Introduction.

In addition to the previous exercise, the elasto-plastic modelling of soil behaviour is now applied to the footing problem. This enables the calculation of a bearing capacity (failure load). Moreover, the exercise demonstrates the use of the load-displacement curves module.

Aims:

- Calculating a bearing capacity (failure load).
- Using the load-displacement curves module.

SCHEME OF OPERATIONS:

A) GEOMETRY INPUT

- Use previous input file
- Save as new data file
- **Use 15-noded elements <<NEW>>**
- Change material properties, (**Mohr-Coulomb** for clay) **<<NEW>>**
- Mesh generation

B) INITIAL CONDITION

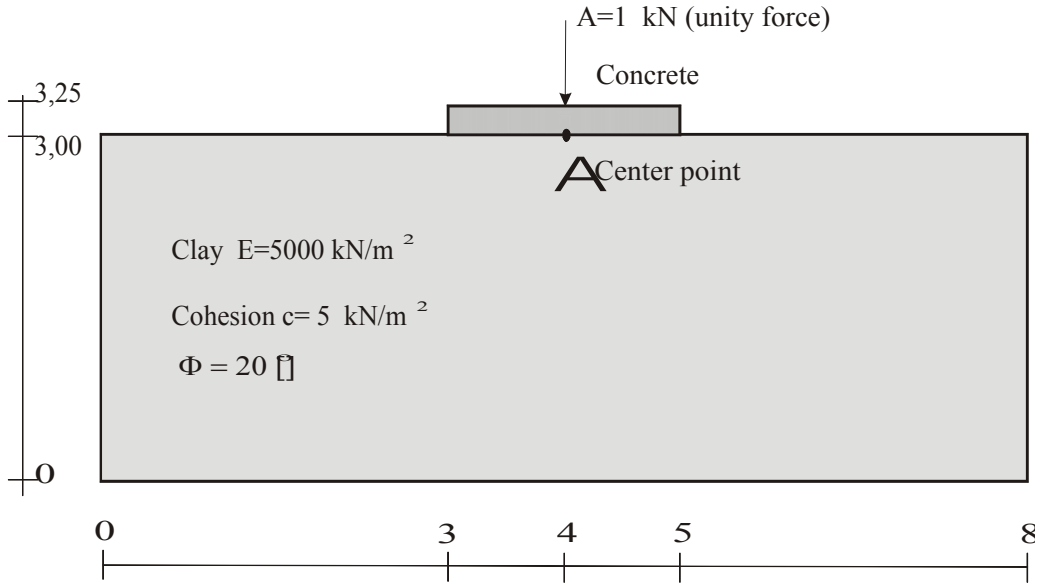
- (Re) generation of pore pressures
- (Re) generation of initial stresses

C) CALCULATIONS

- Define load displacement points **<<NEW>>**
- Re-define existing calculation phases
  - $ Construct footing
  - $ Apply vertical force

D) LOAD DISPLACEMENT CURVES

- Create load displacement curves. **<<NEW>>**



Only apply vertical (point) load A

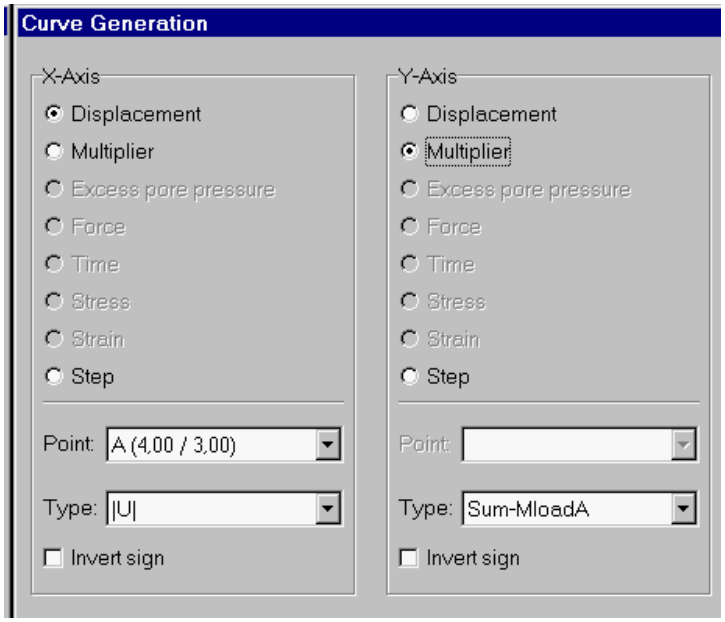
Parameter	Name	Clay	Concrete	Unit
Material model	Model	Mohr Coulomb	Linear elastic	-
Type of material behaviour	Type	Drained	Non-porous	-
Dry soil weight	γ_{dry}	16.0	24.0	KN/m^3
Wet soil weight	γ_{wet}	18.0	--	KN/m^3
Permeability in horizontal direction	k_x	0.0	--	m/day
Permeability in vertical direction	k_y	0.0	--	m/day
Youngs modulus (constant)	E_{ref}	5000	1.35e6	KN/m^2
Poisson's ratio	ν	0.35	0.35	-
Cohesion (constant)	c	5	-	KN/m^2
Friction angle (constant)	φ	20	-	°
Dilatancy angle	ψ	0	-	°

Material properties for exercise 2

- enter for the second calculation step an Ultimate level of 500 kN/m^2.

Load displacement curves

- Start the curves program by clicking on the Curves button.
- Create a New Curve and indicate the appropriate problem in the file requester
- The group box Curve Generator as indicated below will appear.



- In the combo box X-Axis Displacements of type |U| (absolute) should be selected

Questions:

- What is the failure load (bearing capacity of the footing) in **drained** conditions, see also last page for Vesic's solution.
  Note: The failure load is given by:

$$\frac{Q_u}{B} = \frac{\Sigma MloadA}{B} + \gamma_{concrete} * d = ...kN / m$$

- make a load-displacement curve using the x and y axis as shown above.

The same exercise could be done using undrained conditions of the clay.

- what is the failure load in undrained conditions?
- make a load-displacement curve using the x an y axis as shown above.

An analytical solution for this drained footing problem is given by Vesic:

$$\frac{Q_f}{B} = c'^{*} N_c + \frac{1}{2}\gamma'^{*} B * N_\gamma = \ldots\ldots kN / m$$

$$N_\gamma = 2(N_q + 1)\tan(\phi) = \ldots\ldots$$

$$\phi = 20 ==>> N_c = \ldots\ldots\ldots$$

With: c' the cohesion and ϕ' the angle of internal friction

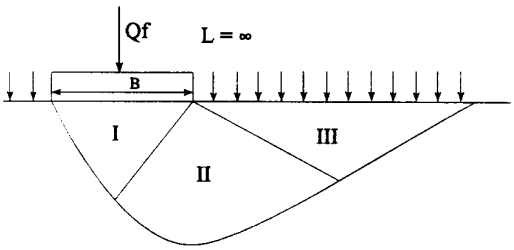


Table 3.1 BEARING CAPACITY FACTORS

φ	Nc	Nq	Nγ	Nq/Nc	tan φ
0	5.14	1.00	0.00	0.20	0.00
1	5.38	1.09	0.07	0.20	0.02
2	5.63	1.20	0.15	0.21	0.03
3	5.90	1.31	0.24	0.22	0.05
4	6.19	1.43	0.34	0.23	0.07
5	6.49	1.57	0.45	0.24	0.09
6	6.81	1.72	0.57	0.25	0.11
7	7.16	1.88	0.71	0.26	0.12
8	7.53	2.06	0.86	0.27	0.14
9	7.92	2.25	1.03	0.28	0.16
10	8.35	2.47	1.22	0.30	0.18
11	8.80	2.71	1.44	0.31	0.19
12	9.28	2.97	1.69	0.32	0.21
13	9.81	3.26	1.97	0.33	0.23
14	10.37	3.59	2.29	0.35	0.25
15	10.98	3.94	2.65	0.36	0.27
16	11.63	4.34	3.06	0.37	0.29
17	12.34	4.77	3.53	0.39	0.31
18	13.10	5.26	4.07	0.40	0.32
19	13.93	5.80	4.68	0.42	0.34
20	14.83	6.40	5.39	0.43	0.36
21	15.82	7.07	6.20	0.45	0.38
22	16.88	7.82	7.13	0.46	0.40
23	18.05	8.66	8.20	0.48	0.42
24	19.32	9.60	9.44	0.50	0.45
25	20.72	10.66	10.88	0.51	0.47
26	22.25	11.85	12.54	0.53	0.49
27	23.94	13.20	14.47	0.55	0.51
28	25.80	14.72	16.72	0.57	0.53
29	27.86	16.44	19.34	0.59	0.55
30	30.14	18.40	22.40	0.61	0.58