Landmarks in Earth Reinforcement, Ochiai et al. (eds),
© 2001 Swets & Zeitlinger, ISBN 90 2651 863 3

The settlements of a continuous foundation footing resting on the geogrid-reinforced sand layer

J. Adamczyk
P.B.P. "GEOSTAFF", Warsaw, Poland

T. Adamczyk
Warsaw University of Technology, Environmental Engineering Faculty, Poland

ABSTRACT: The paper presents the values of settlements for building founded on the geogrid-reinforced sand layer. The settlements of the continuous foundation were also determined at the similar load for the following conditions direct foundation on the silty loam subsoil, foundation resting on the non reinforced soil layer and foundation with several layers of geonet. The foundation resting on the soil layer shows the settlements several time lower when compared with the foundation resting directly on the silty loam subsoil.

1 INTRODUCTION

1.1 *Foundation conditions*

During modernization of the industrial plant the necessity has arisen to apply the continuous foundation footing directly into the silty loam subsoil. Existing machinery, equipment and installations made another method of walls foundation of the modernized object impossible. The width of the foundation footing was limited to 120 cm.

1.2 *Types of foundation footing taken into consideration*

The following methods of continuous foundation footing were taken under consideration:

- directly on silty loam subsoil,
- on the sand cushion,
- on the sand cushion reinforced with 4 layers of geonet.

The dimensions of the foundation footing cross-section: 120 cm x 40 cm.

The dimensions of the reinforcing geonet layers: width 360 cm, spacing 30 cm, thickness 0.26 cm.

The loads applied to the footing: p = 0.1 – 0.5 MPa.

For material parameters, see Table 1.

Table 1. Material parameters.

The subsoil of foundation	E [MPa]	ν	γ [kN/m^3]	C [kPa]	ϕ [°]
Silty loam	15	0.2	20	17	14
Light compacted sand	45	0.26	17.5	0	28
Medium compacted sand	80	0.26	18	0	28
Layer reinforced	150	0.25	14.2	30	30

2 SETTLEMENT OF FOUNDATION FOOTING

2.1 *Numerical model*

The calculations were peformed assuming the planar deflection concept using HYDRO-GEO software (Dłużewski, 1997). The method of finite elements was used in relation to deflections description.

The elasto-plastic model of the subsoil was adapted based on Culomb-Mohr plasticity conditions. The independent plastic flow law were applied assuming that materials within a plastic range of stress are un-compressible. In all numerical analyses six-noded triangular isoparametric elements were used of second stage shape functions. The settlement calculations were carried out for the foundation footing of the width 120 cm founded as follows:

a) directly on silty loam,
b) on sand cushion of modulus E = 45 MPa
c) on sand cushion of modulus E = 80 MPa
d) on sand cushion of modulus E = 45 MPa reinforced with 3 layers of geonet
e) on sand cushion of modulus E = 80 MPa reinforced with 3 layers of geonet
f) on sand cushion of modulus E = 45 MPa reinforced with 4 layers of geonet
g) on sand cushion of modulus E = 80 MPa reinforced with 4 layers of geonet.

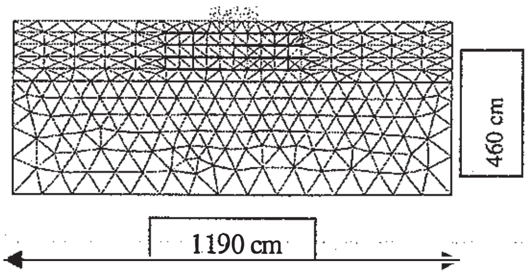

Figure 1. Finitte-element model.

2.2 *Foundation resting directly on silty loam subsoil*

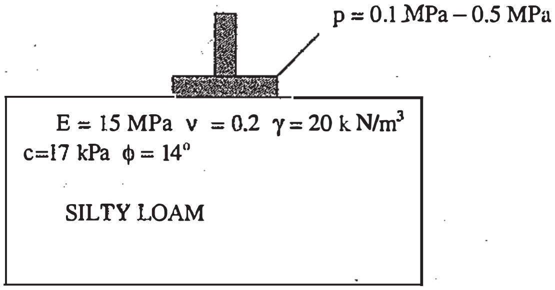

Figure 2. Direct foundation.

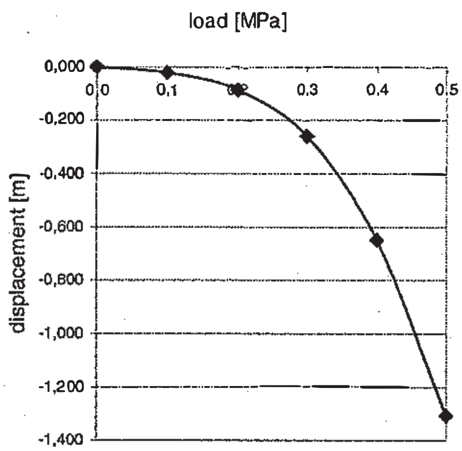

Figure 3. Settlemet of the foundation resting on loam (case a).

2.3 *Foundation resting on un-reinforced sand cushion*

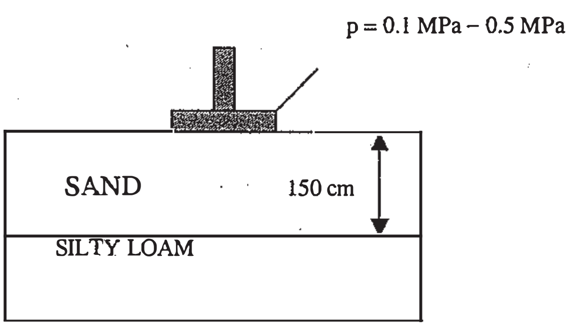

Figure 4. Settlement of foundation footing resting on un-reinforced sand cushion.

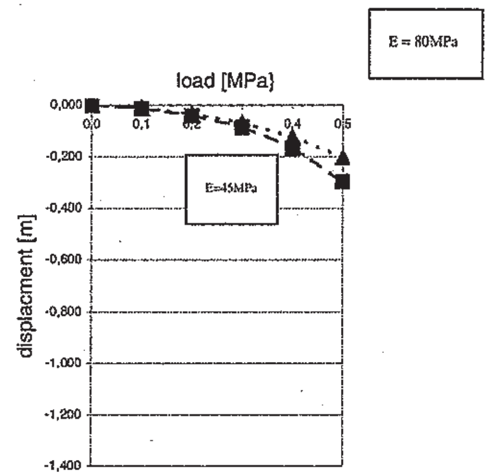

Figure 5. Settlement of a foundation footing resting on un-reinforced sand cushion.

The settlements were calculated for the foundation resting on sand cushion of 150 cm in thickness and 1190 cm in width. To variable densities of the cushion were taken into consideration.

2.4 *Foundation resting on reinforced sand cushion*

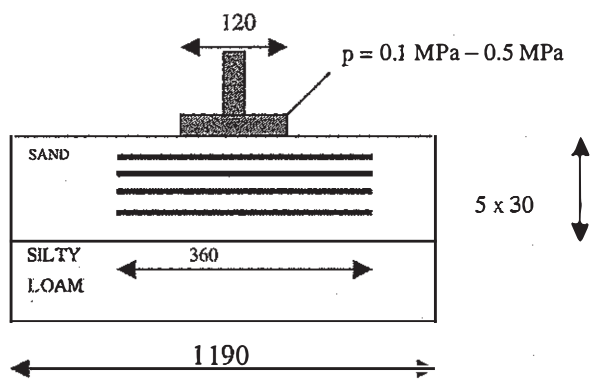

Figure 6. Foundation resting on a sand-cushion resting reinforced with 4 layers of geonet 30 cm apart.

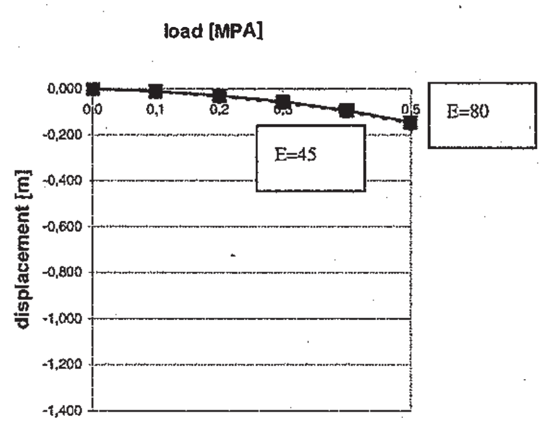

Figure 7. Settlement of foundation footing resting on sand cushion reinforced with 4 layers of geonet. (cases "g" and "f").

The results of settlements for different types of footing foundations are given in tables.

Table 2. Settlements of foundation resting directly on the subsoil.

Load [MPa]	Settlement S [cm]
0.1	-2.2
0.2	-8.5
0.3	-26.1
0.4	-84.9
0.5	-130.7

Table 3. Settlements of foundation resting on sand cushion.

Load [MPa]	Sand cushion modulus E = 45 MPa Settlement S [cm]	Sand cushion modulus E = 80 MPa Settlement S [cm]
0.1	-1.5	-1.2
0.2	-4.2	-3.4
0.3	-8.8	-6.9
0.4	-18.8	-12.3
0.5	-29.6	-20.3

Table 4. Settlements of foundation resting on sand cushion reinforced with 4 layers of geonet.

Load [Mpa]	Sand cushion modulus E = 45 MPa Settlement S [cm]	Sand cushion modulus E = 80 MPa Settlement S [cm]
0.1	-1.3	-1.1
0.2	-3.4	-3.0
0.3	-6.1	-5,7
0.4	-10.0	-9.5
0.5	-15.2	-14.6

Designed 120 cm wide continuous foundation footing is resting on silty loam subsoil. Usually for cohesive soils the maximum settlements are limited to 3% of the footing width. At the direct foundations the settlements are to be limited to slim = 3.6 cm (Brząkała and Hung Son, 2000). For the industrial plants foundations, due to the existing machinery and equipment, such high values of settlements can not be accepted.

Therefore, the maximum allowable settlement of 1% the footing width has been accepted slim = 1.2 cm. For such settlement value the foundation footing under consideration will be founded on the cushion of 150 cm in thickness, reinforced with 4 layers of geonet vertically spaced every 30 cm. The sand incorporated in the cushion will possess the modulus of elasticity above E ≥ 80 MPa. At this method of foundation the footing may transmit the load p = 0.1 MPa. Notwithstanding the application of sand cushion, the weak layer of silty loam underlying the cushion possess significant influence on a settlement values.

The computations completed show, that maximum effect of application the sand cushion exists when loads on foundation footing are p > 0.30 MPa. At these loads the difference between settlements calculated for the reinforced and un-reinforced cushion reaches few centimetres. At lower loads, those differences in settlements are ranging from 2 to 3 cm. A significant effect of the cushion application has the compressibility of the underlying soil layer. The silty loam existing beneath the designed footing made impossible to aplly the loads above 0.1 MPa. The calculations completed show, that insufficient compaction of sand in a cushion causes its additional settlement of about few millimetres, at the loads below p < 0.3 MPa and of few centimetres at loads above 0.3 MPa. The compaction of sand in the cushion has higher influence on settlements values of the un-reinforced cushion when compared to one reinforced with geonet.

3 CONCLUSIONS

- The application of sand cushion reinforced with 4 layers of geonet allowed the foundation of footing on soft silty loam subsoil.
- The compressibility of underlying subsoil exerts significant influence of a sand cushion application.
- Insufficient compaction of sand in a cushion exerts higher influence on the settlements values of an un-reinforced cushion than one reinforced with a geonet.

REFERENCES

Brząkała B. & Hung Son N., 2000. O poduszkach, poszewkach i materacach. XII National Conference of Soil Mechanics and Foundation Techniques, Szczecin–Międzyzdroje, Poland, May 2000.

Dłużewski M.J., 1997. Hydrogeo-program of finite elements for geotechnics and environmental engineering. Wydawnictwa Politechniki Warszawskiej, Poland Warsaw, 1997.