The application research of a main machine hall for a thermal power plant with BRB

Tao Xue a, *, Guolei Xing b
State Nuclear Electric Power Planning, Design & Research Institute CO., LTD., Beijing, China

*, a Corresponding author e-mail: xuetao@snpdri.com, b xingguolei@snpdri.com

Abstract. As a kind of energy dissipation brace members by the yielding of metal, Buckling Restrained Brace (BRB) can overcome shortcomings of the common brace’s compression buckling, which has good energy dissipation capacity and ductility in earthquake. To study the Buckling Restrained Brace effect in the main machine hall, the nonlinear finite element analysis software ABAQUS is adopted to analyze the seismic performance of a main machine hall with BRB under the action of the rare earthquake and compare the elastic-plastic analysis results under the action of different seismic wave in this paper. The results show the structural seismic performance has been improved significantly, "no collapse under strong earthquake" can be achieved.

Keywords: BRB; Elastic-plastic time history analysis; Seismic control; Seismic performance evaluation.

1. Preface
Traditional anti-seismic design method by adjusting component is the basic train of thought of cross section, increasing the reinforcement measures, such as storage and consume the earthquake energy use structure itself, so as to ensure the safety of the structure of main body, but because of structures that may be encountered in the future of the ground motion intensity and features cannot be accurately estimated, and the structure of the damage in the earthquake after the earthquake the cost of maintenance and recovery is huge, so energy dissipation damping technology is gradually used to compensate for this problem, and successfully applied in many engineering practice.

Energy dissipation technology [1] USES additional substructures or energy dissipation devices to consume the energy transferred to the structure by the earthquake. Anti-buckling support (generally including steel core, filling material and outsourcing steel tube) USES the plastic deformation of the intermediate constrained yield section to achieve hysteretic energy dissipation. Its clear energy dissipation mechanism, remarkable shock absorption effect, stable performance and convenient construction and installation have attracted the attention of researchers and engineers all over the world. In the literature [2], Yang carried out a dynamic analysis of the frame-bent structure system commonly used in the houses of thermal power plants in China at the present stage, and studied the influence of anti-buckling support on the seismic performance of frame-bent structure based on ABAQUS software. The results show that BRB can effectively eliminate the uncoordinated torsion mode and displacement among different layers, reduce the displacement of each layer and improve the integrity of the structure.
In literature [3], Li Hongxing et al. adopted SAP2000 and PERFORM3D to conduct elastic analysis under multiple earthquakes and elastoplastic dynamic time history analysis under rare earthquakes. The study showed that the new structure system with anti-buckling support has better seismic performance, which can be applied in the main workshop in seismic zone and has good economic benefits. In literature [4], Xing Guolei et al. used nonlinear finite element analysis software ABAQUS to conduct finite element analysis under the action of rare earthquakes for a conventional island main workshop structure with anti-buckling support, and compared the elastic-plastic analysis results of the structure under the action of different seismic waves. The results show that the seismic performance of the structure is improved significantly after the installation of anti-buckling support. Xi Haobo et al. In literature [5] took the coal bunker structure of the phase II project of Tianjin Beijiang Power Plant as the background, adopted SAP2000 model to conduct static elastic-plastic analysis and dynamic nonlinear analysis, and studied and compared the calculation results of the original structure scheme and the BRB energy dissipation and shock absorption scheme. The results show that the BRB energy dissipation scheme can improve the torsion deformation of the workshop structure under the action of earthquakes, and reduce the base shear in both directions of the structure under the action of frequent earthquakes by 28% and 20% respectively, which proves that the BRB energy dissipation scheme adopted by the project has more advantages than the original structure scheme. In literature [6], Qi Hui discussed the feasibility of applying buckling restrained support to the main steel structure workshop of power plants in high-intensity areas. Based on the analysis results of elastic and elastoplastic stages of the steel structure with buckling restrained supports, the reasonable arrangement of buckling restrained supports and the improvement of seismic performance of the structure are discussed. The analysis results show that the smaller the proportion of the total steel amount, the more obvious the advantage is, so the BRB supporting economic value of the main double-frame workshop is better than that of the single frame. In order to effectively improve the seismic resistance of large coal-fired power factory building structure, increase safety, reduce the cost, in this paper, the structure of a large coal-fired power factory plant for prevent buckling earthquake-reduction design support energy dissipation, energy consumption and using the large general finite element software ABAQUS compared the main factory building structure seismic performance before and after the shock, for large thermal power factory building structure of suspension design and provides a strong basis for engineering applications.

2. Project summary

According to the process requirements, the main workshop of a large thermal power plant adopts reinforced concrete frame structure, and the spatial model of the main workshop of the thermal power plant is shown in Figure 1. The engineering design of use fixed number of year for 50 years, seismic fortification intensity of 7 degrees, seismic fortification category b, design earthquake are grouped into the second group, site category for III classes, design basic earthquake acceleration value of 0.15 g, seismic grade level.

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 1 to figure 3 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 scheme and optimization of anti-buckling support

It is necessary to adopt the method of installing anti-buckling supports to realize the shock absorption control of the main building structure of large thermal power plants. Factors. Choosing prevent buckling support model, in this paper, the method of reference literature according to the common support structure in small earthquake off 1.5 times the size of the elastic support, to determine the buckling yield bearing capacity of support, and then according to the above principles to determine the buckling other performance parameters of the support, through repeated trial after the basic parameters as shown in table 1:

| Number | Length (m) | Capacity (KN) | Cross area (mm²) |
|--------|------------|---------------|------------------|
| BRB1   | 4.5        | 580           | 2400             |
| BRB2   | 6.0        | 1350          | 10000            |
| BRB3   | 6.5        | 1800          | 17500            |

5. Elastic-plastic time-history analysis of structures under rare earthquakes

In this paper, ABAQUS, a large general finite element software, is used to investigate the seismic performance of the main workshop structure of thermal power plant under the action of large earthquake, and the seismic performance of the main workshop structure in the elastic-plastic stage before and after shock absorption is studied from the following two aspects:

1) Whether the inter-layer displacement Angle is within the scope specified in the specification.
2) Whether the deformation of structural members is within its bearable range mainly refers to the plastic deformation of the section of frame members (beams and columns).

5.1. Material

1) Reinforcement: Adopt the three-linear model of Clough (as shown in Figure 4 below). Considering Bauschinger effect, stiffness degradation is taken into account in the cycling process to simulate the sliding effect of rebar and concrete.

2) Concrete: The concrete uniaxial constitutive model adopted in this paper is the same as that in the OPENSEES model developed by the Pacific Seismic Engineering Center of America. The skeleton line and unloading rule are shown in Figure 5:
Fig. 4 The clough three linear model of reinforcement

Fig. 5 The stress-strain curves and hysteresis rules of concrete

5.2. Comparative analysis of displacement angles between layers

FIG. 6 shows the inter-storey displacement Angle curve of the main workshop structure before and after shock absorption:

It can be seen from the figure that:
The maximum interlayer displacement angle and layer displacement of the original structure are $1/65$ and $0.64m$ respectively. After the installation of anti-buckling support, the maximum interlayer displacement angle and layer displacement of the structure are reduced to $1/73$ and $0.60m$ respectively. The weak layer of the original structure is obviously controlled.

6. Conclusion

This paper uses the nonlinear buckling analysis software ABAQUS to set against the support of a large coal-fired power factory building structure under the action of the rarely met earthquake dynamic elastic-plastic time history analysis, seismic waves from a set of artificial wave and natural wave in both groups, seismic waves principal direction considering two cases, respectively applied to horizontal structure, a total of 6 earthquake movement of the farming conditions. ABAQUS analysis mainly includes macroscopic displacement (interlayer displacement angle, layer displacement) and component layer damage (frame damage state). Through the design and comparative analysis of the structure, the following conclusions can be drawn:

1) The structure of the main workshop of large thermal power plant is characterized by uneven distribution of mass and stiffness and multiple internal staggered floors. The displacement angle between the lower floors of the structure is abrupt in the event of rare earthquake, and weak floors are easy to form. After the installation of anti-buckling support, the inter-layer displacement angle of the structure is effectively controlled, and the inter-layer displacement angle of the damping structure is less than $1/50$, which meets the requirements of the limit value of the specification, and the damping effect is very obvious.

2) The settings prevent buckling support later, significantly reduce component damage degree, this is mainly because the brace can provide larger lateral stiffness, adjust the stress distribution of structures, providing damping energy dissipation at the same time to share some of the earthquake effect, make the stress of the structures tend to be even, effectively protect the structures. Under the action of 7 degree earthquake, the seismic performance of the main workshop structure with anti-buckling support and the seismic performance of various components all meet the design requirements, and can meet the requirements of the code "no major earthquake".

3) Set the brace of large thermal power factory workshop design method of damping structure remains to be further study, can through to prevent buckling support amount and optimization of design to enhance the buckling support energy shock absorption effect, reduce the earthquake damage of main components, more effectively improve the seismic performance of main building structure. Due to the similarity of the structure of thermal power plants and the typicality of the structural model, the conclusions obtained from the analysis are also applicable to the main plant of the common thermal power plants in China.

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