



**DakoSoftware**  
Spreadsheets for Structural Engineering

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# VALIDATION REPORT

SPREADSHEET "GE Subgrade spread footing"

Version 1.0

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# 1 VERIFICATION SPREADSHEET

This spread sheet can be used to make a rough estimate of settlement below an uniformly loaded plate. Verification has been done by carrying out FEM Calculations using the computer programme Plaxis.

## 1.1 Verification calculations

Assumptions:

- Plane strain: spread footing width 4 m, length 40 m
- Axisymmetric: circular footing diameter 4 m

Soil strata:

Layer	Name	Bottom	Thickness	$\gamma'$	Eoed	E50	E50;u
[-]	[-]	[m NAP]	[m]	[kN/m <sup>3</sup> ]	[Mpa]	[Mpa]	[Mpa]
1	E = 15	15	5.00	20	22.2	15.0	16.9
2	E = 5	5	10.00	15	7.4	5.0	5.6
3	E = 25	0	5.00	25	37.0	25.0	28.2

The spread footing is uniformly loaded by 100 kN/m<sup>2</sup>.

The following verification calculations have been carried out:

Plaxis 2D:

Plane strain of the strip footing B = 4 m

Axisymmetric for the circular footing D = 4 m

Plaxis 3D:

Rectangular footing B = 4 m, L = 40 m

Circular footing D = 4 m



## 1.2 Spread sheet calculations

The following models have been used:

Rectangular footing	Circular footing
Plaxis 2D plane strain	Plaxis 2D Axisymmetric
Plaxis 3D	Plaxis 3D
Rectangular 2:1	Westergaard
Strip 2:1, B = 4 m	Boussinesq, m = 3
Westergaard	Boussinesq, m = 5
Poulos & Davis	



Example graphic user interface spread sheet:

Settlement of footing on linear elastic soil

Input | Information

General Information

Consultant:

Project name:

Project number:

Description:

Name reference level:

Ground level (relative to ref. level):

Geometry

Rectangular      Width B [m]:

Strip                  Length L [m]:

Circular              Diameter D [m]:

Rigidity footing

Rigid     Flexible     Used defined

Elasticity modulus foundation [MPa]:

Elasticity modulus soil (z < 2B) [MPa]:

Thickness foundation [m]:

Soil

Neglect deformation below depth (z/B) [-]:

Poisson's ratio soil [-]:

Use E50

Convert to E50/undrained

Convert to Eoed

Loading

Point Load [kN/m1]:

Uniform load [kN/m2]:

Soil Profile

Layer no.	Layer name	Bottom	$\gamma'$ [kN/m3]	E50 [MPa]	$\epsilon_{v;E0}$ [%]	E0/E50	$\epsilon_{min}$ [%]	$\epsilon_{max}$ [%]
1.	zandcem.	28.3	20	50	0.1	3	0.07	0.23
2.	Zand1	25	10	18	0.1	3	0.27	0.44
3.	Zand2	18.5	10	36	0.1	3	0.05	0.07
4.	Zand3	15	10	72	0.1	3	0.02	0.02

Add layer

Remove layer

Help

Stress distribution models

2:1 v:h (strip)

2:1 v:h (rectangular)

Westergaard (rectangular)

Poulos & Davis (rectangular)

Westergaard (circular)

Boussinesq / Fröhlich (circular)

Stress concentration factor m\* (3 - 5)

Results

Settlement [m]      0.0207

kv [kN/m3]            12106

Update form      OK



Settlement of footing on linear elastic soil

Input Information

Information on model

This sheet calculates the elastic settlement below a spread footing. Basis of the model is the presence of Linear Elastic Soil.

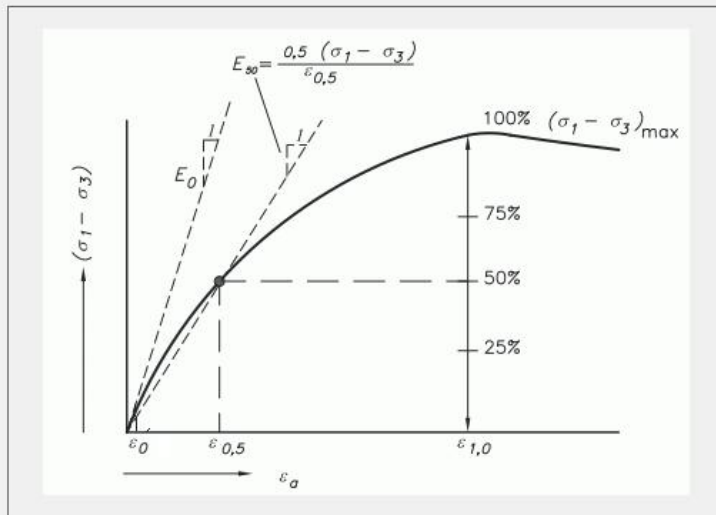
Different stress distribution models are available. Depending on the shape of the spread footing in x- and y-direction, one can choose from these available models.

In the design of spread footings, generally a sufficiently high safety factor on bearing capacity is present (e.g. 2 - 2.5). The use of an E50 Young's modulus therefore applies when loading up to 50% of the soil strength. For loads (much) smaller than 50% of the capacity, a (much) higher soil stiffness is applicable. To take into account this higher stiffness, the use of the E0 stiffness and associated maximum strain ( $\epsilon_{00}$ ) is incorporated.

The flexibility of the foundation is taken into account by using a flexibility factor. (Rigid: If = 1.0; flexible: If = 0.78) By default, only settlement below the center of the footing is calculated.

It should be noted that this sheet only gives an estimate of the elastic settlement. Effects such as consolidation and creep of impermeable soft sediments are not implemented.

Information on Elasticity Modulus



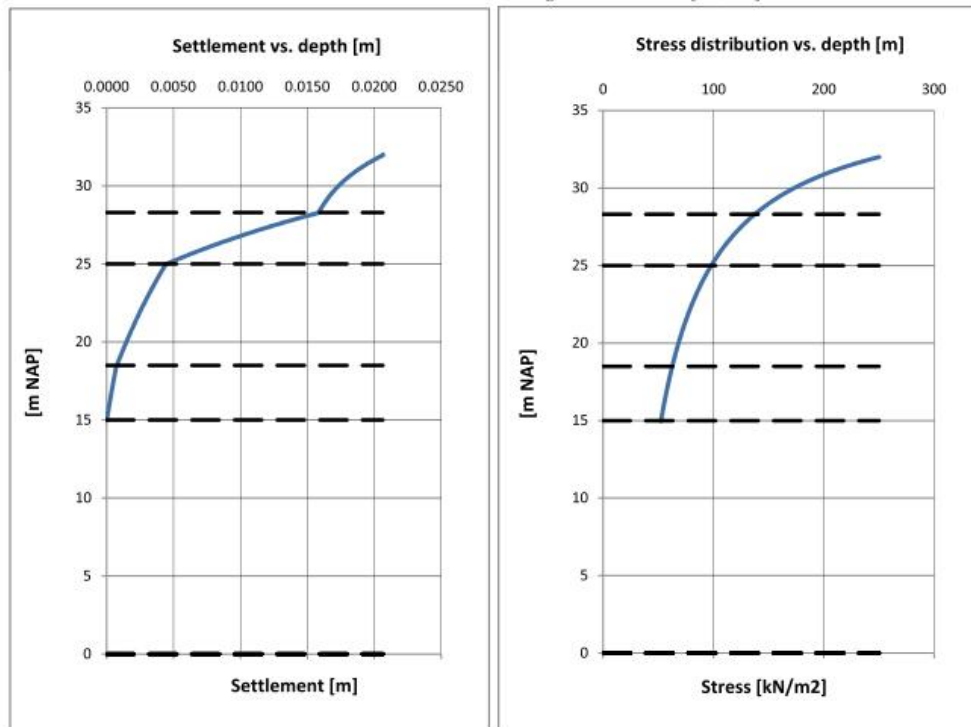


<b>Project name:</b> N.A.			
<b>Project number:</b> N.A.	<b>Part:</b> example calculation		
Engineer:	Rene Thijssen	Date:	28-11-2012
		Version:	

Calculation of elastic settlement below spread footing			
<b>Footing</b>		<b>Soil</b>	
Type of footing:	Strip	Neglect deformation below (z/B):	100 -
Width:	4.5 m	Poisson's ratio soil:	0.3 -
		Elasticity modulus:	E50 -
Flexibility:	Rigid	<b>Loading</b>	
Flexibility factor:	1 -	Uniform load:	250 kN/m2/m1
Groundlevel:	32 m NAP	Stress distribution model:	2:1 [v:h] distribution (

Layer	Name	Bottom	h	$\gamma'$	$E_{\text{oed}}$	$E_{50}$	$E_{50:10}$	$E_0/E_{50}$	$\epsilon_{s,\text{strain}}$	$\sigma_{s,\text{strain}}$	$\epsilon_{\text{min}}$	$\epsilon_{\text{max}}$	settlement	contrib.
[-]	[-]	[m NAP]	[m]	[kN/m3]	[Mpa]	[Mpa]	[Mpa]	[-]	[%]	[kN/m2]	[%]	[%]	[m]	[%]
1	zandcem.	28.3	3.70	20	67.3	50.0	57.7	3	0.1	150	0.07	0.23	0.0048	23%
2	Zand1	25	3.30	10	24.2	18.0	20.8	3	0.1	54	0.27	0.44	0.0114	55%
3	Zand2	18.5	6.50	10	48.5	36.0	41.5	3	0.1	108	0.05	0.07	0.0037	18%
4	Zand3	15	3.50	10	96.9	72.0	83.1	3	0.1	216	0.02	0.02	0.0007	4%

Total settlement: [m] 0.0207  
 Modulus of subgrade reaction kv: [kN/m3] 12106

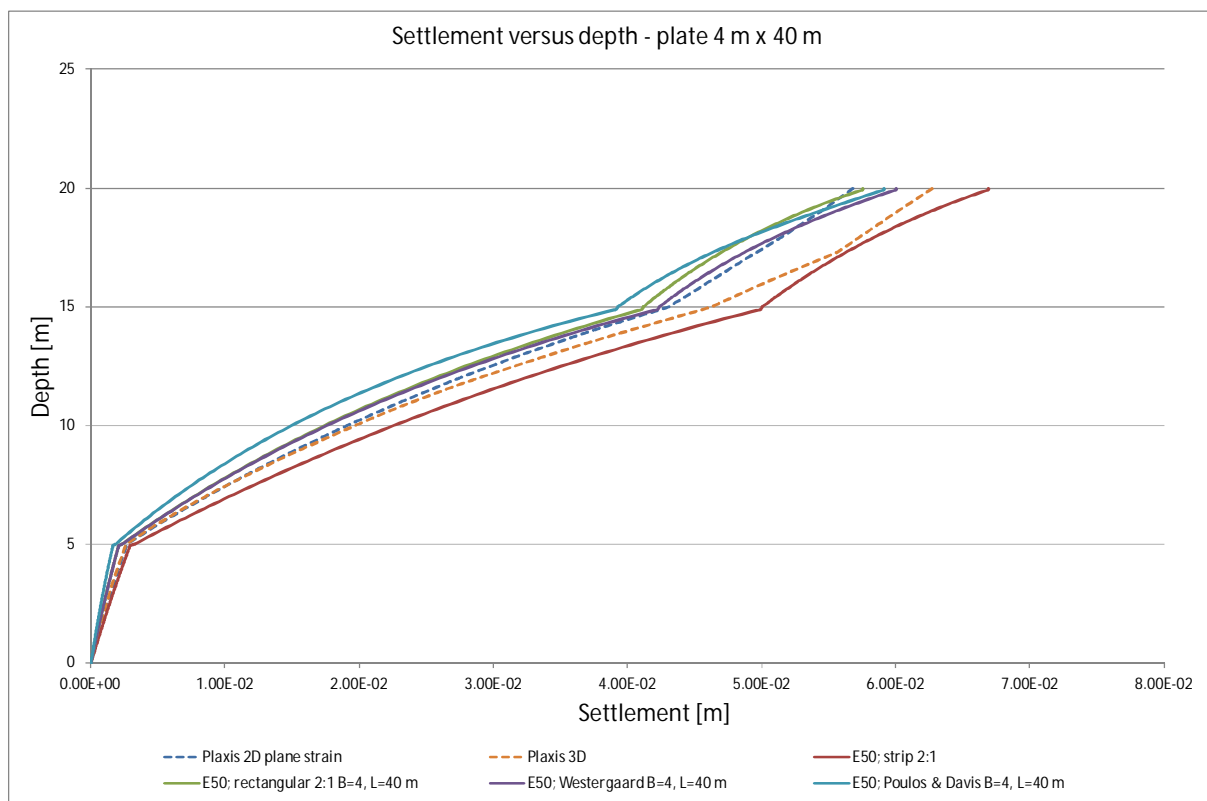




### 1.3 Summary results

#### Analyses of rectangular footing

The following diagram shows all calculation results combined.



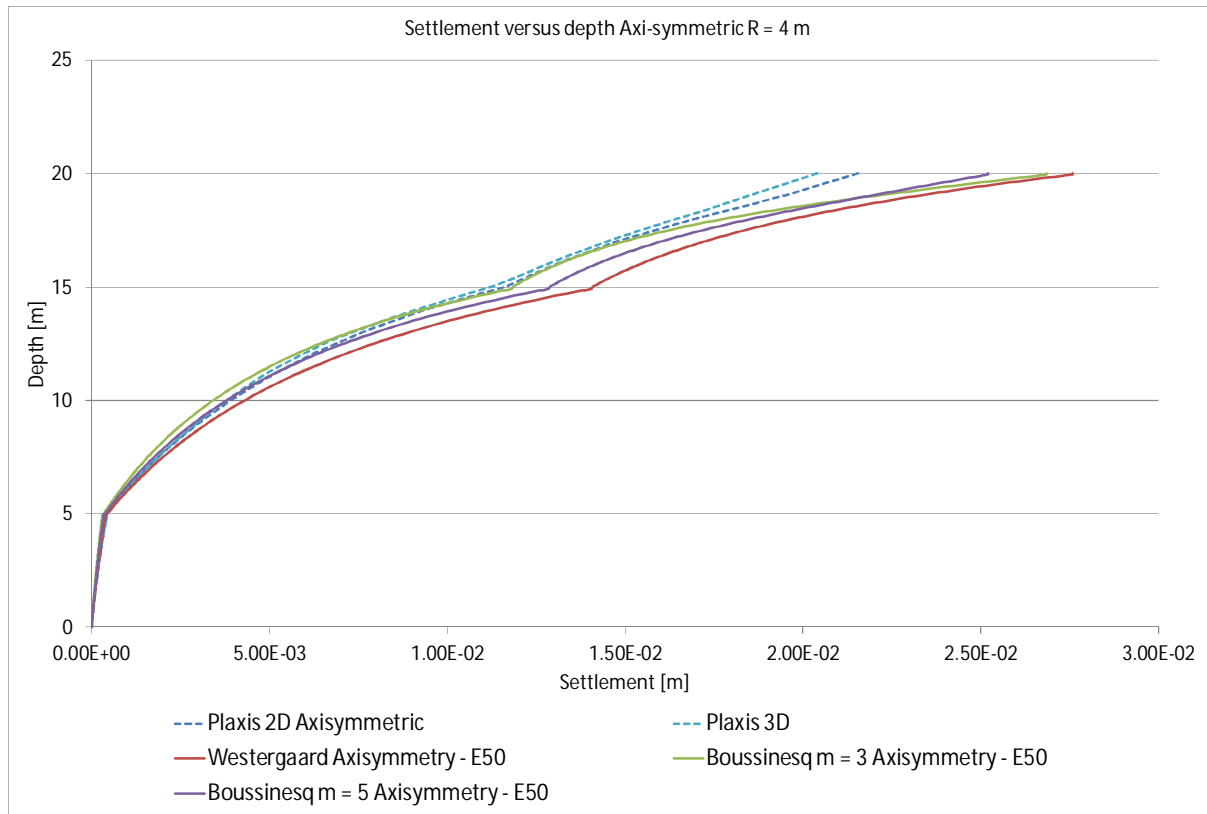
Model	Settlement footing
Rectangular 2:1	0.057 m
Strip 2:1, B = 4 m	0.067 m
Westergaard	0.060 m
Poulos & Davis	0.059 m
<i>Plaxis 2D plane strain</i>	<i>0.057 m</i>
<i>Plaxis 3D</i>	<i>0.063 m</i>

It can be seen that all models closely match at this scale.





### Analyses of circular footing



Model	Settlement footing
Westergaard	0.028 m
Boussinesq, m = 3	0.027 m
Boussinesq, m = 5	0.025 m
<i>Plaxis 2D Axisymmetric</i>	<i>0.022 m</i>
<i>Plaxis 3D</i>	<i>0.020 m</i>

It can be seen that Plaxis 2D and 3D give somewhat lower values for settlement than the other models. A rough estimate of settlements of a circular footing can however be properly assessed using the spreadsheet.



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