The Application of base isolation in a power plant structure

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Abstract. In this paper, large general finite element software ABAQUS is used to contrast the isolation before and after the seismic performance of a large coal-fired power plants, the application of isolation technology in the main factory building structure has carried on the preliminary discussion. Through to the main factory building structure system of isolation design and comparison analysis, get the following conclusion: after using isolation technology, obviously improve the seismic performance of the structure, under the effect of earthquake resistance, the structure of the floor shear, layer displacement and acceleration were significantly decreased, and the upper structure under earthquake is basic to keep translation, isolation effect is obvious.

Keywords: The main machine hall; Base isolation; Seismic performance evaluation; Damping control

1. Preface
The isolation structure achieves the expected defense requirements by setting the isolation layer between the superstructure and the foundation, prolonging the natural vibration period of the structure and reducing the seismic energy of the input superstructure. The setting of the isolation layer changes the natural vibration period of the superstructure, and a "weak layer" is artificially set, so that most of the deformation is concentrated in the isolation layer, so as to ensure that the superstructure can remain in the elastic state in the event of a major earthquake. Fixed traditional anti-seismic structure foundation, upper structure shearing or bending deformation, the displacement between layers is opposite bigger, and the isolation structure between the foundation and upper structure set the isolation bearings, isolation bearings produce a larger displacement, the displacement between layers is small, the acceleration response of superstructure can be reduced to 1/5 ~ 1/3 of traditional anti-seismic structure. Therefore, when the isolated structure is subjected to a major earthquake, the horizontal force of the superstructure is much smaller than that of ordinary buildings, so it is easy to design the superstructure flexibly. Therefore, under the effect of strong earthquakes, isolated buildings can usually maintain the normal use function of the superstructure to ensure the normal operation of large thermal power plants and protect people's life safety [1].

In literature [2], Chen Zhen et al. analyzed and designed a complex frame structure located in the region of high intensity with isolation technology of 9 degrees. The results showed that: the selected isolation bearing layout was reasonable, and the adoption of isolation technology could significantly
reduce the superstructure's floor shear, inter-storey displacement Angle and torsional deformation. In literature [3], taking a project as an example, Jiang Yujian discussed the basic principles and methods of earthquake isolation design, and the analysis results showed that the use of earthquake isolation design has obvious economic and social benefits. Fan Shikai in ref. [4] in a nuclear power plant emergency command center for base isolation design, established the floor response spectrum of the floors, the analysis results show that the earthquake isolation structure obviously reduce the seismic response of the emergency command center, at the same time, the floor response spectrum is also greatly reduced, and ensure that nuclear power plant emergency command center in the emergency rescue and give full play to its functions. In literature [5], Xie Lili et al. mainly discussed how to apply this kind of fairly mature isolation technology to nuclear power projects which are very special, very important, very sensitive and very complex. With the deepening of the application research of foundation isolation, in order to improve the seismic capability of the main plant structure of thermal power plant, this paper designed the foundation isolation of a large thermal power plant structure, and compared the seismic performance of the main plant structure of thermal power plant before and after the isolation by using the large general finite element software ABAQUS.

2. Project summary
The main structure adopts the cast-in-place reinforced concrete frame and frame structure, and the typical flat facade of the structure is shown in Figure 1~2. The fortification intensity is 7 degrees 0.15g, the site characteristic period \( T_g = 0.25s \), and the site type of the project is Class I. According to the relevant provisions of the "Classification Standards for Seismic Fortification of Building Projects", the fortification category of thermal power plants should be divided into key fortification category, that is, class B buildings.

![Fig. 1 The structural plan](image1)

![Fig. 2 The structural elevation](image2)

3. Selection of ground motion
The Code for Seismic Design of Buildings provides that, when using time-history analysis method, the time-history curve of actual strong earthquakes and artificial simulated acceleration should be selected according to the type of building site and the design earthquake grouping, and the number of actual strong earthquakes should not be less than 2/3 of the total. The project selected the 2 set of natural ground motion records and 1 set of artificial wave are analyzed in the schedule, working condition of each analysis adopts two-way input, the main direction of seismic wave intensity and time than press 1:0.85 to determine, severe earthquake peak acceleration take 310 gal, figure 3 to figure 5 shows the three groups respectively acceleration spectrum of seismic wave corresponding damping ratio (5%), frequency spectrum analysis showed that the selected seismic wave spectrum characteristics meet the requirements, it can be seen that the three groups of wave response spectrum in accordance with the standard response spectrum in the key period of good ("00", and "90" to the east, and west respectively from the ground motion).
4. Layout of isolation support and damper

According to the function of the structure and the requirements of the building, the foundation isolation scheme is determined. The scheme places the isolation support on the top of the foundation, so as to separate the building from the foundation.

The design principles of foundation isolation are as follows:

In this calculation model, if only the isolation bearing is set, the displacement of the isolation layer under the action of a major earthquake is calculated to exceed the limit specified in the code. Therefore, viscous dampers are considered to increase energy dissipation, so as to reduce the energy input of the superstructure.

Again, it is assumed that the damping index = 0.30. Through trial calculation of different damping coefficients, the interlayer shear force is taken as the control target to determine the relevant parameters of the additional damper.

Finally, after repeated trial calculation, the final arrangement scheme is shown in Figure 7 (GPZ800, GPZ600 and GPY100 are the selected isolation bearing models).

5. Analysis of time history under earthquake protection

According to the code for seismic design of buildings [6], the calculation of the maximum overturning moment or the maximum inter-storey shear force in the case of isolated and non-isolated structures is generally required to be based on the input of the designed basic seismic acceleration (medium earthquake) and to be calculated by time history analysis method. This paper makes a comparative analysis of the interlayer displacement, layer displacement and layer acceleration before and after the isolation support is adopted in the main workshop of a large thermal power plant. The analysis results are as follows:

5.1. Comparison of inter-storey shear forces

FIG. 8 shows the comparison curve of shear forces on the main floors of the structure before and after isolation, as shown below:

As can be seen from the figure:
(1) After using isolation scheme, more obviously reduce the earthquake effect, under the action of 
earthquake resistance in the floor shear is decreased obviously.
(2) Compared with traditional anti-seismic structure, the use of base isolation scheme, the structure 
of the interlayer shear change more evenly.
(3) After isolation layer shear force with the original structure of the maximum ratio of 38%, after 
considering the safety factor of 0.7 the damping coefficient of about 50%, and the earthquake effect can 
be reduced to carry on the design for a time.

5.2. **Comparison of layer acceleration**

For example, the top acceleration isolation and non-isolation are shown in figure 9 below. It can be seen 
from the figure that: after the isolation scheme is adopted, the top acceleration response is reduced to a 
large extent, and the seismic action of the structure is also reduced accordingly.

![Fig. 8 The contrast of acceleration](image)

It can be seen from the figure that under the action of earthquake, the isolation support and the damper 
will absorb a large amount of energy, thus reducing the viscous energy consumption of the structure 
itself. For different input ground vibrations, both the isolation bearing and the damper dissipate a large 
amount of input energy, which is basically above 70%, which greatly reduces the energy consumption 
of the superstructure itself and thus improves the seismic performance of the structure.

5.3. **Structural energy dissipation analysis**

FIG. 10 shows the time-history curves of the input energy and energy dissipation of the isolated structure 
under the action of earthquake:

![Fig. 9 Time history curve of artificial wave](image)

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itsel. For different input ground vibrations, both the isolation bearing and the damper dissipate a large
amount of input energy, which is basically above 70%, which greatly reduces the energy consumption of the superstructure itself and thus improves the seismic performance of the structure.

6. Conclusion
In this paper, the seismic performance of a large thermal power plant before and after isolation was analyzed using ABAQUS, a general finite element software, including inter-storey shear force, floor displacement and floor acceleration. On the basis of isolation design and comparative analysis of the main workshop structure of a thermal power plant, the following conclusions were drawn:

(1) Due to the complexity of the structure, the main building structure of large thermal power plant is prone to form a weak layer under the action of rare earthquakes. The seismic performance of the main workshop is obviously improved after the foundation isolation technology is adopted. Under the earthquake protection, the seismic performance of all kinds of components of the main workshop structure meets the requirements of the code.

(2) After the adoption of the isolation scheme, the seismic action is significantly reduced. The floor shear force under the earthquake protection is significantly reduced, and the inter-storey shear force of the structure changes evenly. After isolation, the maximum value of the ratio of layer shear to the original structure is 38%, and the shock absorption coefficient is 50% after considering the safety factor of 0.7, which can reduce the earthquake action by one degree for design. The horizontal displacement of the isolated layer accounts for about 82% of the displacement of the roof layer after the isolation scheme is adopted, which indicates that the superstructure basically remains translational under the action of earthquake.

(3) the application of seismic isolation technique in power plant is still in the phase of theoretical research, the late can through to the isolation device performance and optimization design and test of exploration to enhance the energy shock absorption effect of vibration isolation structure, more effectively improve the seismic performance of large-scale coal-fired power plant main building structure, the popularization and application for isolation technology in power plant in this paper provides the beneficial reference.

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