Design on soil-nailing wall Supporting of Foundation Pit in Bao Tou

Yingzi Yin [1, a] , Ya-li Xu [1,b]

[1]The school of architecture and civil engineering, Inner Mongolia University Of Science & Technology, Baotou 014010, China

[a]811489571@qq.com

[b]1050277615@qq.com

Keywords:deep foundation pit; soil-nailing wall; design; check

Abstract: According to the surrounding environment condition, the rock engineering site condition and the excavation depth, soil-nailing wall as its main form combining with the practical engineering case.the paper introduces the characteristics of the engineering and design soil-nailing wall excavation and check anti-bump and anti-overturning.to meets project requirements.

Soil nailing wall retaining structure are widely used in soil nailing construction because of simple construction, high construction efficiency, flexible, light structure, low engineering cost. For the calculation of soil nail, the typical specification method is the construction of foundation pit supporting technology regulation method[1]and the regulations of technology of soil nailing supporting of foundation pit[2],but the calculation method is not the same .There are some research methods calculate soil nail force and displacement[3-4].Finite element numerical analysis is also useful, but it is more complex and inconvenience promotion in terms of engineering practicability. This paper uses the construction of foundation pit supporting technology[1]to meet the engineering requirements. It provide a reference for similar project.

Project Summary

Proposed site is located in the north of the west of the east river road at bao tou . The side of the building has leisure square and commercial shop and underground garage on the north and south of village .The excavation depth is11 meters .

Engineering geology

According to the geological survey report, the soil is divided into miscellaneous fill,collapsible loess, silt, coarse sand. The physical and mechanical indexes of soil are shown in table 1.

Table 1 Physical and mechanical properties of soils

Layer	soil type name	Layer thickness(m)	Severe(kN/m^3)	cohesive force(kPa)	Angle of internal friction(°)
1	miscellaneous fill	2.60	16.0	5.0	15.0
2	collapsible loess	3.40	16.1	13.1	22.0
3	scoarse sand	1.40	19.0	0.0	40.0
4	silt	9.10	18.9	13.9	22.0

edetermination of supporting schemes

According to the construction of foundation pit supporting technology regulations (JGJ120-2012)[1],the engineering safety set the secondary level.Considering the surrounding area is smooth and the soil quality is good, no buildings around,soil nailing can meet the requirements, but we will strictly control the deformation of foundation pit.

the calculation of soil nailing

Calculate of soil nailing

According to the engineering geology and the surrounding environment, the foundation pit engineering arrange7 soil nail.Index of soil nailing are shown in table 2 .

calculation of earth pressure

The earth pressure calculation method is the Rankine's earth pressure theory of foundation pit supporting technology regulation.The lateral earth pressure of graphics is the triangular distribution, the soil pressure distribution pattern of soil nail length increases with the increase of the depth of foundation pit.

Coefficient of earth pressure: Ka=tan2（45°-φ/2) (1)

Intensity of soil nail force： $E = (q + gh_i) - 2c\sqrt{Ka}$ (2)

In the formula:q-ground overload r_i-i row of soil nailing in severe soil layer soil

h_i-i row of soil nail distance on the surface of the side slope distance

Kai-i row of soil nailing in the active earth pressure coefficient of soil layer soil

Table2 Design parameters of soil-nail

number of soil nail	Vertical distance (m)	horizontal spacing distance(m)	horizontal angle(°)	Soil nail aperture(mm)
1	1.5	1.5	10	110
2	1.5	1.5	10	110
3	1.5	1.5	10	110
4	1.5	1.5	10	110
5	1.5	1.5	10	110
6	1.5	1.5	10	110
7	1.5	1.5	10	110

calculate of tensile load standard value

In accordance with the provisions of slope of soil nail wall, so it need put on slope soil pressure reduction. This project adopts the single-stage slope soil nail wall. In accordance with the relevant provisions, single soil nail tensile load standard values can be pressed. $T_{jk} = \frac{xe_{ajk} s_{xj} s_{yj}}{\cos a_j}$ (3)

In the formula:T_{jk} - tensile load standard values of the j root soil nail ξ- load reduction factor

E_{ajk} - j root soil nail location of foundation pit horizontal load standard values

S_{xj}, S_{yj} -horizontal and vertical spacing of the j root soil nail and soil nailing adjacen

α_j - angle of the soil nailing with horizontal plane

β - soil nail wall slope and the horizontal plane angle φ_k -angle of internal friction values

The first layer of soil:miscellaneous fill(2.6m),β=63.4°, J_k = 15°,ξ1=0.554

The second layer of soil:collapsible loess（2.6m-6.0m),β=63.4°,φk=22°,ξ2=0.485

Similarly,ξ3=0.276,ξ4=0.485

Therefore, the above results are shown in table 3.

length of soil nail design

Length of soil nail design is directly related to the safety of the foundation pit slope stability, it is also the important factors that affect the project cost. Length of soil nail Divided into anchorage length and free length.

anchorage length: $l_{bi} = T_i g_s / p d_i t_i$ (4)

In the formula:r_s - bearing capacity of soil nail tensile subentry coefficient, it takes 1.6

d_i-solid diameter of root soil nailing anchor , it takes 110 mm

t_i-soil nail through the layer of soil with anchor solid limit friction resistance standard

free length：

$$l_{ai} = \frac{(h-h_i)\left[\tan(90°-\frac{b+f_k}{2})\right]}{\sin(180°-f_k-\frac{b+f_k}{2})}\sin(180°-\frac{b+f_k}{2}) \quad (5)$$

In the formula:β-soil nail wall slope and the horizontal plane angle

φ_k-angle of internal friction values h-the depth of foundation pit excavation

h_i- the height of the top layer of soil nail

Length of soil nail: $l_{bi} = T_i g_s / p d_i t_i$ (6)

Table3The calculation results of soil parameters

The number of soil nail	Earth pressure （KN)	Reduction factor	Tensile load standard values (KPa)	Length of soil nail (m)
1	14.43	0.554	18.26	5.8
2	9.45	0.485	10.47	5.4
3	20.42	0.485	22.62	5.7
4	31.38	0.485	35.28	4.6
5	33.61	0.276	21.19	6.6
6	64.08	0.485	70.99	8.8
7	76.95	0.485	85.30	6.4

Observation point

Figure 2 Observation point of foundation

Stability checking

The anti slip

According to the Specification for supporting technology building foundation pit[1],the anti sliding stability safety factor of soil nailing wall should satisfy this condition:Ks>1.3.The anti slip stability of foundation pit slope checking should be pressed type: $K_k = F_t / E_a$ (7)

In the formula:K_k-The safety factor of anti sliding F_t-Anti sliding force on the wall bottom section Ea -Wall active soil pressure

The anti sliding force on the wall bottom section is: $F_t = (B \cdot S_h \cdot H \cdot g + B \cdot S_h \cdot q)\tan j + cBS_h$ (8)

The wall active soil pressure of unit width is: $E_a = qHK_a + 1/2gH^2K_a - 2c\sqrt{K_a} + 2c^2/g$ (9)

In the formula:B—Wall width,B=11/12LCOSα c—Each layer cohesion weighted average

S_h—Average space of soil nail H—Vertical height of foundation pit

γ—soil severe q—Top overload value of foundation pit

φ—Weighted average value of friction angle in each layer

K_a—Coefficient of active earth pressure

So:Ft=942.305,Ea=384.39,K_k=F_t/Ea=2.45≥1.3,Meet anti sliding checking.

The Anti overturning

According to the Specification for supporting technology building foundation pit[1],the anti sliding stability safety factor of soil nailing wall should satisfy this condition:Ks>1.3.The anti overturning of foundation pit slope checking should be pressed type: $K_q = \frac{M_w}{M_o} \geq 1.5$ (10)

In the formula:, $M_w = 1/2B(B \cdot S_h \cdot H \cdot g + B \cdot S_h \cdot q)$ $M_o = \frac{1}{2} H \cdot E_a$ (11)

M_w=5306.05,M_o=2114.16,K_q=M_w/M_o=2.51≥1.5,Meet anti overturning checking.

Through calculation and analysis,the soil nailing wall internaland external stability could meet the design requirements.

Foundation pit monitoring

According to the relevant regulations and requirements of design[5],Combined with the specific circumstances of the project, the monitoring scheme is as follows: in the surface layer of the top surface (pit apron) buried observation point, distance of about 20 meters.In the foundation pit top embedment length is about 150mm with a steel tape, steel tape fixed by cement mortar, as shown in Figure 2.

In the reference point on both sides of angle displacement observation of foundation pit, to ensure the two basis point visibility line through all of the observation point.The foundation pit monitoring content of this project is mainly on the top layer displacement monitoring, monitoring results show:The maximum horizontal displacement of foundation pit side slope is 11.4mm, far less than 0.3%H (H is the excavation depth and the maximum displacement monitoring value).

Conclusion

(1)Through the design and calculation of soil nailing support scheme, checking the anti sliding coefficient, anti overturning are respectively 2.45,2.51,both to meet the safety requirements, meet the needs of engineering.

(2)The monitoring results show that the maximum horizontal displacement of foundation pit slope, the slope of 11.4mm specification,no obvious cracks, shows that the soil nailing system.

(3)The construction of foundation pit with soil nailing,effectively control the deformation of foundation pit, and achieved good results.

References:

[1]The national standard of the people's Republic of China.JGJ120-2012 Specification for supporting technology building foundation pit[S].China Building Industry Press,2012.In Chinese.

[2]The national standard of the people's Republic of China.JGJ120-2012 Technical specification for retaining and protection of foundation pit soil nail[S].China Building Industry Press,2012.In Chinese.

[3]Hongxian Guo,Erxiang Song,Zhaoyuan Chen.Analysis of the axial forces of soil nails during construction[J].Journal of Civil Engineering,2007,20(11).In Chinese.

[4]Zhikun Guo,Jingdong Yang,Shuguang Ma.Incremental calculation method of soil nails internal force[J].Journal of PLA University of Science and Technology (NATURAL SCIENCE EDITION),2005,6(4).In Chinese.

[5]Junyan Guo.GB50497- 2009Manual implementation of technical code for monitoring of building foundation pit engineering[S].Building Industry Press,2010.In Chinese.