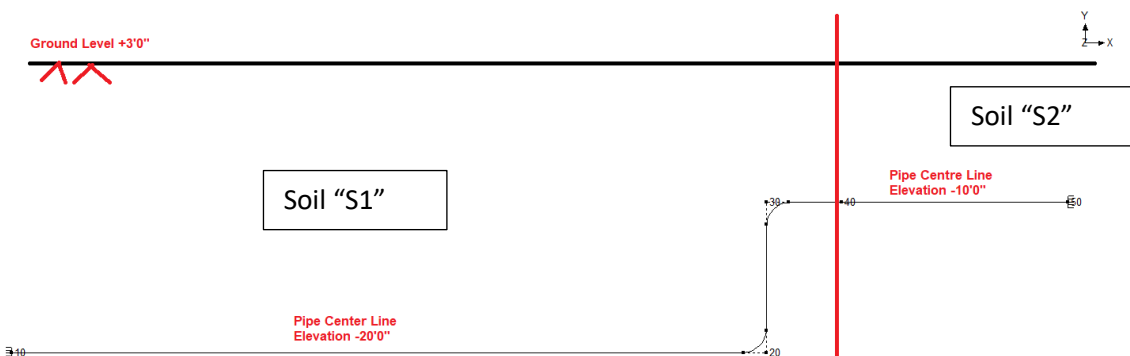


#	Name	Nom Dia	Sch	OD (inch)	Thk (inch)	Cor.Al (inch)	M.Tol (%)	Ins.Dens (lb/ft3)	Ins.Thk (inch)	Lin.Dens (lb/ft3)	Lin.Thk (inch)	Soil
1	SC1	12"	5S	12.75	0.156							S1
2												

#	Node	Type	DX (ft'in")	DY (ft'in")	DZ (ft'in")	Mat	Sect	Load	Data
1	Title = Buried Piping Sample								
2	10	From	200'0"	-20'0"	50'0"				Anchor
3	20	Bend	150'0"			C6	SC1	R	
4	30	Bend		10'0"		C6	SC1	R	
5	40		5'0"			C6	SC1	R	
6	50		15'0"			C6	SC1	R	Anchor
7									

Case 2: Piping Layout buried under different type of soils



In the Figure shown above, 12" Schedule STD piping is assumed to be buried under two type of soils "S1" and "S2" with Ground level as +3'0".

To represent this case, you need to define two section cards say "SC1" and "SC2" with their Nominal size as 12" and Schedule as "STD". Following this, define two soils "S1" and "S2" with their required properties and Ground level as +3'0". After defining the soils, tie the soil "S1" with "SC1" and "S2" with "SC2". Then in the layout define the Section as "SC1" for Elements from Node 10 through Node 40 and define the Section as "SC2" for Element between Node 40 and 50. When done, CAEPIPE will automatically compute the depth of soil above Nodes 10 through 50 as explained in Case 1.

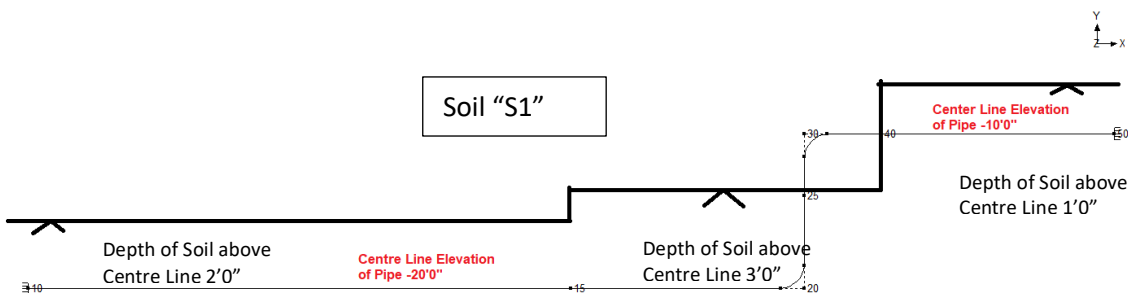
See the model SampleBuriedPiping_TwoSoils.mod for details.

#	Name	Type	Density (lb/ft3)	Strength (psi)	Delta (deg)	Ks	Ground Level (ft'in")	Include Ins. Thk	Depth of Soil (ft'in")
1	S1	Cohesive	150	100			3'0"	No	
2	S2	Cohesive	180	120			3'0"	No	

#	Name	Nom Dia	Sch	OD (inch)	Thk (inch)	Cor.Al (inch)	M.Tol (%)	Ins.Dens (lb/ft3)	Ins.Thk (inch)	Lin.Dens (lb/ft3)	Lin.Thk (inch)	Soil
1	SC1	12"	STD	12.75	0.375							S1
2	SC2	12"	STD	12.75	0.375							S2

#	Node	Type	DX (ft'in')	DY (ft'in')	DZ (ft'in')	Mat	Sect	Load	Data
1	Title = Buried Piping Sample								
2	10	From	200'0"	-20'0"	50'0"				Anchor
3	20	Bend	150'0"			C6	SC1	R	
4	30	Bend		10'0"		C6	SC1	R	
5	40		5'0"			C6	SC1	R	
6	50		150'0"			C6	SC2	R	Anchor
7									

Case 3: Depth of soil above pipe centre lines are varying for the stress layout



In the Figure shown above, 12" Schedule STD piping is assumed to be buried under same type of soil with depth of soil above centre line is varying for the stress layout as given above.

To represent this scenario in CAEPIPE follow the steps given below.

1. Define three (3) section cards "SC1", "SC2" and "SC3" with same Nominal Size as 12" and Schedule as STD.
2. Generate the layout as shown in the attached model "SampleBuriedPiping_StepSoils.mod".
3. From the Coordinate list of CAEPIPE (can be seen through Layout Window > View > List > Coordinate), calculate the Ground Level for Nodes 10 and 15. For this example, Ground Level is -18'0" (= Y Coordinate for Node 10 + Soil Depth = -20'0" + 2'0").
4. Follow Step 3 and calculate the Ground Levels above Nodes 20 and 40. For this example, it is -17'0" and -9'0" respectively.
5. Define three (3) soils "S1", "S2" and "S3" with Ground Levels as -18'0", 17'0" and -9'0" respectively and associate "S1" with "SC1", "S2" with "SC2" and "S3" with "SC3" as shown in the attached model "SampleBuriedPiping_StepSoils.mod".
6. Save the model and perform the analysis.

Caepipe : Soils (3) - [SampleBuriedPiping_StepSoils.mod (C...

File Edit View Options Misc Window Help

#	Name	Type	Density (lb/ft3)	Strength (psi)	Delta (deg)	Ks	Ground Level (ft'in')	Include Ins. Thk	Depth of Soil (ft'in')
1	S1	Cohesive	150	100			-18'0"	No	
2	S2	Cohesive	150	100			-17'0"	No	
3	S3	Cohesive	150	100			-9'0"	No	
4									

Caepipe : Pipe Sections (3) - [SampleBuriedPiping_StepSoils....

File Edit View Options Misc Window Help

#	Name	Nom Dia	Sch	OD (inch)	Thk (inch)	Cor.Al (inch)	M.Tol (%)	Ins.Dens (lb/ft3)	Ins.Thk (inch)	Lin.Dens (lb/ft3)	Lin.Thk (inch)	Soil
1	SC1	12"	STD	12.75	0.375							S1
2	SC2	12"	STD	12.75	0.375							S2
3	SC3	12"	STD	12.75	0.375							S3
4												

Caepipe : ...

File Edit View Options Misc Window Help

#	Node	X (ft'in')	Y (ft'in')	Z (ft'in')
1	10	200'0"	-20'0"	50'0"
2	15	335'0"	-20'0"	50'0"
3	20A	348'6"	-20'0"	50'0"
4	20	350'0"	-20'0"	50'0"
5	20B	350'0"	-18'6"	50'0"
6	25	350'0"	-14'0"	50'0"
7	30A	350'0"	-11'6"	50'0"
8	30	350'0"	-10'0"	50'0"
9	30B	351'6"	-10'0"	50'0"
10	40	355'0"	-10'0"	50'0"
11	50	370'0"	-10'0"	50'0"

Caepipe : Layout (8) - [SampleBuriedPiping_StepSoils.mod (C...

File Edit View Options Loads Misc Window Help

#	Node	Type	DX (ft'in')	DY (ft'in')	DZ (ft'in')	Matl	Sect	Load	Data
1	Title = Buried Piping Sample								
2	10	From	200'0"	-20'0"	50'0"				Anchor
3	15		135'0"			C6	SC1	R	
4	20	Bend	15'0"			C6	SC2	R	
5	25			6'0"		C6	SC2	R	
6	30	Bend		4'0"		C6	SC2	R	
7	40		5'0"			C6	SC3	R	

Caepipe : Pipe Sections (6) - [SampleBuriedPiping_SlopedSoi...

File Edit View Options Misc Window Help

#	Name	Nom Dia	Sch	OD (inch)	Thk (inch)	Cor.Al (inch)	M.Tol (%)	Ins.Dens (lb/ft3)	Ins.Thk (inch)	Lin.Dens (lb/ft3)	Lin.Thk (inch)	Soil
1	SC1	12"	STD	12.75	0.375							S1
2	SC2	12"	STD	12.75	0.375							S2
3	SC3	12"	STD	12.75	0.375							S3
4	SC4	12"	STD	12.75	0.375							S4
5	SC5	12"	STD	12.75	0.375							S5
6	SC6	12"	STD	12.75	0.375							S6
7												

Caepipe : Layout (27) - [SampleBuriedPiping_SlopedSoils.mo...

File Edit View Options Loads Misc Window Help

#	Node	Type	DX (ft'in')	DY (ft'in')	DZ (ft'in')	Mat	Sect	Load	Data
1	Title = Buried Piping Sample								
2	10	From	200'0"	-20'0"	50'0"				Anchor
3	20		15.5590	0.5763		C6	SC1	R	
4	30		15.3896	0.5700		C6	SC1	R	
5	40		15.6210	0.5786		C6	SC2	R	
6	50		15.5084	0.5744		C6	SC2	R	
7	60		15.6845	0.5809		C6	SC3	R	
8	70		15.7169	0.5821		C6	SC3	R	
9	80		15.7496	0.5833		C6	SC3	R	
10	90		15.7828	0'7"		C6	SC4	R	
11	100		9.7061	0.3595		C6	SC4	R	
12	110		2'1-1/2"			C6	SC4	R	
13	120		2'1-1/2"			C6	SC4	R	
14	130		2'1-1/2"			C6	SC4	R	

For all the Cases given above, CAEPIPE will compute internally the Soil stiffnesses in three directions (axial, transverse and vertical) and apply them ONLY at node points defined in the stress layout. For further details, see the Section titled "Buried Piping" in CAEPIPE Technical Reference manual. This manual and other three (3) manuals of CAEPIPE can be downloaded from the link www.sstusa.com/caepipe-docs.php.

As an example, from the sorted stress results for model "SampleBuriedPiping_StepSoils.mod", you will observe that the piping is overstressed in Sustained load case as CAEPIPE applies the soil stiffnesses in three directions only at nodes defined in the stress model.

Caepipe : B31.1 (2022) Code compliance (Sorted stress...

File Results View Options Window Help

#	Sustained				Expansion			
	Node	SL (psi)	SH (psi)	SL/SH	Node	SE (psi)	SA (psi)	SE/SA
1	10	29416	19885	1.48	30A	27603	42573	0.65
2	15	25914	19885	1.30	20B	22371	40743	0.55
3	20A	10524	19885	0.53	30B	16758	42679	0.39
4	20B	9961	19885	0.50	20A	11526	40168	0.29
5	25	8321	19885	0.42	40	6939	42498	0.16
6	40	8242	19885	0.41	25	5482	42417	0.13
7	30A	8169	19885	0.41	15	2496	30608	0.08
8	30B	8065	19885	0.41	10	2340	30608	0.08
9	50	7710	19885	0.39	50	2647	43042	0.06

So, it is important that you should discretize the long section of the straight pipe manually into smaller lengths to best simulate soil to pipe interaction by following the procedure given in Buried Piping Tutorial. Long straight pipe sections can be discretized automatically using the command “Layout Window > Edit > Refine Nodal Mesh.

By discretizing the long pipe sections into smaller lengths for model “SampleBuriedPiping_StepSoils.mod” by following the procedure given in Buried Piping tutorial, you will observe that the over stresses for Sustained case is resolved. See the model “SampleBuriedPiping_StepSoils_refined.mod” for details.

#	Sustained				Expansion			
	Node	SL (psi)	SH (psi)	SL/SH	Node	SE (psi)	SA (psi)	SE/SA
1	200	8034	19885	0.40	30A	26021	43091	0.60
2	10	8012	19885	0.40	20B	23801	43018	0.55
3	180	8009	19885	0.40	30B	18040	43079	0.42
4	160	8008	19885	0.40	20A	15809	43016	0.37
5	170	8007	19885	0.40	120	9163	43080	0.21
6	150	8004	19885	0.40	40	5774	42979	0.13
7	190	8000	19885	0.40	130	5239	43078	0.12
8	50	7958	19885	0.40	25	4657	43098	0.11
9	210	7905	19885	0.40	110	3981	43000	0.09
10	40	7771	19885	0.39	140	3683	43003	0.09
11	100	7765	19885	0.39	10	2721	42733	0.06
12	110	7751	19885	0.39	150	2721	42741	0.06
13	140	7748	19885	0.39	90	2686	43047	0.06

Lastly, using the “Soil restraints” results of CAEPIPE (can be seen through “Results Window > Results > Results...”) you can view the Stiffness and Loads of all the elements that are buried in soil(s).