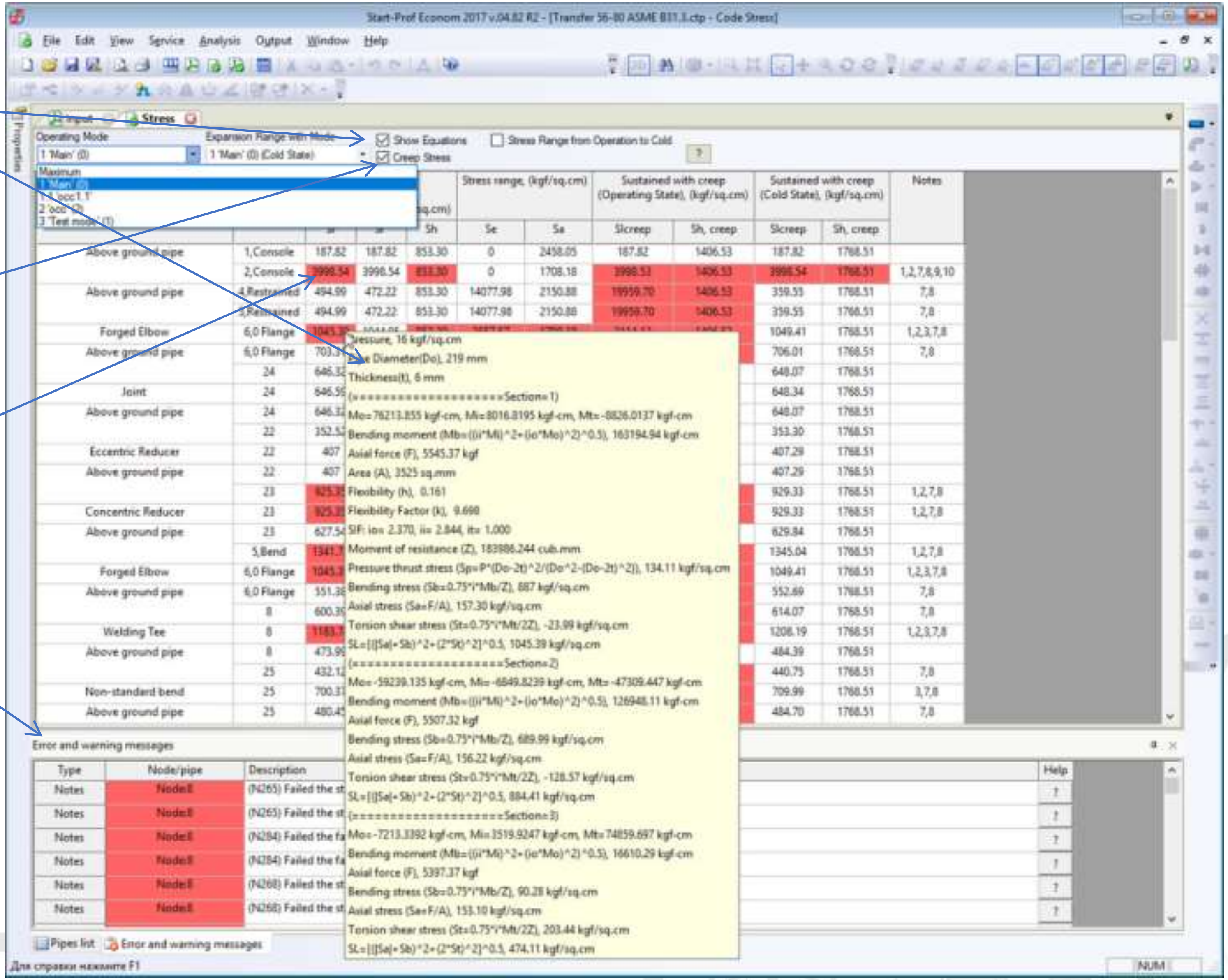


PASS/Start-Prof | Reports



PASS/Start-Prof | Reports

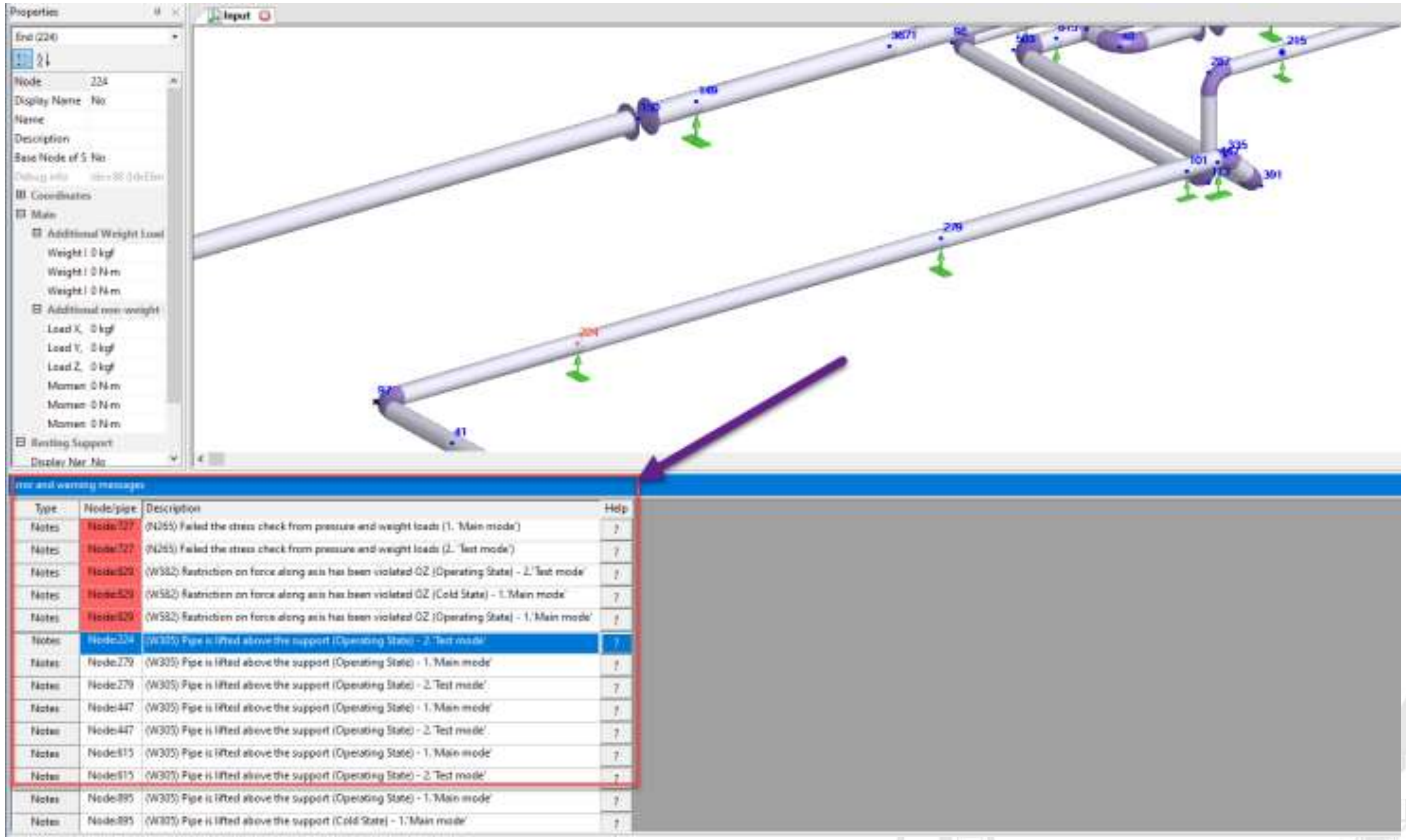
- Stress report show all used equations
- You can add/remove stress from axial force
- Activate individual features for each pipe stress code
- Cells where the check fails has a red color
- Messages about stress check fail duplicated in the errors and warning window



PASS/Start-Prof | Reports

PASS/START-PROF has smart warnings in error checker.

It show all engineering warnings like support is lifting off, support loads are greater than allowable, expansion joint deformation exceed the limits, buckling analysis failed, flange leakage failed, spring hanger variable range greater than 25%, spring load in one of load cases is greater than allowable, rod rotation exceed the limit and many others.

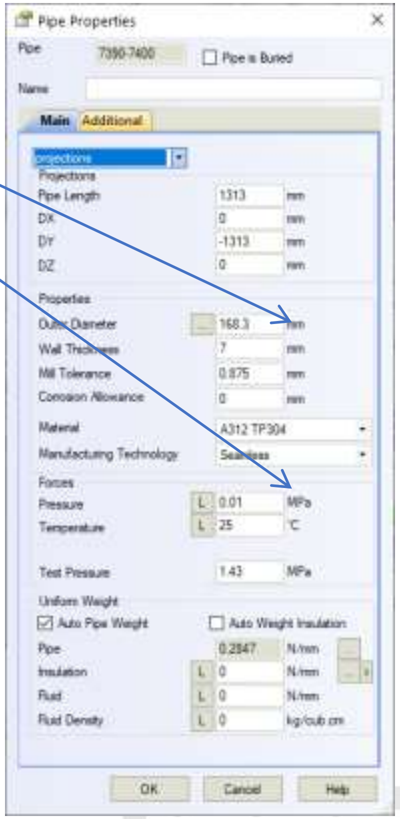


PIPING AND EQUIPMENT
ANALYSIS & SIZING SUITE

PASS/Start-Prof | Features

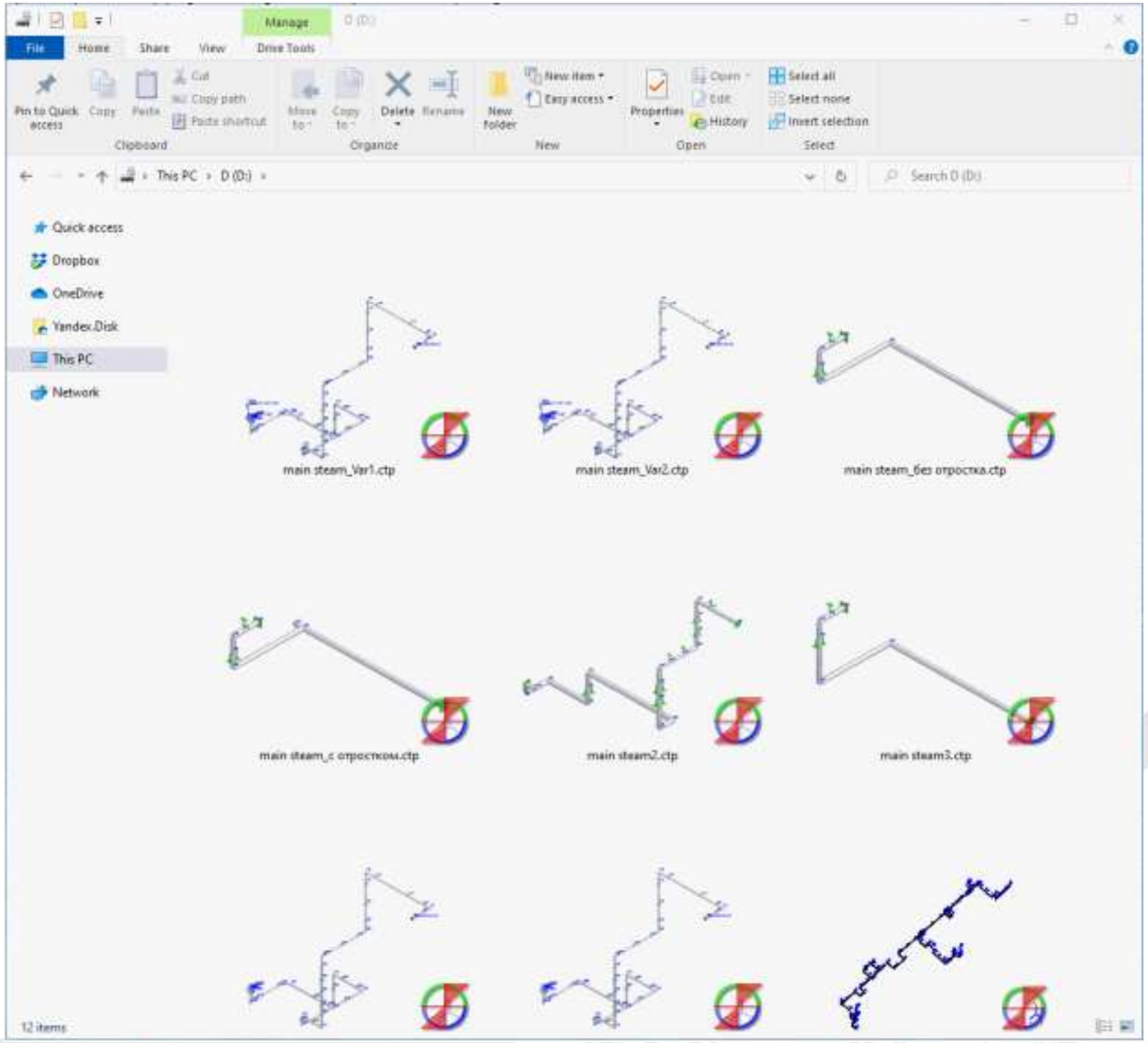
Change of the model units available at any moment of time on-the-fly, <u>even after analysis is done</u>.

The units are always displayed for each input field.



PASS/Start-Prof | Features

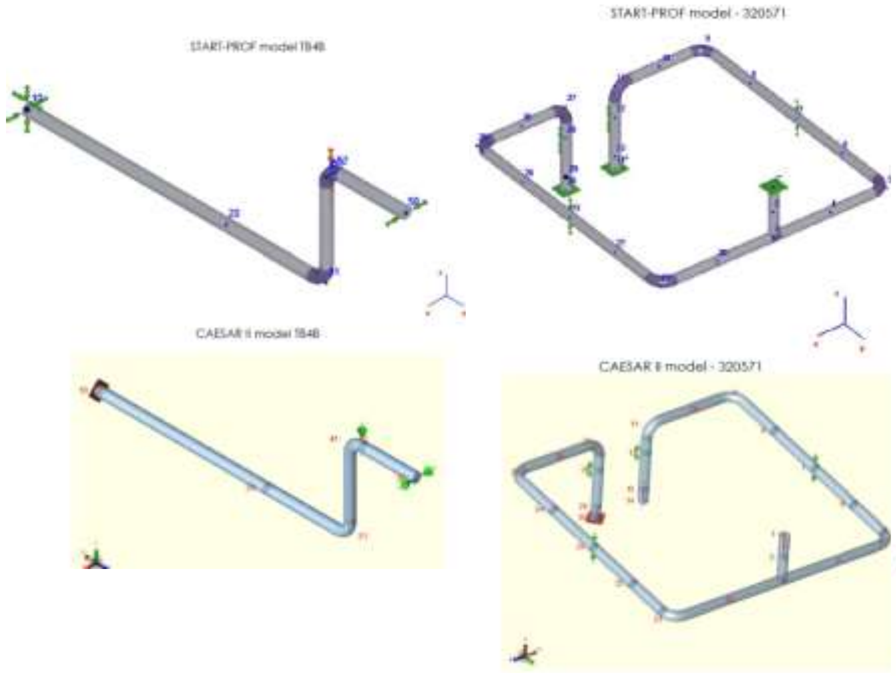
- Each piping system project is stored in just one file
- Thumbnails for windows explorer. You can preview all piping models right in the explorer before opening the file
- Fast opening even big models
- High speed of stress analysis and working with a really big models

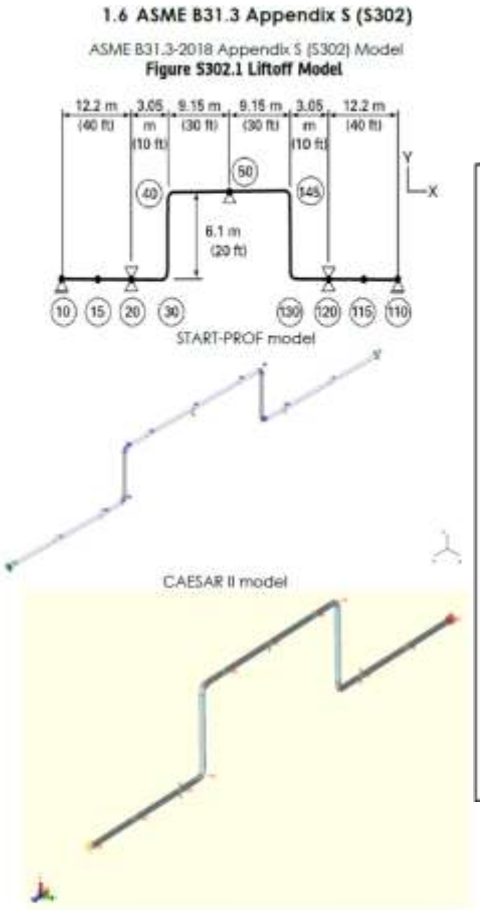


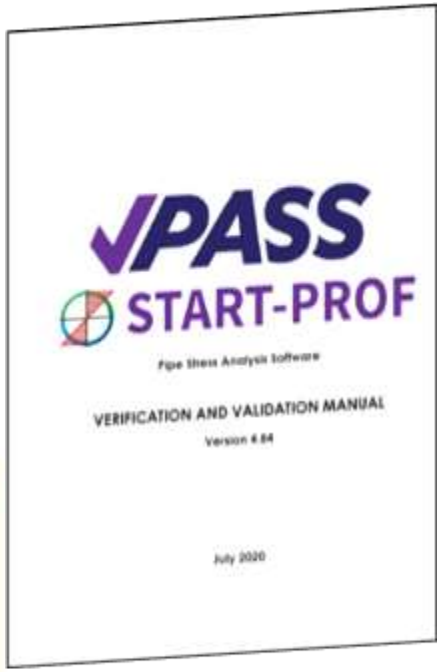
PIPING AND EQUIPMENT ANALYSIS & SIZING SUITE

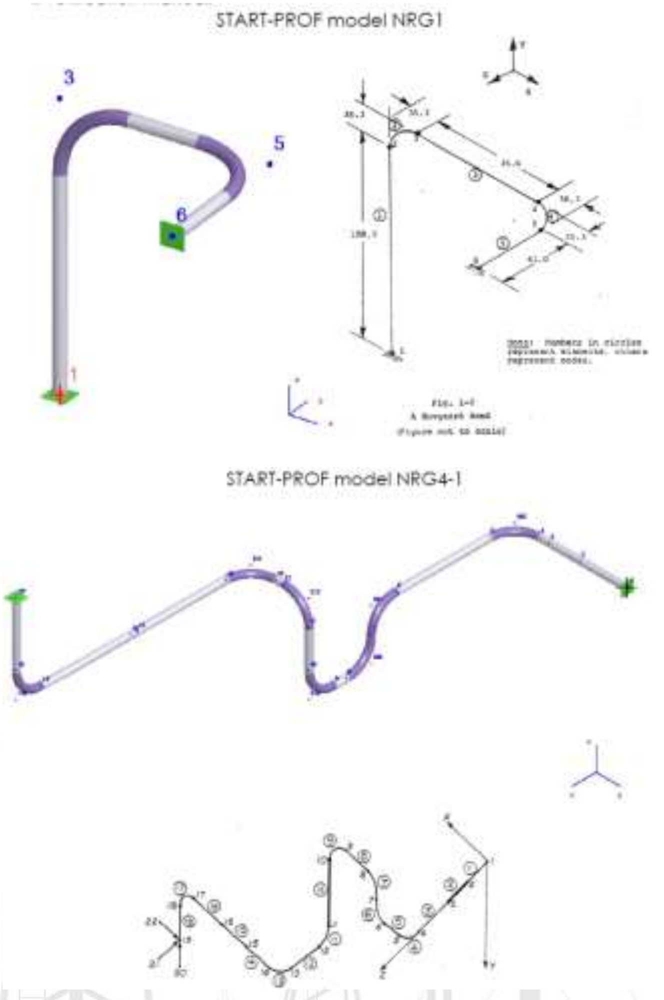
PASS/Start-Prof | Reliability

Full Verification and Validation manual. Added a lot of verification examples, compared to manual calculations and other software.









PIPING AND EQUIPMENT
ANALYSIS & SIZING SUITE

PASS/Start-Prof | Reliability

Each new PASS/START-PROF release is:

- Automatically verified on more than 300 examples with previous versions (quality assurance system)
- Checked manually with group of pipe stress experts (testers)
- Each release pass through 1-3 pipe stress trainings with 10-20 students before official release
- After release, all bugs reported by our 2000 companies active users are quickly fixed and new release is provided

PASS/Start-Prof | Licensing

Configurations/Pricing Options

PASS/Start-Prof Complete Advanced

Simulation and sizing for any piping network considering all applicable national codes.

PASS/Start-Prof Complete Standard

configuration includes only worldwide popular standarts.

PASS/Start-Prof Process Advanced

Simulation and sizing for piping networks based on applicable national codes for process plants as well as for gas and oil transportation systems.

PASS/Start-Prof Process Standard

configuration includes only worldwide popular standarts.

PASS/Start-Prof Power Advanced

Simulation and sizing for any piping networks based on applicable national codes for power generation piping as well as for central heating networks.

PASS/Start-Prof Power Standard

configuration includes only worldwide popular standarts.

PASS/START-PROF HDPE+FRP

Piping stress analysis of high density polyethylene and/or fiberglass reinforced plastic piping systems.

- Permanent License at Affordable Price (+1 year maintenance for free!)
- Maintenance Renew 1 Year: 25%
- Annual License: 40%
- Semi-Annual License: 25%

Configurations Comparison

Code	Complete Advanced	Process Advanced	Power Advanced	Complete Standard (40% discount)	Process Standard (40% discount)	Power Standard (40% discount)	HDPE+FRP (40% discount)
ISO 14692	✓	✓	✓				✓
HDPE Piping	✓	✓	✓				✓
ASME B31.1	✓		✓	✓		✓	
ASME B31.3	✓	✓		✓	✓		
ASME B31.4	✓	✓		✓	✓		
ASME B31.5	✓	✓	✓	✓	✓	✓	
ASME B31.8	✓	✓		✓	✓		
ASME B31.9	✓	✓	✓	✓	✓	✓	
EN 13480	✓	✓	✓	✓	✓	✓	
GB 50316	✓	✓	✓	✓	✓		
GB/T 20801	✓	✓		✓	✓		
GB 50251	✓	✓		✓	✓		
GB 50253	✓	✓		✓	✓		
DL/T 5366	✓		✓	✓		✓	
CJJ/T 81	✓		✓				
RD 10-249-98	✓		✓				
GOST R 55596	✓		✓				
GOST 32388	✓	✓					
SNiP 2.05.06-85	✓	✓					
SP 36.13330	✓	✓					

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PASS/Start-Prof | Resources

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- Facebook: www.facebook.com/PASSuite
- Twitter: twitter.com/passuitecom
- More than 50 articles about pipe stress analysis and PASS/START-PROF features https://whatispiping.com/category/start-prof

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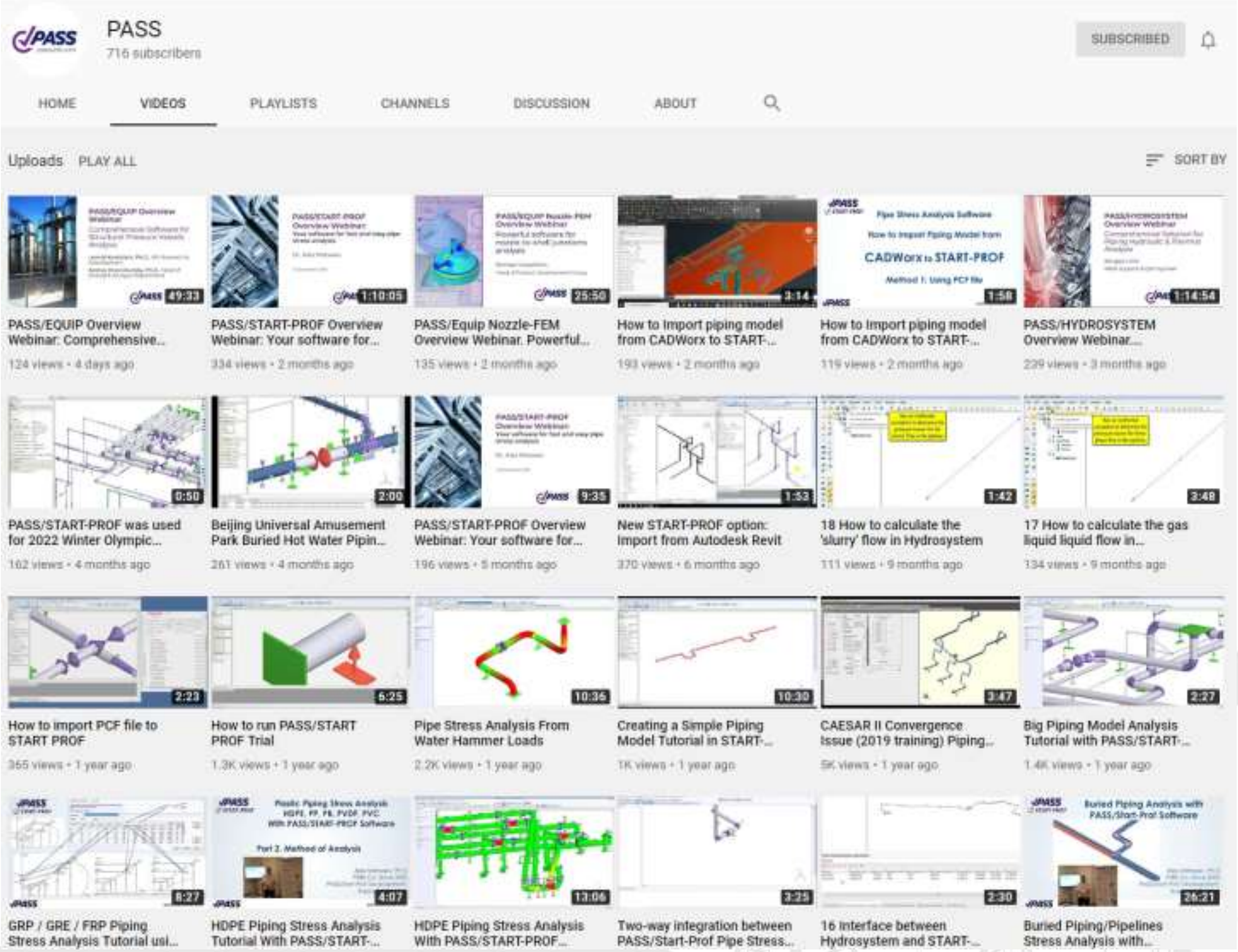
PASS/Start-Prof | Resources

- Online Help: https://www.passuite.com/kbase/doc/start//WebHelp_en/index.htm

PASS/Start-Prof | Resources

Subscribe our YouTube channel, you will find a lot of PASS/START-PROF training videos

www.youtube.com/passuite



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Thank YOU!