Analysis of the Influence of Structural System Selection on Foundation Isolation Houses

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Abstract. According to the modeling and analysis of the structural design software (ETABS and SATWE), the data are obtained, and the mechanical properties and preliminary economic indicators of the three structural systems of frame structure, frame shear structure and shear structure of shear wall structure in the basic isolation design.The time course analysis data are summarized and compared, and the actual foundation isolation in the selection stage.Under the premise of the site type, seismic fortification intensity and building height determination, the best structure selection and layout are obtained by analyzing the stress performance and economic indicators of the structure.The influence of the structure selection on the stress performance and economic cost is discussed.

Keywords: Vibration isolation; structural design; stress performance.

1. Selection and Modeling of Housing Structure System

The seismic waves selected by time course analysis in this chapter are ELCentro, TH2TG090 and TH3TG065. The input acceleration is 1000 mm/s2, 2000 mm/s2, 2200 mm/s2 for 7 ° earthquake, and 4000 mm/s2 for 8 ° earthquake

The construction condition of the structure is set as follows:

(1) 20 storey structure, class site, fortification intensity is 7 or 8 degrees, the height of the superstructure is 20 floors, the height of 3.6m, the isolation layer is on the foundation, the height is 1.8m, the total height of the building is 73.8m, the building plane is 21.6m×21.6m.

(2) 10 Floor structure, class site, fortification intensity is 7 degrees or 8 degrees, the height of the building superstructure is 10 floors, the height of 3.6m, the earthquake isolation layer is located on the foundation, the height is 1.8m, the total height of the building is 37.8m, the building plane is 21.6m×21.6m.

There are many factors affecting the isolation effect of foundation isolation. Under the same site and height condition, the main factors affecting the isolation effect are the selection of the upper structure and the layout of the isolation layer. The layout of the insulation layer considers the economic and building mechanics requirements, and selects seismic waves and establishes finite element model. The whole isolation design process meets the requirements of Code for Seismic Design of Buildings and Technical Regulations for Concrete Structure of High-rise Buildings. The selection of the isolation support is initially controlled according to the flexion weight ratio and the axial pressure of the support, and finally the isolation layer displacement under the large shock is checked.

In order to achieve the optimal insulation effect, the stiffness of the isolation layer is controlled to ensure that the flexion weight ratio of the frame structure, frame shear structure and shear wall structure is within the optimal range. The best value of the isolation design is controlled at about 2%. Table 1 and table 2,20 layers of three models below 2.5%, 10 layers of weight ratio above 2.5%, thus the higher the building, the smaller the weight ratio in the isolation design, the building height is the same, the isolation effect of structure, combining figure 2 structure of the damping coefficient comparison, the smaller the insulation effect is better.

Table 1. Comparison of the flexion-weight ratio of layer 20 structure.

Structure type	The total yield(kN)	quality(kN)	Quit weight than
Framework	4377.4	177940	2.46%
Frame-shear	3861.2	157600	2.45%
Shear Wall	3065.2	135040	2.27%

Table 2. Comparison of weight ratio of 10 layers.

Structure type	The total yield(kN)	quality(kN)	Quit weight than
Framework	2442	87703	2.78%
Frame-shear	2362	78463	3.01%
Shear Wall	1758	70420	2.50%

2. Structural Software Data Analysis

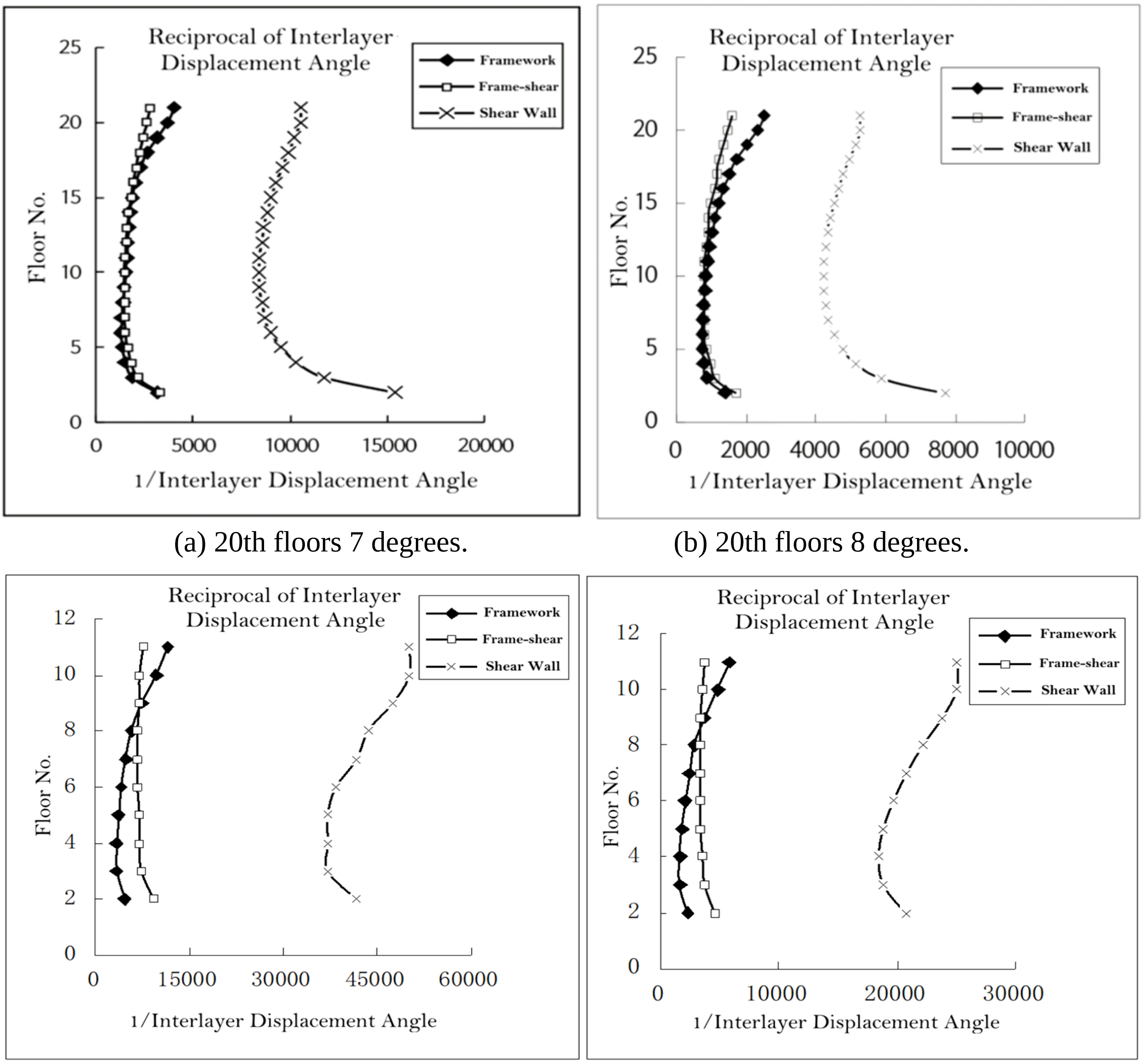
Figure 1 shows the contrast of the reciprocal displacement angle of the lower layer in the isolation structure, the larger the reciprocal displacement angle, the smaller the displacement between the structures. According to the figure, the reciprocal of the shear wall structure is much smaller than the frame structure and the frame shear structure, while the interlayer displacement angle is similar to that of the frame shear structure and the shear wall structure. The code for Seismic Design of the building for the frame structure, frame shear structure and shear wall structure are 550,800 and 1000 respectively. According to Figure 1, all the three structural systems after the earthquake can meet the specification requirements under the action of moderate earthquake. It shows that in the isolation structure, the vertical transverse stiffness of the shear wall structure is very large, which makes the displacement between the structures is very small, while the influence of the shear wall in the frame shear structure is not very obvious, so the interlayer displacement is equivalent to the frame structure.

Figure 2 shows the comparison of the damping coefficient under various working conditions. The damping coefficient selected in this chapter is the shear ratio of the isolation structure and the non-isolation structure in the X direction. From 0.253 to 0.619, the damping coefficient of the frame shear structure is from 0.28 to 0.25 to 0.228, and the shear wall structure is easier to meet the safety and comfort in the insulation design of high-rise buildings. Frame structure and frame shear structure can also meet the requirements of structural safety, applicability and durability in earthquake isolation engineering.

Figure 3 shows the top acceleration time comparison diagram of the isolation structure. The time analysis seismic wave is ELCentro wave, 7 degrees is 1000 mm/s2,8 degrees is2000 mm/s 2,

Then, the acceleration reaction of different structural systems is compared under the same working condition. By comparison, in the time-course analysis, the absolute value of the top-level acceleration of the three structural systems is not much different after the isolation design.

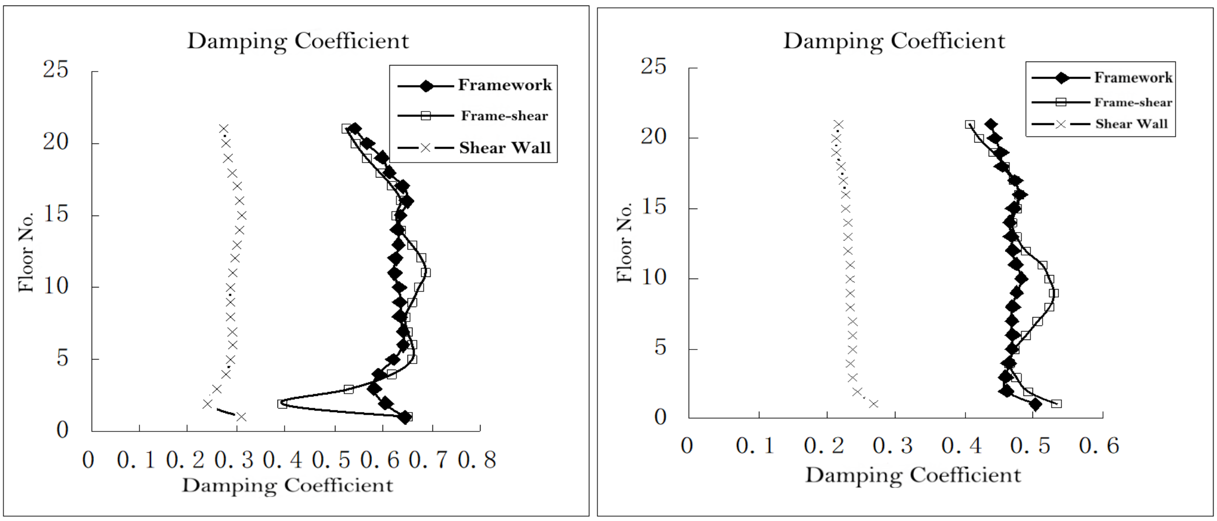
Figure 4 shows the comparison diagram of the top acceleration time of the non-insulated structure, which shows that the top acceleration reaction between the non-insulated frame and the frame shear structure is not different, the top acceleration of the shear wall structure is the largest, and the top acceleration of the 10-shear wall structure is known from Figure 3 (c) and (d). Structure responds strongly to seismic acceleration.



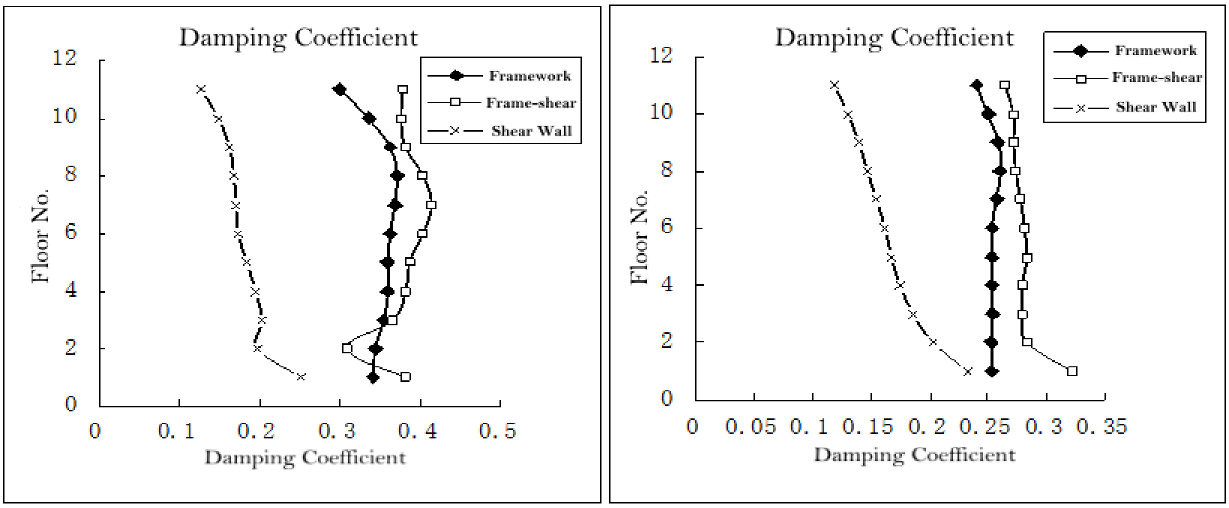
(a) 20th floors 7 degrees. (b) 20th floors 8 degrees.

(c) 10th floors 7 degrees. (d) 10th floors 8 degrees.

Figure 1. Comparison of the displacement angles between the layers of the isolation structure.

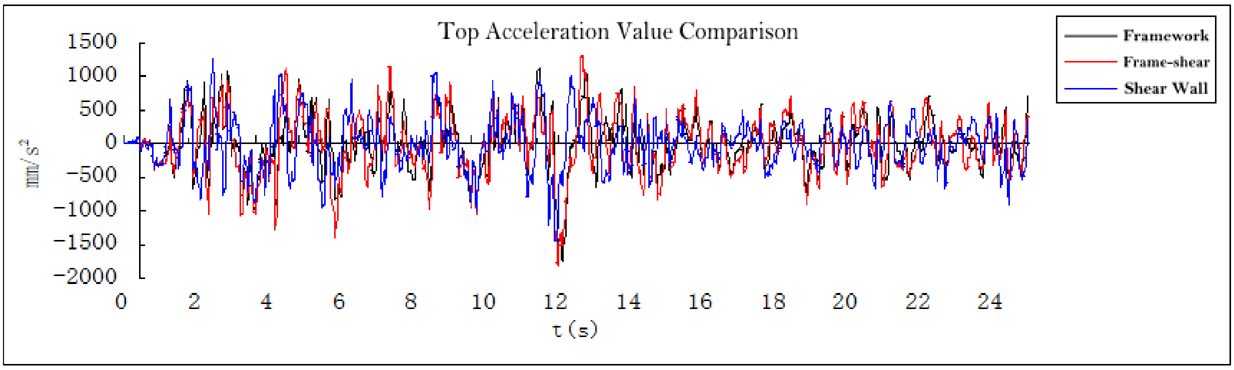


(a) 20th floors 7 degrees. (b) 20th floors 8 degrees.

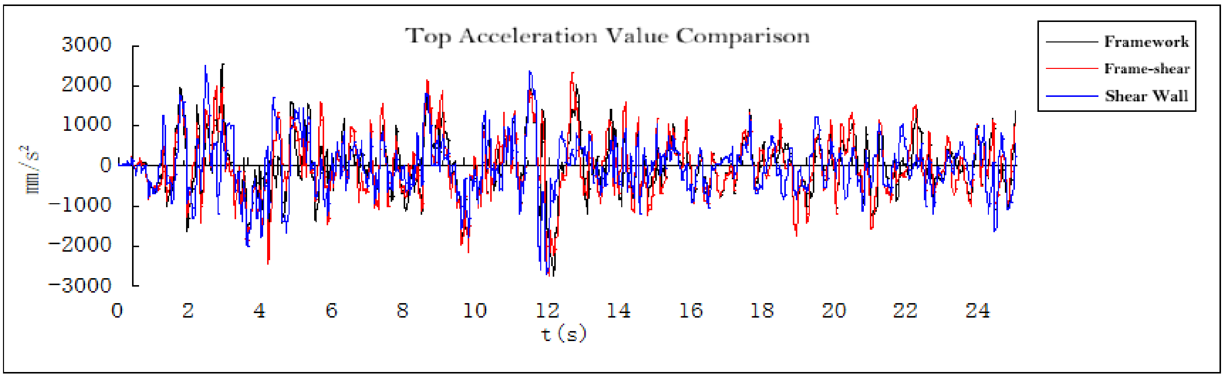


(c) 10 layer 7 degrees. (d) 10 layers at 8 degrees.

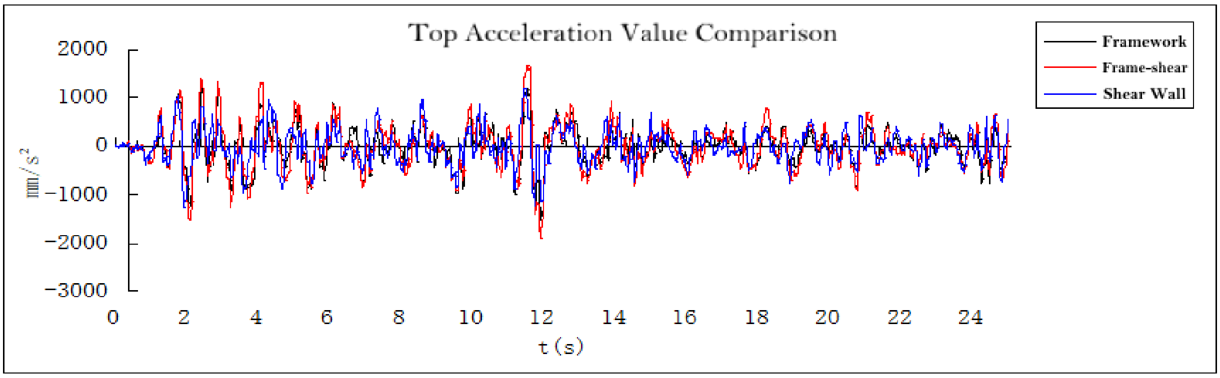
Figure 2. Comparison of structural shock absorption coefficient.



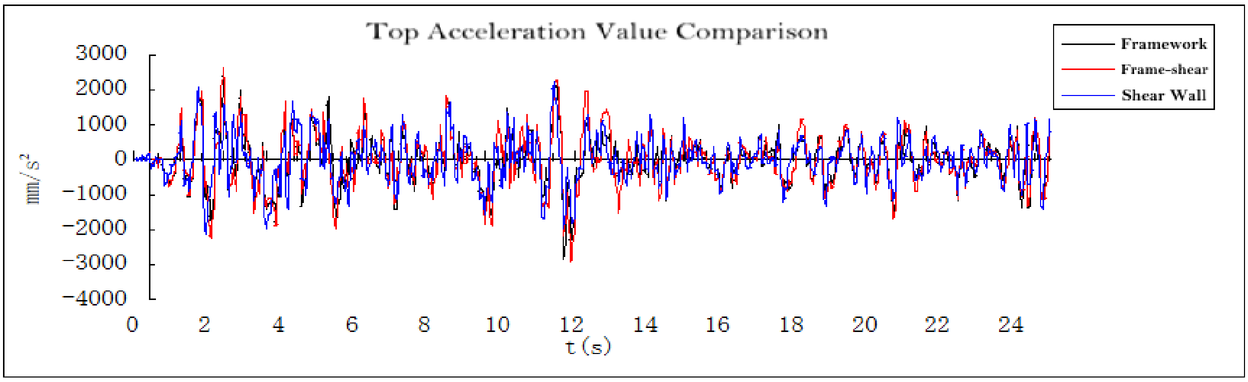
(a) 20 layer 7 degrees.



(b) 20 layers at 8 degrees.

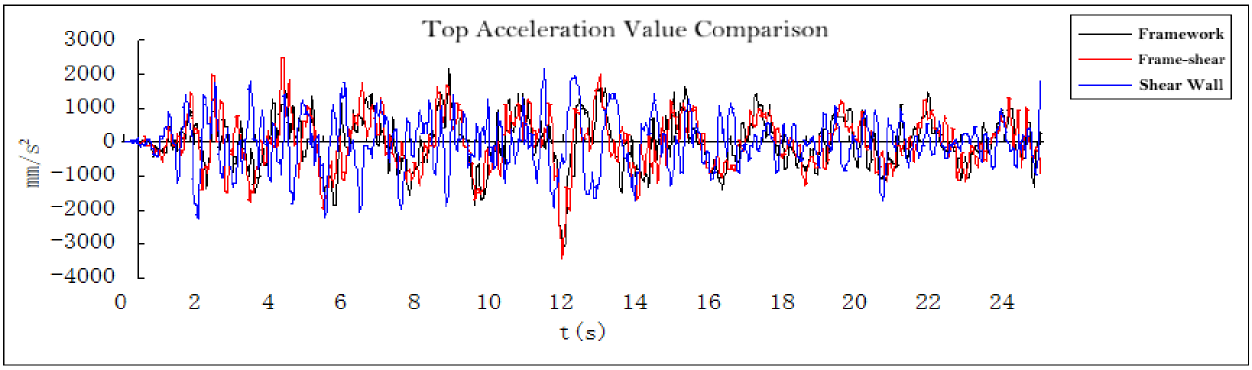


(c) 10 layer 7 degrees.

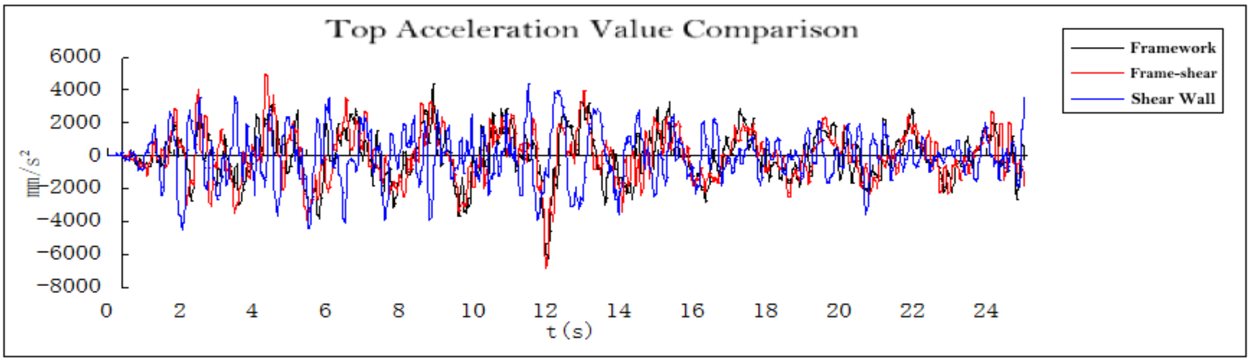


(d) 10 layers at 8 degrees.

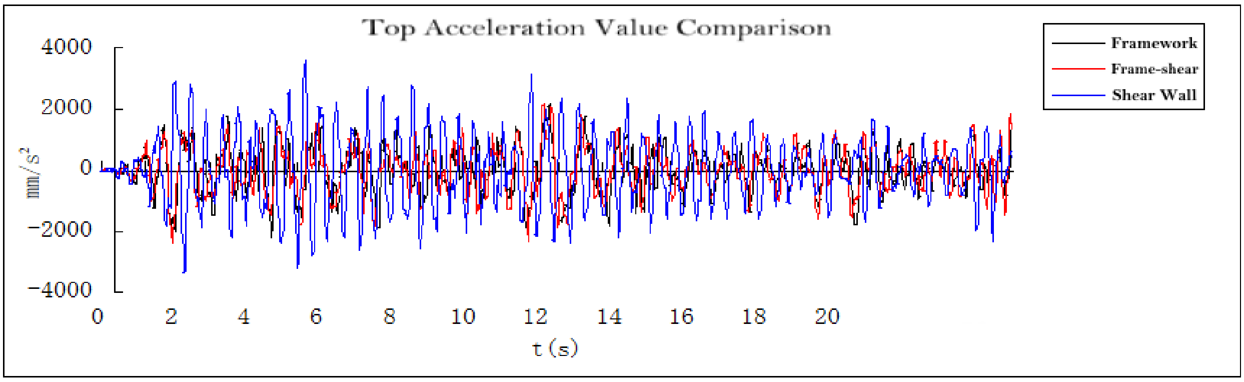
Figure 3. Comparison of the acceleration time course at the top layer of the shock isolation Structure.



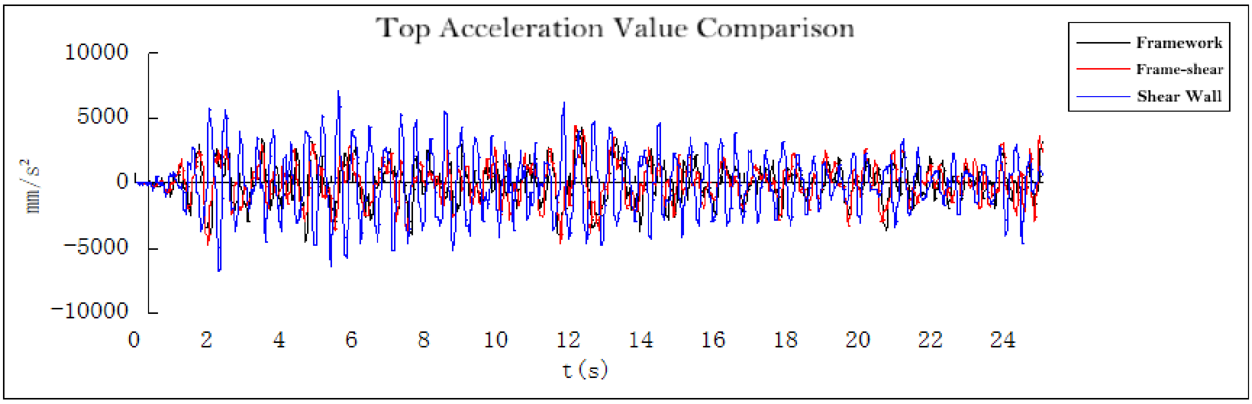
(a) 20 layer 7 degrees.



(b) 20 layers at 8 degrees.



(c) 10 layer 7 degrees.



(d) 10 layers at 8 degrees.

Figure 4. Comparison of the top-layer acceleration time course of the non-isolation structure.

Table 3 shows the comparison of the maximum acceleration of the top structure, the smaller the ratio of isolation structure and non-isolation structure, the better the isolation effect of the structure. According to the data in the table, the input earthquake acceleration of different structural systems to the earthquake. The top acceleration of the shear wall structure in the isolation structure is the smallest, while the top acceleration of the shear wall structure in the non-isolation structure is larger. Therefore, the ratio of isolation and non-isolation structure is smaller than the frame and frame shear structure. When the working conditions are certain, the acceleration ratio of the top level is higher to the frame, frame shear and shear wall respectively. It shows that the greater the structural stiffness, the more favorable to the shock isolation.

Table 3. Comparison of acceleration at the top of the structure.

Working condition	structural system	The isolation (mm/s^2)			Isolation (mm/s^2)			The average ratio
		ELEW	TH2TG090	TH3TG065	ELEW	TH2TG090	TH3TG065	
20th floors 7 degrees	framework	3122	2086	3071	1745	1580	1729	0.626
	Box shear	3404	2242	3900	1785	1846	1659	0.591
	shear wall	2268	3637	4104	1456	1638	1939	0.522
20th floors 8 degrees	framework	6244	4055	6142	2690	2909	2889	0.540
	Box shear	6809	4485	6411	2728	2766	2893	0.490
	shear wall	4536	7274	8207	2656	2938	2989	0.451
10th floors 7 degrees	framework	2204	3679	4058	1495	1625	1883	0.528
	Box shear	2395	4449	4369	1897	1777	1959	0.547
	shear wall	3582	3401	3052	1260	1313	1263	0.384
10th floors degrees	framework	4408	7358	8115	2840	2791	3084	0.468
	Box shear	4791	8898	8739	2921	2871	3521	0.445
	shear wall	7164	6801	6104	2224	2416	2690	0.369

Note: The average ratio term is the average of the top acceleration ratio of the isolation structure and the non-isolation structure under the time course analysis of the three seismic waves.

Table 4 and Table 5 show the displacement of the top layer of the non-isolated structure and the isolation layer of the isolated structure under the action of large earthquakes respectively. As can be seen from Table 4, among non-isolated structures, the displacement of shear wall structure is the smallest, indicating that the greater the stiffness of the structure, the smaller the displacement. As can be seen from Table 5, the displacement of shear wall structure in the isolated structure is the largest. It can be seen that the selection of superstructure affects the displacement of isolation layer of the isolation structure, and the larger the displacement of isolation layer, the better the isolation effect.

Table 4. Top layer displacement of non-isolated structures under major shock action.

Working condition		20 Layer 7 degrees			20 Layer 8 degrees			10 Layer 7 degrees			10 Layer 8 degrees		
Structural system		Framework	Frame -shear	Shear Wall	Framework	Frame -shear	Shear Wall	Framework	Frame -shear	Shear Wall	Framework	Frame -shear	Shear Wall
Non-isolation (top floor)	ELEW	338	338.5	110.5	614.5	615.5	230	112.2	165	37.4	203.9	182.9	67.9
	TH2TG090	250.3	274.4	146.2	455.1	498.5	265.9	147	100.6	32.7	267.4	300.7	59.5
	TH3TG065	361	270.2	214	656.4	713	389.1	207.1	242	36.9	376.6	440	59.4

Table 5. Isolation layer displacement under the action of large earthquakes.

Working condition		20th floors 7 degrees			20th floors 8 degrees			10th floors 7 degrees			10th floors 8 degrees		
Structural system		Framework	Frame -shear	Shear Wall	Framework	Frame -shear	Shear Wall	Framework	Frame -shear	Shear Wall	Framework	Frame -shear	Shear Wall
Isolation layer	ELEW	218.8	212.8	238.7	439.5	415.2	519.3	214	172.8	194.6	493	418.6	450
	TH2TG090	111.6	143.6	151.6	303.2	251.2	326.1	141.4	132.7	154.7	302	319.5	369.5
	TH3TG065	131	155.2	159.7	251.5	219.9	296	164.5	146.2	164.8	306	300.2	337.9

Above all, selection of structural system's influence on the vibration isolation effect under different working conditions, mainly reflected in the structure of the displacement, acceleration and shear layer and interlayer displacement Angle, etc., through the comparison and analysis, induces structural system selection effect on structure of isolation, isolation effect from good to bad, followed by shear wall structure, frame structure, frame shear structure. However, when the height of the building is reduced (10 stories), the seismic isolation effect of frame structure and frame shear structure is equal. The shear wall structure has a good isolation effect, but compared with the non-isolation structure, the displacement of the shear wall isolation structure is much larger, the energy dissipation effect of the structure is good, while ensuring the isolation effect, and it should control the displacement of the isolation layer under large earthquakes.

Figure 5 shows the top acceleration contrast curve, where the average ratio is the average ratio of the top acceleration maximum of the top isolation structure of the three selected seismic waves. The smaller the ratio, the smaller the top reaction of the isolation structure, the better the isolation effect. Using different working conditions as the horizontal axis, the linear regression of each point is conducted to obtain the top acceleration contrast line formula (1):

$$\alpha = -0.0177x + 0.6115 \quad (1)$$

In the above formula, α is the ratio of the top-level acceleration of the isolation structure; x is sorted by working conditions, starting from the 20-layer 7-degree frame in accordance with the working order shown in the figure, and taking 1,2,3 to 12 in turn. The effect of top floor acceleration absorption of isolation design can be predicted according to this line.

Figure 6 shows the contrast curve of the shock absorption coefficient. The smaller the shock absorption coefficient, the better the shock isolation effect. The linear regression of each point is the same as formula (2) to obtain the linear formula of the damping coefficient (2):

$$\beta = -0.0345x + 0.0083 \quad (2)$$

In the above formula, β is the damping coefficient of the structure, and x is sorted according to working conditions. According to the working order shown in the figure, starting from the 20-story 7-degree frame, take 1, 2, and 3 to 12 in sequence. The effect of seismic isolation design can be predicted according to this line, and the seismic influence coefficient of structure can be estimated at the beginning of seismic isolation design, and the section of component can be preliminarily determined.

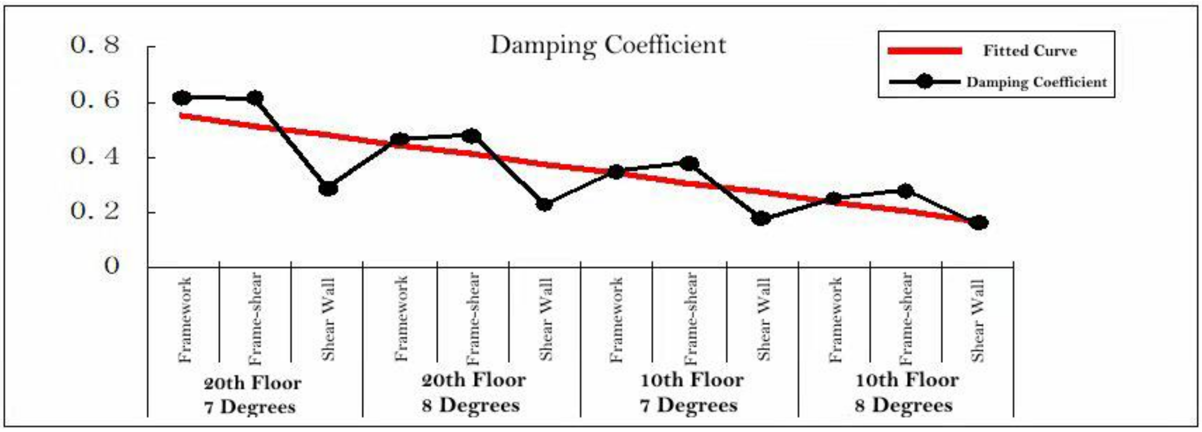


Figure 5. Top-level acceleration comparison curve.

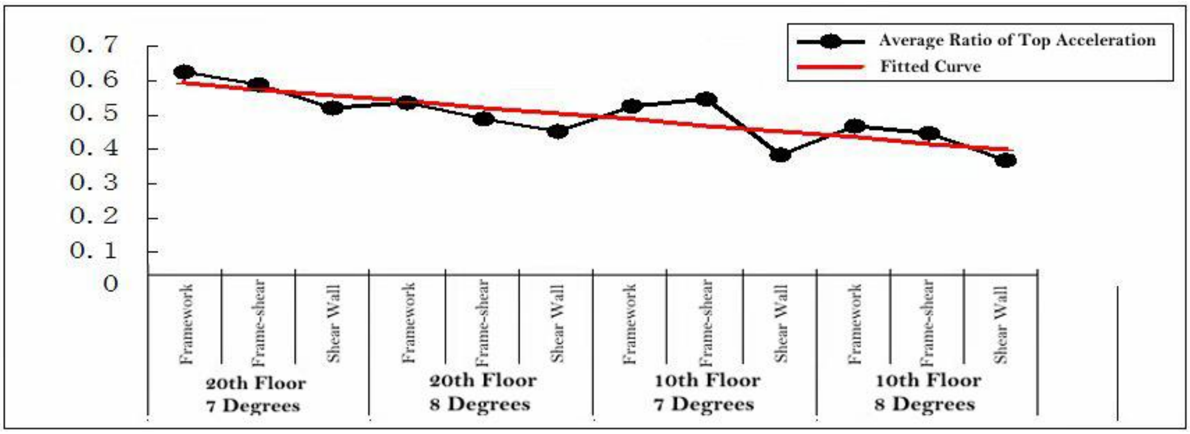


Figure 6. Shock absorption coefficient.

3. Conclusion

According to the above analysis, the most reasonable selection of base isolation structure is obtained, and the most reasonable selection of shear wall structure is 20 floors 7 degrees of fortification. The most reasonable structure selection is shearing wall structure, frame shear structure is the second. Frame shear structure is the most reasonable structure selection when 10 floors and 7 degrees of fortification; Frame shear structure is the most reasonable structure selection when 10 floors 8 degrees fortification.

Practical research and engineering design show that the structural analysis results are similar under the condition of similar number of floors. Since the building height selection is random in practical engineering, the formula and conclusion of this structural analysis model can be used as reference for the selection of earthquake-isolated buildings.

Acknowledgments

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