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A CASE HISTORY OF GROUND TREATMENT FOR A POWER STATION IN CHINA

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ABSTRACT

This paper presents a case history of ground treatment for a large power station —— Zhang Ze Power Station, which locates in the south -east region in Shanxi, P R China. In the second phase of this project, a comprehensive treatment program including pile foundation, dynamic consolidation, and natural foundation has been used successfully according to significance of structure, conditions of loading, characters of technology, and so on. After 6 years working, the Station operates normally, and settlements of structures distribute well, proving the program is reasonable, workable, and economic. It is suggested that the choice of foundation treatment in a large project must consider comprehensively various factors, such as sorts of structure, types of loading, and geology in site, cost of construction, environment of site, etc.

KEYWORDS

Different settlement, Ground treatment, Pile foundation, Dynamic consolidation.

GEOLOGICAL CONDITIONS

Zhang Ze Power Station is one of the largest power stations in China. Now its total electric energy production is 1040MW. The first phase of the project completed in 1985, 2x100MW installed capacity. In the second phase of project, generating sets were imported from Russia, 4x210MW installed capacity. The second phase of project has a larger generating units, higher capacity, in turn, heavier loading, and more strictly requirement of bearing capacity and deformation of soil than first phase. Thus this paper mainly presents and discusses the ground treatment program in second phase of Zhang Ze Project.

Zhang Ze Power Station locates in the south-east region of Shanxi Province, P R China. The topography of the site is flat, ground water level is - 4.8m, ground level is about 920.0m. In the range of exploration, the soil can be mainly divided into three stratums as follows:

Stratum I, loessial silty clay; about 4.0m of thickness; medium compressibility, average coefficient of collapsibility $\delta_s = 0.0479$, belongs self-weight non-collapse loess grand I, according to 《Chinese Loess Foundation Standard》.

Stratum II, loessial silty clay; about 13.0m of thickness, medium compressibility, plastic, non-collapsible. It can be divided into 3 substratums, amount which, stratum II-3 is the main part, about 8.4m of thickness.

Stratum III, sandwich of silty clay and clay; about 35.0m of thickness; low to medium compressibility, non-collapsible, this is second bench of Zhang He River. It can be divided into 5 substratums. Most of the soil in this stratum is in hard

Table 1 Indexes of Mechanical and Physical Characteristics of soil

Stratum	Name	Water Content (%)	Unit Weight (KN/m^3)	Void Ratio e	Modules Comp. (MPa)	Cohesion C (MPa)	Angle of Friction (ϕ) (^{0})	Plastic Index I_p	Liquid Index I_l
I	Loessial silty clay	23.9	18.7	0.805	7.82	47.6	18.4	12.7	0.123
II-1	Loessial silty clay	26.5	19.2	0.789	6.81	54.9	20.0	13.2	0.299
II-2	Loessial silty clay	31.5	18.9	0.89	7.92	32.1	21.1	12.4	0.774
II-3	Loessial silty clay	28.3	19.4	0.799	10.65	46.8	22.8	13.1	0.419
III-1	Loessial clay	30.8	19.3	0.867	15.08	75.3	16.9	20.8	0.205
III-2	Loessial silty clay	30.7	19.2	0.855	12.62	31.3	22.1	14.6	0.484
III-3	Loessial clay	28.6	19.7	0.794	15.28	125.9	18.2	20.2	0.115
III-4	Loessial silty clay	26.0	20.2	0.71	15.19	36.6	29.0	15.9	0.188
III-5	Loessial clay	23.4	20.4	0.685	22.5			19.2	-0.01

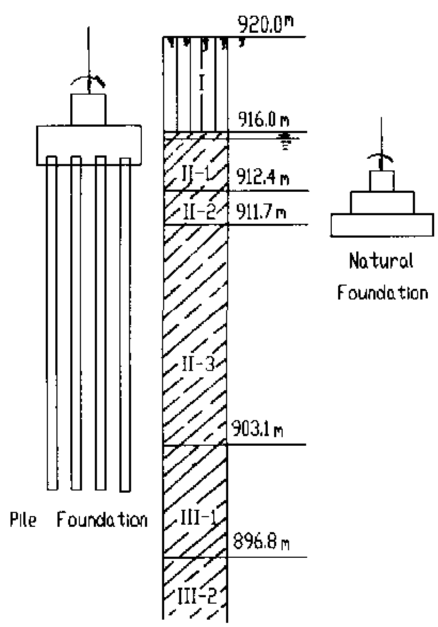

Fig. 1 Geological Columnar Section

state, see Table 1 and Fig. 1.

DESIGNING CONDITIONS

Second phase of Zhang Ze Power Station project was built after first phase of the project, thus it has some special requirements for designing. Mainly, they can be drawn out as following:

1. In order to ensure the cooperation well of new and old structures, the different settlement between two phases should be limited. Structures in second phase of project would be built and connected to the rebuilding end of first phase of the project, see Fig.2. The main workshops for both phases of project would be joined together. The equipment and technology would be shared. Therefore, it becomes the key point to be considered in designing how to reduce the different settlement between two phases of project to make them work smoothly.

2. The second phase of the project has larger capacity (4x210MW), heavier set weight, and heavier loading as well as stricter requirement for foundation deformation than the first phase. Thus it demands more strictly bearing capacity and settlement of soil. In addition, the constructing period is limited.

3. The collapsibility of loess should be removed even for light or auxiliary constructions.

4. Constructing of new structures can not affect normal operations of existing structures.

PROGRAM OF GROUND TREATMENT

Overview of Ground Treatment in First Phase of Project

Both of dynamic consolidation and replacement method have

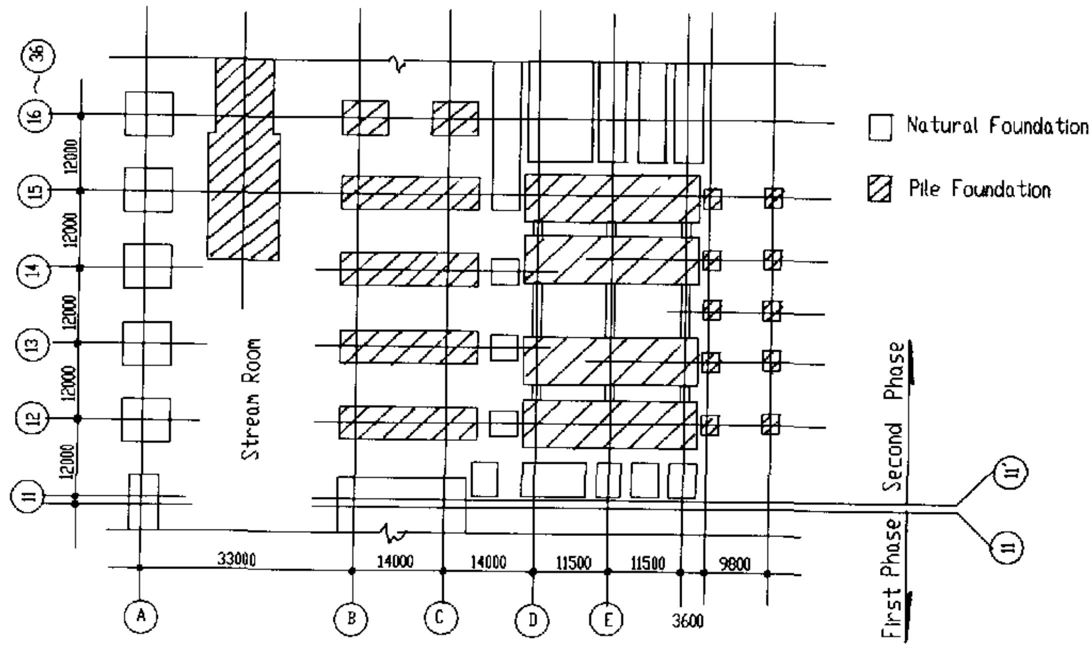

Fig. 2 Layout of Foundations of Main Workshop

been adopted in first phase of the project. For dynamic consolidation, the compacting energy was 3000 KN-m,compacted from 4 m below the ground level. Since it was rain season during constructing and the water content was higher, efficiency of compacting would not be very good, so gravel was used to fill into the pit in order to accelerate dissipation of pore pressure and to increase the effect of improvement. The replacement method with cyclopean concrete was used for some of heavy equipment foundations, such as turbine generator foundation, chimney foundation.

The measured results show that the maximum settlement of coal bunker bay is as high as 160 mm, the different settlement between columns of frame and bent being 0.0026, basically meets the requirement of Technical Code for Designing Fossil Fuel Power Plants at that time.

Choice of Program of Ground Treatment

The determination of ground treatment methods should comprehensively consider the experience of ground treatment in first phase of project, geological conditions and environment in the site, the special demands in second phase of project, as well as economic factor and work time.

In second phase of project, dynamic consolidation method could not be used in main workshop because dynamic consolidation produces vibration of ground which will affect normally operating of equipment and its improving affection may not meet the demands of settlement. In addition, such technique also needs a rather longer work time.

Natural foundation was another considered treatment method. To meet the bearing capacity of soil, embedment of columns for axes B and C (i.e. coal bunker bay, see Fig,2) must be -8.5m at least and raft foundation must be adopted. Thus it would result in excavating and dewatering in whole area of workshop. Also excavation and dewatering next to existing structures would undoubtedly affect them stability and normally operating. Natural foundation brings about rather larger settlement for same foundation pressure and embedment than pile foundation. However, natural foundation can be used for foundations of light loading structures, for examples, boiler operation floor, turbine operation floor. The embedment for such kind of foundations is -5.5m.

Concrete pile foundation was finally chosen for most of foundations in main workshop. It has the advantages of high bearing capacity, low settlement, high constructing efficiency, and so on. Even when driving piles vibration can be produced, it is not serious and dose not affect the operation of the existing structure.

As mentioned above. the different settlement is the main problem which should be carefully solved. According to the experience of first phase of project, settlements of some foundations at main workshop are rather higher, for example, columns at axes B and C in Fig.2. However, the settlement of columns at axis A are smaller because the loadings on them are not heavy. Therefore, in second phase of project the different settlement between columns at axes A and B (or C) has to be limited, otherwise, it would affect the operation of main workshop. Based on the current Code for Fossil Fuel Power Plants in China, we calculated settlements of columns at axes A, B, C by using different ground treatment methods pile foundation, natural foundation and composite foundation (axis A uses natural foundation, embedment -8.5m and other two axes use pile foundation). The results list in Table 2.

Table 2 Calculated Settlements for Columns at Axes A,B,C

Type of Foundation	Max.Settle. Axis A	Max.Settle. Axis B	Max.Settle. Axis C	Max. Diffe.Settle
Natural	10.0cm	29.2cm	29.2cm	19.2cm
Pile	2.0cm	19.8cm	20.3cm	18.3cm
Composite	10.0cm	19.8cm	20.3cm	10.3cm
Measured	5.0cm	6.5cm	6.5cm	1.5cm

From Table 2 it can be seen that when using same type of foundation for columns at axes A. B, C, the maximum different settlement is quite large, exceeding the demand of Code; by using pre-cast concrete pile foundation for columns at axes B and C. the maximum settlement is 20.3cm. Considering reducing different settlement, cutting down the cost of construction, speeding up the construction under the condition of ensuring safety of soil and foundation. finally the composite type of soil and foundation has been adopted, i.e. natural foundation for axis A and pre-cast concrete pile foundation for axes B and C. Measured settlements of such composite soil and foundation are listed in Table 2 too. the maximum different settlement is 1.5cm only.

For light and auxiliary buildings, such as office room, shift room, maintenance shop, and so on, normal shallow foundation on the natural soil would meet the requirement of bearing capacity of soil and settlement. However, collapsibility of loess must be taken into account. Therefore, dynamic consolidation was used to remove collapsibility of loess. After several year operation, all of the light and auxiliary buildings do not produce superimposed deformation caused by collapsibility, proving that dynamic consolidation is a successful technique for treatment of collapsible loess.

CONCLUSIONS

In summary, three types of soil and foundation have been used in second phase of Zhang Ze Power Station project. The practice proves that the choice of program of ground treatment is reasonable, feasible, and economic. For large engineering project, the design and construction of soil and foundation are one of the most important parts. How the program of soil and foundation directly affects the safety , the operation, the cost, and work time of whole project is a complicated and varied problem. Thus, designer must comprehensively consider various factors to make a reasonable, feasible and economic program. The case history presented here is a successful example.

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