Displacement Response Comparison of Spring Vibration Isolation and Rigid Turbine-generator Foundation under Strong Earthquake

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Abstract

In order to compare seismic behavior of turbine-generator foundation under strong earthquake in different types, the 1/10 scaled model of rigid foundation and the 1/8 scaled model of rspring vibration isolation foundation were designed and fabricated. The pseudo-dynamic tests were conducted under synthesized earthquake waves separately. The loading direction was along the axis of longitudinal. Under the intensity 8 rarely earthquake the maximum plate displacement of the spring foundation is 147.60mm, meanwhile that of rigid foundation is 93.20mm. From the research, it is shown that the displacement response of the plate of the spring foundation is greater than that of the rigid foundation under the action of strong earthquake, but the displacement of the platform and the column is smaller than that of rigid foundation.

Keywords

Spring Vibration Isolation; Seismic Reponse; Drift;

1. Introduction

Turbine-generator is one of the core equipment in power plant, its running environment, running status is directly related to the normal operation and the economic benefit of power plant. Turbine-generator foundation is a complex spatial frame structure, the seismic performance, especially under strong earthquake has not been adequately studied. A 300 MW turbine-generator foundation system is analyzed under excitations from earthquakes[1]. Pseudo-dynamic test of 1251MW turbine-generator foundation was carried out under earthquake [2]. The model is 1/8 scaled. The results indicate that the foundation has preferable seismic capability during the intensity 7 frequently and rarely earthquake. Three examples of finite element analyses for seismic response of spring supported T/G foundation were investigated [3]. Spring supported T/G foundation could decrease velocity, acceleration and inner force response of T/G deck and shaft. Literature [4] uses a simulated earthquake shaking table test to input the El-Centro earthquake records, has measured the acceleration and the stress. Pseudo static test was carried out at the same time. Literature [5] presents an alternative technique to the modal analysis of foundations.

The new design of turbine-generator put forward requirements for the design of the foundation, in order to ensure the safety of the foundation structure, through the seismic experiment, comparing the seismic behavior of the foundation applied spring vibration isolation and the rigid foundation. On this basis, the adjustment and optimization are carried out, and a reasonable turbine-generator foundation form satisfying the safe, reliable and economical operation of the unit is put forward, so as to improve the dynamic characteristics of the foundation.

2. Experimental Model

2.1 Model design

The turbine-generator foundation is a 73.830m×23.000m×25.350m six spans frame structure. There are four independent columns in the third and the fourth span (C3/C4/C10/C11). There is a three-story platform at both ends. The platform is connected with 4 colums (high pressure cylinder end) and 6 columns (Generator end) respectively. The concrete grade is C40 and reinforcement is HRB400. The Structural geometry is shown in Fig. 1. The spring vibration isolation foundation is 0.81m higher than the rigid foundation.

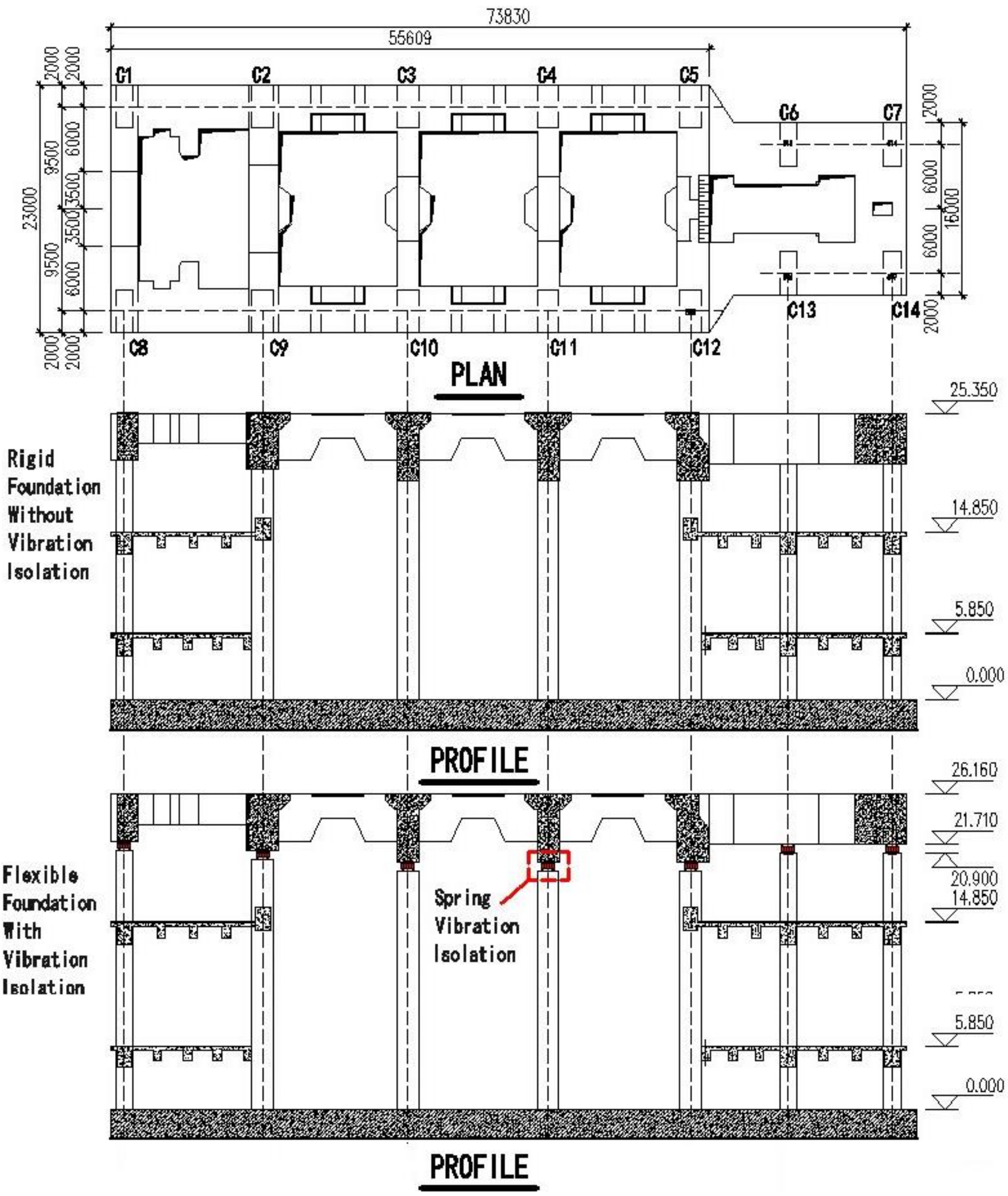


Fig. 1 Plan and profile of the turbine-generator foundation (mm)

2.2 Scaled model

In this paper, seismic tests are carried out on two kinds of turbine-generator. The foundation types are different, the model scale ratio is different, the spring vibration isolation foundation is 1:8, and the rigid foundation is 1:10. The mass and gravity are separated due to the pseudo dynamic test loading. The mass is simulated numerically in the computer, and the gravity is realized by the weight block. There are two separate quantities, L=1:8/1:10, T=1:8/1:10, through calculating, the similarity coefficients used in the tests are shown in the Table 1.

Table 1 Similarity relation of scale model

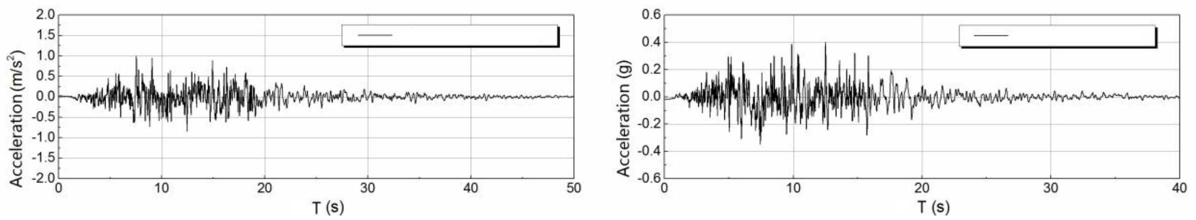
Coefficients	Geometry size	Force	Stiffness	Quality	Time	Acceleration
Spring foundation	1:10	1:64	1:8	1:512	1:8	8:1
Rigid foundation	1:10	1:100	1:10	1:1000	1:10	10:1

The weight of generator concentrated on the foundation plate, accounted for about forty percent of the total mass of the generator and the foundation. According to the similarity ratio of the weight, the weight of the generator is simulated by cast iron in accordance with the mass distribution of the equipment, as shown in Fig. 2.

Fig. 2 Foundation models with and without spring vibration isolation

2.3 Earthquake Input

The synthesized earthquake acceleration were used in the pseudo-dynamic tests. The peak value acceleration of earthquakes were turned into the value 100 cm/s2 when intensity 7 fortification, 400 cm/s2 when intensity 8 rarely. These records were the input of earthquake acceleration for frequently, fortification and rarely earthquake, as shown in Fig. 3.

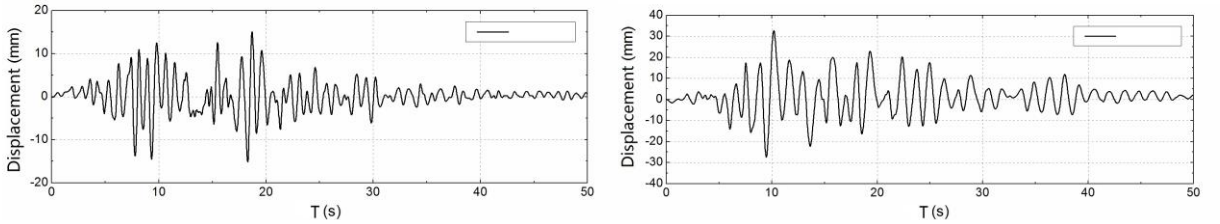


(a) intensity 7 fortification input (b) intensity and 8 rarely

Fig.3 Earthquake acceleration time history curve of synthesized (longitudinal input)

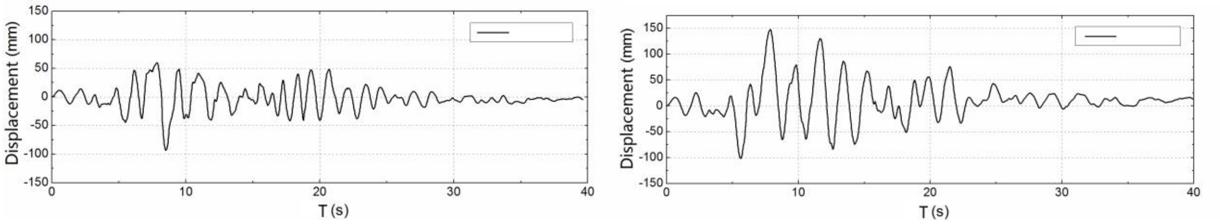
3. Results of seismic response

The LVDT displacement sensors were layout on the foundation model to control the displacement of the pseudo-dynamic test and measurement. The plate, columns top, second platforms and first platforms were layout the displacement measuring points. The displacement responses of the foundation plate are shown in Fi.4 and Fig. 5. The maximum displacement of different location in foundation is shown in Table 2. It can be seen from the Fig. 4, Fig. 5 and Table 2 that the displacement of the spring vibration isolation foundation is greater than that of the rigid foundation, whether it is 7 fortification earthquake or 8 rarely earthquake. Because of the presence of spring vibration isolation device, the deformation concentrated in the columns and the plate, the proportion of column displacement is small. The deformation of columns is a matter of concern and control. The same condition also exists on the platform deformation. Especially in rarely earthquake, the platform displacement of spring isolation foundation is much larger than that of rigid foundation, but the displacement of the second platform is small, which is a kind of protection for the equipment on the platform during the strong earthquake motion.



(a) Rigid foundation (b) Spring foundation

Fig.4 Displacement response curve of intensity 7 fortification of synthesized (longitudinal input)



(a) Rigid foundation (b) Spring foundation

Fig.5 Displacement response curve of intensity 8 rarely of synthesized (longitudinal input)

Table 2 The maximum displacement of different location in foundation (mm)

Intensity	Type/Location	Plate	Column top	Second platform	First platform
7 fortification	Spring foundation	37.17	31.00	14.76	3.75
	Rigid foundation	15.20	13.18	11.49	3.62
8 rarely	Spring foundation	147.60	130.60	57.50	14.08
	Rigid foundation	93.20	88.60	77.67	25.03

4. Conclusion

In this paper, the pseudo dynamic tests of spring vibration isolation foundation and rigid foundation with the same size are carried out, and the displacement and column displacement of two foundations are compared under intensity 7 fortification and 8 rarely earthquake. The results show that the displacement of the plate of the spring foundation is greater than that of the rigid foundation under the action of strong earthquake, but the displacement of the platform and the column is smaller than that of rigid foundation, and the ratio of displacement of platform and column to total displacement is more reasonable.

Acknowledgements

This paper was financially supported by Youthful Top Talents Cultivation Plan of North China University of Technology (XN018034).The authors' deeply express sincere appreciation to them.

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