Development and investigation of the stressed-deformed state of the demountable foundation for support

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Abstract. The development is demountable foundation for support, including separate reinforced concrete blocks in the form of prisms mounted on the surface of the base and pulled together by horizontal strands, and anchor devices for fixing the supports. The reinforced concrete blocks are made in the form of hollow prisms consisting of walls and square bottoms, and the strands are made in the form of bolts that tighten the walls along the top and bottom, while the anchoring devices for fixing the supports are made in the form of anchors on the bottom of the central prism and horizontal spacers between the support and the walls of the prism in its upper part. Numerical studies of the foundation have been carried out and its optimal sizes have been found in the PK Lira SAPR.

The invention relates to the field of construction, namely, to demountable foundations of poles for lightning, cell tower equipment, billboards and etc.

It is known the foundations for support, for example, billboards (see RF Patent No. 2243596. MPK G09F15/00, bulletin No. 36 dated December 27, 2004). The well-known foundation is installed in an open trench and is made in the form of a monolithic or prefabricated reinforced concrete plate with anchor bolts to fix the base of pole [1].

The disadvantage of the foundation is the large transport dimensions, which makes it difficult to transport and install.

It is known a different foundation for lightning pole, including a demountable reinforced concrete plate with anchor bolts for fixing the base of the pole. The foundation is installed directly on the surface of the base (www.kaal.nl, kaal master more than masts).

The disadvantage of the foundation for the pole is its large dimensions, with a high support height and weak bases. Large dimensions make it difficult to transport and install.

The closest to the invention is the demountable foundation (Fig. 1), which includes separate reinforced concrete blocks in the form of rectangular prisms mounted on the surface of the base and pulled through in two directions through horizontal strands, while a part of the blocks is provided with anchor devices for fixing the support in the form of bolts, protruding beyond the surface of the upper facet of reinforced concrete blocks (www.cellblocksinc.com)
The disadvantage of the known solution of the demountable foundation is a large mass during transportation and installation, the difficulty in installing end-to-end long strands and the large costs of anchoring devices for supporting the support.

The purpose of the invention is to reduce the transport and installation weight of the units, simplify the installation of cords and reduce the cost of anchoring devices for supporting the supports.

The goal of the invention is achieved by the fact that in a demountable foundation for a support including separate reinforced concrete blocks in the form of prisms mounted on the surface of the base and pulled together by horizontal strands, and anchoring devices for fixing the supports, reinforced concrete blocks are made in the form of hollow prisms consisting of the walls and square bottoms, and strands are formed as bolts, tightening the wall over the top and bottom, thus, anchoring devices for faixing the supports are in the form of anchors at the bottom of the central prism and horizontal spacers between the support and the prism walls at an upper its part.
Fig. 2. The proposed demountable foundation of ballast type.

Fig. 1 shows a general view of demountable foundation under support; Fig. 2 shows a top view of the demountable foundation section 1-1 on Fig. 1; Fig. 1.3 shows a section 2-2 on Fig. 2; Fig. 4 shows the axonometry of a reinforced concrete block in the form of a hollow square prism with the dimensions of the bottom "a".

The demountable foundation for support includes reinforced concrete blocks in the form of hollow square prisms 1, with holes 2 for bolts 3. The support 4 is fixed by the base with anchor bolts 5 on the bottom of the hollow prism, and in the upper part by horizontal spacers 6 between the support and the walls.

The demountable foundation under the support is realized as follows: the reinforced concrete blocks in the form of hollow square prisms 1 are installed on the base and are tightened together by bolts 3 installed in the holes 2 in the walls of the prisms. The support 4 is mounted on the bottom of the central prism and fixed with anchor bolts 5, and at the top of the prism by spacers 6. To increase the load-bearing capacity of the foundation for overturning, the cavity of the prisms is filled with loose inert material, for example, crushed stone. The foundation is dismantled in the reverse order. First, crushed stone 7 is removed from the prism cavities, then spacers 6 and anchor bolts 5 of the support are released. After dismantling the support 4, the bolts 3, which tighten the prism walls, are released.

**Stress - deformed state of the foundation**

The calculation was carried out in the software package "Lira-SAPR". The design scheme of the building is a spatial finite-element model "foundation - ground base", consisting of voluminous 6 and 8 nodal physically nonlinear soil elements, volumetric 6 and 8 nodal linear elements simulating a reinforced concrete foundation, and core elements of one-sided elastic bonds modeling the boundary layer of supporting the foundation on the ground. To ensure the possibility of applying external loads to the foundation block located in the center, embedded parts are conventionally adopted in the form of cores with rigidity much greater than the stiffness of the elements of the main scheme. The connection of the embedded parts and the surfaces of the foundation block is made using absolutely rigid bodies [4].

Sand is used as soil. A class of concrete foundation is adopted B25. The characteristics of the finite elements are shown in Table. 1.

| № п/п | Name | Characteristics | KE soil | KE foundation | KE One way communication by Z |
|-------|------|-----------------|---------|---------------|-----------------------------|
| 1     | Type KE | 271 - 274 | 34, 36 | 262 |
| 2     | E0, MPa | 10 | 30000 | - |
| 3     | v     | 0.3 | 0.2 | - |
| 4     | ρ, t/m² | 1.6 | 2.5 | - |
| 5     | σ^max, MPa | 0.001 | - | - |
| 6     | σ^min, MPa | -0.05 | - | - |

Table 1

**Physical and mechanical characteristics of finite elements**
Two variants of models consisting of 9 and 25 cells of foundation blocks are considered.

**Method of computer modeling**

The models are calculated in a physically nonlinear formulation. The following parameters have been adopted as the main variable parameters: bending moment value $M$ (5 tm, 7.5 tm and 10 tm), backfilling density $\rho$ (1000 kg / m$^3$, 1300 kg / m$^3$ and 1600 kg / m$^3$). Two consecutive downloads are accepted: loading 1 - vertical loads including own weight of foundation, backfill, loading 2 - bending moment. Each download was included 3 equal steps of the load application. The calculation scheme of the foundation and the scheme for applying loads are shown on Fig. 3.

**Results of computer modeling**

The main results of computer modeling are taken in accordance with Fig. 4 and are presented in Table 2.

| № / \ | The magnitude of the moment original/actual M, tm | Back fill densit y, t/m$^3$ | Results | Note |
|---|---|---|---|---|
| | | | Stress in the ground, MPa | Displacement, mm | Medium stress in concrete, MPa |
| | | | $R_1$ | $R_2$ | $a$, mm | $dz_2$ | $dz_1$ | $dx$ | $N_1$ | $N_3$ |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Foundation 3x3 | | | | | | | | | | | |
| 1 | 1 | 1.6 | -0.009 | 0.00 | 3 | 0 | -1.82 | -3.1 | -0.05 | 0.44 | -0.53 | Reinforcement is not |
|    |    |    |     |     |     |     |     | Reinforcement required |    |
|----|----|----|-----|-----|-----|-----|-----|-------------------------|----|
| 2  | 3.5| 1.6| -0.04| 0.00| 51 | -0.94| -6 | -1 | 1.5 | -1.3 |
| 3  | 3.5| 1.3| -0.039| 0.00| 60| -0.71| -5.57 | -0.93 | 1.5 | -1.3 |
| 4  | 3.5| 1.0| -0.04| 0.00| 75| -0.51| -5.53 | -0.94 | 1.49 | -1.32 |
| 5  | 5 / 3.3| 1.6| -0.045| 0.00| 60| -0.83| -6.8 | -1.5 | 1.69 | -1.45 |
| 6  | 7.5 / 2.5| 1.6| -0.034| 0.00| 30| -1.12| -4.8 | -0.55 | 1.6 | -1.67 |
| 7  | 10 / 3| 1.6| -0.1| 0.00| 17| +300 | 0 | -166 | 41 | 5.2 | -2 |

Foundation 5x5

|    |    |    |     |     |     |     |     | Reinforcement required |    |
|----|----|----|-----|-----|-----|-----|-----|-------------------------|----|
| 7  | 5  | 1.6| -0.027| 0.00| 0  | -1.45| -3.6 | -0.1 | 2.65 | -1.05 |
| 8  | 7.5| 1.6| -0.03| 0.00| 16| -1   | -4.31| -0.3 | 4.11 | -1.53 |
| 9  | 10 | 1.6| -0.037| 0.00| 54| -0.67| -5.4 | -0.8 | 5.56 | -2.01 |

Note.
1. Destruction occurs on the ground.
2. The value dz with the sign "-" corresponds to the downward movement, dx with the sign "-" corresponds to the movement to the left.
3. The stress values with the sign "-" correspond to compression.
4. For concrete, the mean values of the principal stresses are indicated.
Fig. 5 The general view of foundation 3x3m model

Fig. 6 Mosaic of main stresses N1, N3 in the ground
Fig. 7 The isopy of displacements along Z(G)

Fig. 8 Force N in the boundary layer

Fig. 9 Mosaic of the main stresses N3 in the foundation concrete
Conclusion:

1. The proposed new demontable foundation allows to reduce its weight during transportation and installation, as well as to reduce the consumption of materials and labor for fixing reinforced concrete prism blocks and supports.

2. Numerical studies have made it possible to obtain an actual stressed-deformed state of the foundation and soil. On the basis of this, the base dimensions of 3x3m and 5x5m were obtained for the support of the power transmission line.

References

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